SYSTEMATIC DEVELOPMENT OF NEW PRODUCT STRATEGIES IN A MACHINE TOOL COMPANY

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October 1982

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SUMMARY

Towards the end of the 1970's, a successful international machine tool company was facing increasing worldwide competition and a radical technological revolution away from conventional machine tools and towards Numerically Controlled machines. This thesis describes the development of new product strategies in response to this rapidly changing environment.

Conventional new product development methodologies are shown to take insufficient account of corporate factors and so a modified methodology has been developed which incorporates Strategic Market Planning. This is shown to offer some important benefits. In this particular implementation, the methodology involved the selection and development of procedures for Strategic Market Planning, Forecasting and Marketing Research.

The Strategic Market Planning which is described uses the Boston Group's growth/share matrix combined with Product Life Cycle analysis. These two techniques are found to be highly complementary and most suitable for introduction in a multi-product company which is not marketing orientated.

It is shown how three types of Forecasting (Economic, Sales and Technological) can all make an important contribution to the development of a new machine tool. Particular use is made of the Fisher-Pry substitution model which is used to give some valuable forecasts at the rate of substitution of N.C. for conventional machine tools.

Competition and desk research methods are shown to partially overcome the problems which arise from performing Marketing Research in a company which has little confidence in questionnaire techniques.

This project has contributed to the development of a complete portfolio of new high technology machine tools. Two of these new machines have already been launched and these are both successful new products.

From the experience gained in this particular application, it has been concluded that conventional new product development procedures can be improved by adopting the modified methodology.

Key Words: Machine Tool Strategy New Product

ACKNOWLEDGEMENTS

I should like to express my gratitude to all those people who have provided advice and assistance during this work and in particular to the following.

Firstly, my main supervisor, Prof. Keith Foster, who has provided continuous encouragement and support throughout this project.

Also to Dr. George Lesiak and Mr. Peter Gale whose foresightedness originally identified the need for this project, and to Mr. Mike Mortimer who kindly took over the role of industrial supervisor.

Thanks also to Ms Debbi Blood, for providing so much of the early direction, and to Mr. John Bayliss for his considerable assistance with my final script.

I should also like to acknowledge all those who have given their valuable time to answer my questions. In particular I should like to thank Prof. H. Igor Ansoff and Mr. Brian Twiss. Thanks also to Prof. Peter Baron for his valuable help with my final draft.

I am indebted to staff of IHD, both present and past, who have helped and instructed me and particularly to my tutor and mentor Dr. Alistair Cochran.

Thanks also to Mrs. Annette McEntaggart whose excellent typesetting has created order out of chaos, and to Mr. Richard Maruda for his portrayal of the Boston Matrix (Figure 2.4).

Finally, special thanks are due to my wife Margaret, without whose patience and support this work would never have been completed.

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

TABLE OF CONTENTS (Cont'd)

LIST OF FIGURES

LIST OF FIGURES (Cont'd)

CHAPTER 1

BACKGROUND

1.1 INTRODUCTION

This work is a contribution to the new product development process of an international machine tool company. To appreciate the content of this contribution, it is first necessary to describe the world environment within which the company operates.

This chapter will therefore provide a brief description of the international machine tool industry, it's history and current status. The declining stature of the U.K. machine tool industry will also be discussed and reasons for this decline examined.

The position of the company's products within the world environment in 1980 will also be examined and the rapidly changing nature of competitive pressures will be explored.

1.1.1 DEFINITIONS

A metal cutting machine tool is a power driven machine, not operable by hand while in operation, which works metal by a cutting process. (B.S. 4640: 1970).

A milling machine is a machine tool which cuts metal from work which is fed normally against a multi-toothed cutter rotating about its own axis.

Numerical Control (N.C.) is the general term for the process of controlling and operating a machine tool using numerical data.

Computer Numerical Control (C.N.C.) uses computer assistance for the numerical manipulation required. (These two expressions are often used interchangeably).

Manual Data Input (M.D.I.) is the facility for entering a program into an N.C. machine tool through a keyboard attached to the machine. Under normal operation programming is performed at the machine in this manner.

A Machining Centre (M.C.) is an N.C. machine tool, with automatic tool changing, whereby a number of different operations can be performed automatically on two or more faces of the work without disturbing its setting.

Flexible Machining System (F.M.S.). This expression will be used loosely in this work to describe a general accumulation or grouping of machine tools to provide a fully flexible production cell.

1.2 THE WORLD MACHINE TOOL INDUSTRY

1.2.1 HISTORY AND CURRENT SITUATION

The first recognisable machine tools were developed during the industrial revolution in the seventeenth century. Many of these early machines were direct predecessors of modern machine tools which have evolved to attain the present day levels of sophistication. The world demand for machine tools was initially supplied by the U.K., other European countries and America.

The spread of the industry throughout the world has been at the spearhead of industrialisation. It has therefore been an inevitable progression for countries with genuine ambitions towards growth and industrialisation to develop an indigenous machine tool industry. This provides long term investment in the country's industrial infrastructure, reduces dependence on foreign suppliers and can also increase the country's political independence and military strength.

The result of this is that most industrialised countries and many developing countries now manufacture machine tools and the total number of manufacturers is increasing. Since most of these manufacturers have ambitions of growth, the net result has been a considerable increase in international competition.

The problems related to increased competition have been exacerbated during the 1970's by world economic conditions which have resulted in declining growth rates and high inflation. This troika has been particularly damaging in the west where manufacturing industry in particular has suffered a sharp reduction in growth rates and profitability.

Since manufacturing industry is the customer of the machine tool industry, there have been corresponding and amplified consequences in the machine tool industry.

1.2.2 THE BUSINESS CYCLE

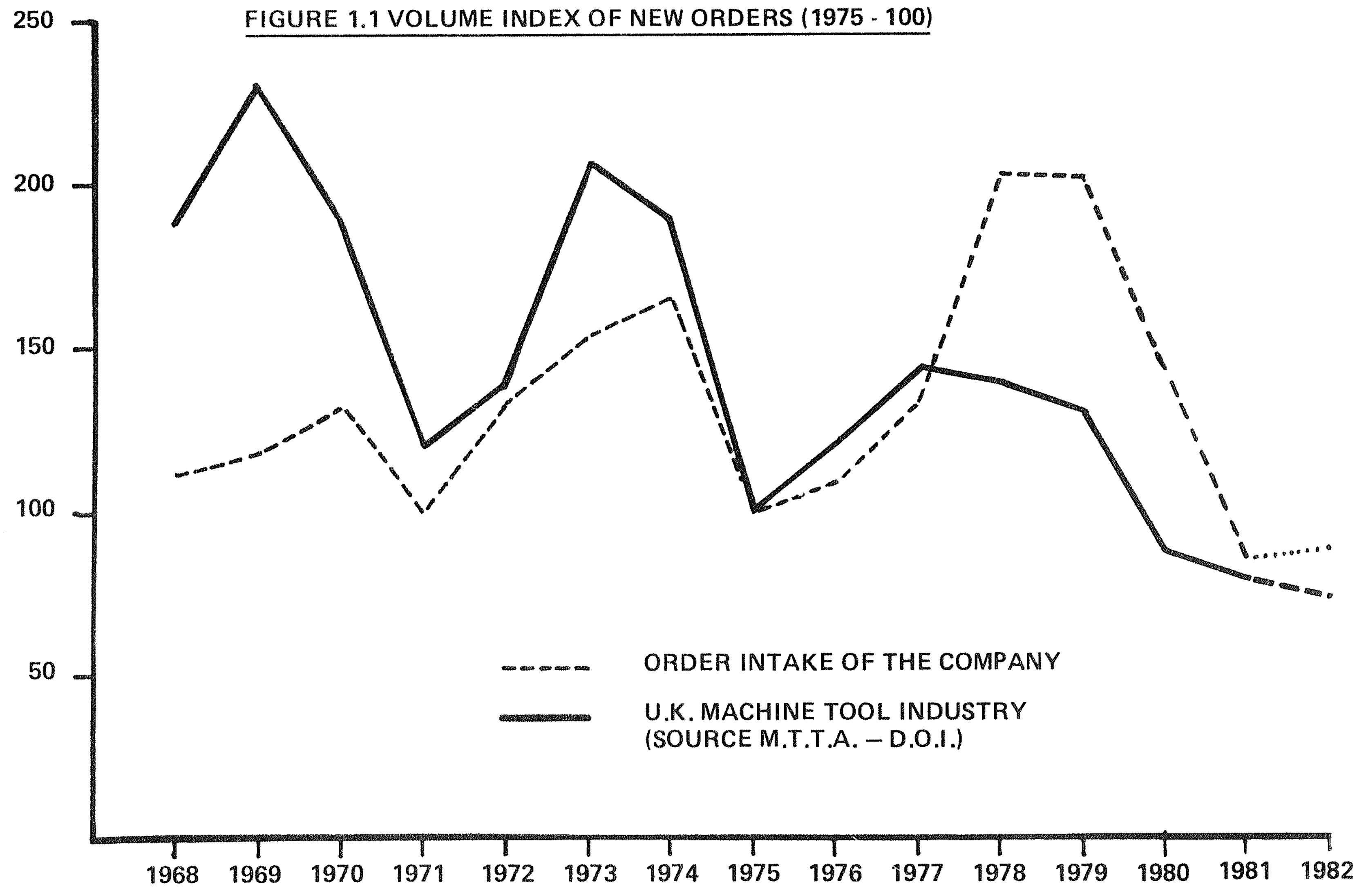
A further problem, apparent in the machine tool industry, is an acute acceleration of the business cycle. This particular aspect of the industry has been recorded by other researchers (e.g. Hummel, 1954; Buzzel et al, 1969) and Figure 1.1 illustrates the effect in the U.K. during the last decade.

When an accelerated business cycle is combined with an industry which is otherwise weakened a consequence becomes apparent which can be called the "Ratchet Effect".

In this, during the high demand periods, the industry or individual company, being in a weakened state and unaccustomed to high growth rates, fails to satisfy demand and loses market share to competitors. As the subsequent slump arrives, the competition, having established and strengthened sales, service and spares facilities, is in a stronger position to improve market penetration during the next upturn.

Hence the "Ratchet Effect" in which weakened industries or companies decline during each business cycle while the more successful companies and countries can achieve real growth.

FIGURE 1.1 VOLUME INDEX OF NEW ORDERS (1975 - 100)



1.3 THE U.K. MACHINE TOOL INDUSTRY

The U.K. machine tool industry has suffered particularly badly from the effects of increased competition, economic conditions and the business cycle, but has additionally experienced other problems.

Since the U.K. is the home and largest market of the division which initially commissioned this research some specific discussion on this country is necessary.

Figure 1.2 shows the top ten machine tool producing countries in 1979. This shows that the U.K. was the sixth largest producer of machine tools and the fifth largest consumer, thus showing that the U.K. is one of the major industrial countries in the world.

However, this Figure shows the U.K. as being the world's third largest importer and yet only ranking eighth in the export league. This disparity indicates that compared with other major machine tool manufacturing nations, the U.K. has a poor performance in its domestic market.

This relatively poor performance in the U.K. machine tool industry has developed over a considerable number of years, but the trend has accelerated in recent years. For comparison, it is valuable to examine the indices of industrial production produced by the Department of Industry and Trade over the last five years, a period which covers both growth and recession. These indices are shown in Figure 1.3

This Figure shows not only how the machine tool industry has declined relative to "all industries", but also to "other manufacturing industries".

This decline has been matched by a corresponding increase in imports which have steadily increased from virtually zero 100 years ago to present day levels of approaching 50%. Figure 1.4 illustrates how imports have increased over the past decade.

FIGURE 1.2 WORLD TRADE IN MACHINE TOOLS 1979

(Million Dollars) (Not including spares and accessories)

COUNTRY	PRODUCTION	EXPORT	IMPORT	CONSUMPTION
F.R.G.	4100	2460	541	2181
U.S.A.	3890	660	1060	4290
U.S.S.R.	2892	350	800	3340
JAPAN	2698	1114	115	1739
ITALY	1386	699	265	952
U.K.	1106	468	574	1213
FRANCE	918	479	352	791
D.D.R.	806	662	244	388
SWITZERLAND	797	678	140	259
POLAND	684	191	518	1012

(Source: AMERICAN MACHINIST, FEBRUARY 1980)

FIGURE 1.3 U.K. INDICIES OF INDUSTRIAL PRODUCTION

(Base of index: 1975 average monthly sales = 100)

YEAR	ALL INDUSTRIES	MANUFACTURING INDUSTRIES	MACHINE TOOL INDUSTRY (MLH 332)
1975	100.0	100.0	100.0
1976	102.0	101.5	84.0
1977	105.9	103.0	80.0
1978	109.8	103.9	81.0
1979	112.6	104.2	81.0
1980	105.3	95.0p	73.0
1981	99.8p	89.6p	51.0p

Note: p = provisional

(Source: DEPT. OF INDUSTRY AND TRADE)

FIGURE 1.4 VALUE AND MARKET SHARE OF U.K. MACHINE TOOL IMPORTS 1970 - 1980

(Values at current prices)

YEAR	U.K. CONSUMPTION (£ million)	IMPORTS (£ million)	MARKET SHARE OF IMPORTS
1970	190	55	28.9%
1971	160	49	30.6%
1972	153	51	33.3%
1973	192	67	34.9%
1974	246	99	40.2%
1975	276	115	41.7%
1976	317	142	44.8%
1977	362	144	39.8%
1978	491	208	42.4%
1979	640	283	44.2%
1980 (prov.)	590	268	45.4%

Note: Figures indicate trends only as no single source gives all the above information.

(Source: DEPT OF INDUSTRY & H.M. CUSTOMS & EXCISE, Compiled by the MTTA)

The "Ratchet Effect" previously decribed illustrates one of the mechanisms by which imports have increased and the indigenous machine tool industry has declined. Other reasons are:

1. Failure of the U.K. machine tool industry to keep up with modern technology resulting in large increases in the number of imported CNC and NC machines.

2. Rapid advances by developing countries in producing medium to low technology machines at highly competitive prices.

3. The high rates of inflation, which have had the effect of improving the competitiveness of many imports on the U.K. market (ref. Bond 1981).

4. The high level of the so-called "petro-pound".

5. The absence of any significant import tariffs which has led the U.K. to become an "open market" for foreign manufacturers.

6. Weak infrastructure, particularly in the area of technologically advanced products such as D.C. motors and electronic controls.

7. Since the industry is in decline it is regarded as a "lame duck" and receives no general assistance from Government sources. This puts the industry at a disadvantage with countries such as France and Spain, whose governments acknowledge the strategic importance of a healthy machine tool industry.

1.4 THE COMPANY'S PRODUCTS

The products which are manufactured by the company are milling machines. The range of machines made by the company covers a wide spectrum of technology from the simple manual machine to the sophisticated machining centre. The company specialises in small No. 1 and No. 2 size machines. The most powerful machine in the range has only a 7½ h.p. spindle motor.

The range of products falls conveniently into 5 segments which are differentiated by machine configuration and specification, also by selling price and by customer type. In 1980 these segments were:

1. TURRET MILLING MACHINES

This range of machines covers two No. 1 and No. 2 size manual turret mills and also includes more sophisticated semi-automatic copying versions. It is these machines which have made the company famous worldwide.

2. 2S MILLING MACHINES

This is a range of machines, horizontal and vertical designated 2S. A more sophisticated MDI option is also offered which is included in this segment.

3. MANUAL TOOLCHANGE CNC MACHINES

No. 1 and No. 2 size CNC machines constitute this segment.

4. AUTO TOOLCHANGE CNC MACHINES

The machining centres are only manufactured in No. 1 size and this machine has a vertical knee and column configuration.

5. HORIZONTALS

This is the general name given to a range of manual milling machines with horizontal spindles.

All the above product segments can be classified into either high or low technology such that the CNC machines and machining centres can be considered high technology and turret mills, 2S and Horizontals are low technology.

Subsequent sections will make use of these generalised classifications to describe the competitive environment.

1.5 HIGH TECHNOLOGY COMPETITION

1.5.1 INTERNATIONAL CHARACTERISTICS

Over the last 30 years the level of technology applied to milling machines has advanced considerably. This is mainly due to the advent and application of the new generation of powerful and cost-effective electronic controls. The highest level of technological achievement of the stand alone milling machine is the Machining Centre which is a multi-function tool changing machine, often with automatic pallet change mechanisms and swarf removal systems.

These high technology milling machines and machining centres offer considerably increased levels of productivity over conventional machines and the machine tool industries of most industrial countries have developed machines of this type, so that by 1980 there were probably around 150 manufacturers worldwide.

Some of these manufacturers build special purpose or large machines. Excluding these, there still remain over 100 manufacturers of standard CNC machines with spindle power of 10 h.p. (7.5 Kw) or less, who are directly or indirectly in competition with the company.

The adoption and exploitation of these technological advances is not uniformly distributed throughout the industrialised world. It is almost possible to rank countries in order with Japan being the most ahead. Although not necessarily ahead technically (ref. Smith 1982) the rate of implementation is clearly greatest in that country.

The growth in production of NC machines in Japan has been considerable in recent years. Figure 1.5 illustrates this growth.

The success of Japanese manufacturers in this area has mainly resulted from providing high quality, reliable machining centres of small and medium size. Machines of this size are suitable for the majority of metalworking operations and because of the increasing economies of large scale integrated (L.S.I.) electronics, these machines have become considerably more cost effective in recent years.

The next most advanced country is the U.S.A. which follows behind Japan. It is very difficult to compare these two countries because of the nature of the products produced by them.

While Japan tends to be very strong in the mid-size range of machining centres, the U.S.A. has been successful in the manufacture of Manual Data Input (M.D.I.) systems and retro-fit equipment and also small vertical manual tool change machines and machining centres. These are produced in volume, use custom built electronic controls and sell at relatively low prices.

At the other extreme, the U.S.A. builds the physically larger machines which use more powerful and versatile controls.

FIGURE 1.5 JAPANESE PRODUCTION OF NC MACHINE TOOLS

YEAR	NC MILLING MACHINES	MACHINING CENTRES	TOTAL NC MACHINES	NC AS % TOTAL METALCUTTING (By value)
1974	382	577	3040	16.3
1975	257	401	2188	17.3
1976	325	526	3312	22.4
1977	394	926	5436	25.7
1978	549	1371	7336	30.0
1979	977	2936	13514	41.0
1980	1451	5231	22069	44.7

(Source: JAPANESE MINISTRY OF INTERNATIONAL TRADE & INDUSTRY)

The third most advanced country in the world, and the most advanced in Europe, is West Germany. This country is a net exporter of machine tools which set high standards of quality and reliability.

Following behind these three market leaders are the other European countries, often with little national identity, complementing their indigenous capabilities with machines imported from all over the world and controls imported from the three technological leaders.

1.5.2 COMPETITION TO MANUAL TOOL CHANGE CNC MACHINES

There are a number of configurations of manual tool change machines but by far the most common is the low horsepower, vertical or universal spindle, knee and column type which accounts for over 90% of the total market.

Within this market there are two designs which stand out as being the most common and these can be referred to as the "Bridgeport" type and the "Deckel" (or "Maho") type, the latter having a powered overarm and vertical bed.

There is a considerable amount of nationalistic preference apparent in these two designs with the "Bridgeport" type completely dominant in English speaking countries and some developing countries, while the "Deckel" type is by far the most popular in Europe.

For the first three or four years after launching the manual tool change CNC machines, the company had very few competitors and achieved high market shares. This situation started to change at the end of the 1970's when a new generation of micro-processor controls came onto the market. These controls brought three new major competitive pressures onto the company's machines.

Firstly, these cheap controls were being sold as retro-fit packages. These offered a relatively crude but inexpensive way of converting an existing machine to numerical control.

Secondly, the controls were being bought by machine tool manufacturers worldwide to enable them to offer relatively low priced CNC machines with a minimum of risk.

Thirdly, a new generation of companies was spawned which either reconditioned and retro-fitted machines or bought new machine carcasses, fitted controls and marketed a CNC machine. Since these companies can often operate with low overheads they can sell at competitive prices.

1.5.3 COMPETITION TO MACHINING CENTRES

There are five sections to the market for machining centres manufactured by around 150 companies worldwide:

1. Vertical knee and column machines under 10 h.p.

2. Vertical bed type machines under 10 h.p.

3. Horizontal machines under 10 h.p.

4. Vertical machines over 10 h.p.

5. Horizontal machines over 10 h.p.

The company's machining centres compete in section 1, but a discussion of the competitive environment must include sections 2 and 3 since all machines in this horsepower range are mutually competitive.

Competition in all sections is fierce and taking the U.K. as an example, there were eight manufacturers competing in section 1 in 1980. In the same year, there were fourteen manufacturers in section 2 and thirteen in section 3. (By 1982 these numbers had increased by over 50%).

Most of the competitors in section 1 are British or U.S. owned subsidiaries, but in sections 2 and 3 the Japanese manufacturers have complete dominance. The growth of the Japanese in the machining centre market can be illustrated by market share statistics. In 1975 their combined market share was zero. By 1980 the volume market share had reached 30%.

In addition to the current strength of the Japanese in this market there is the future threat from the developing countries. A South Korean manufacturer has already launched a sophisticated machining centre which was built in collaboration with a Japanese firm. In 1981 the first Taiwanese machining centres were seen in the West, built largely with Japanese technology and very competitively priced.

These machining centres from the developing countries are based on proven high quality components and could offer considerable competition in the near future. (ref. Astrop 1981).

1.6 LOW TECHNOLOGY COMPETITION

1.6.1 INTERNATIONAL CHARACTERISTICS

Section 1.2 showed how the machine tool industry has spread throughout the world in the last 150 years. Since the milling machine is the second most common machine tool after the lathe, conventional milling machines are manufactured in every country with an established machine tool industry. This has resulted in a considerable amount of international competition to the company's range of manual milling machines.

The world market for these machines can be conveniently sub-divided into two basic areas of supply, namely the developed western countries where manual milling machines are established products, and the developing Eastern countries where these machines are still important growth products.

1.6.2 THE EXPERIENCE CURVE EFFECT

The Experience Curve concept as developed by the Boston Consulting Group is well documented (e.g. ref. Hedley 1976) and is an illustrative method of describing the effect whereby manufacturing costs tend to decline systematically with increases in accumulated experience (production).

The key implications of the Experience Curve are given by Hedley as:

A. Failure to reduce costs along an experience curve equivalent to that achieved by competitors will lead to an uncompetitive cost position.

B. Failure to grow as rapidly as competitors will lead to an uncompetitive cost position. The competitor with the largest market share and hence the largest accumulated experience should have the lowest costs and thus the highest profitability.

Western machine tool manufacturers are faced with low growth rates and very few are investing heavily in conventional machine tools. In contrast, the developing countries output is increasing rapidly and so investment in modern cost saving plant and equipment is high. The effect of this is that the limit of the experience curve has been reached in the West and cost savings are not being achieved, while real cost savings are still being achieved in developing countries.

If this trend continues, and if the current improvements in quality are maintained, the conventional machines from developing countries could eventually achieve world market dominance at the expense of western manufacturers.

1.6.3 COMPETITION FROM TAIWAN

The most outstanding example of growth in a developing country is Taiwan which has achieved dramatic production and export growths during the 1970's (ref. Astrop 1980 and 1981, Anon. 1980).

Figure 1.6 shows how Taiwanese milling machine production has increased 21000% in volume during the eight years to 1979. If this growth continues then Tai manufacturers could soon achieve a strong competitive advantage along the experience curve effect in spite of internal factors which are tending to increase their costs.

The leading product of the Taiwan milling machine industry is the turret mill and so competition from this country is particularly relevant to the company.

The largest manufacturer of this type of machine is Yeong Chin Machinery Industries Co. Ltd. of Tai-Chin, Taiwan, which was established in 1969. Yeong Chin initially manufactured an exact copy of the Bridgeport Turret Mill which is still marketed under various brand names. This company has recently brought on stream a £5,5 million plant, fully equipped with machining centres and modern special purpose machines. This plant will increase the annual capacity from 3500 to 7000 milling machines per year and NC machines will be added to the range in 1981 (ref. Astrop 1980).

1.7 COMPETITIVE MACHINING PROCESSES

Over the years a number of metalworking processes have been developed which are competitive to conventional milling. The following is a list of processes which can be used to advantage to replace milling operations in certain specific applications:

a. Forming

b. Casting

c. Sintering (Powder Metallurgy)

FIGURE 1.6 TAIWANESE MILLING MACHINES (PRODUCTION & U.K. IMPORTS)

YEAR	PRODUCTION	U.K. IMPORTS
1971	429	0
1972	504	0
1973	692	0
1974	1194	0
1975	1937	2
1976	2473	8
1977	5290	21
1978	7168	193
1979	9361	432
1980		116

(Source: METAL INDUSTRIES DEVELOPMENT CENTER

AND HER MAJESTY'S CUSTOMS & EXCISE)

d. Broaching

e. Grinding

f. Electrical Machining

g. CNC lathes with milling attachments

h. Fabrication

In recent years, grinding and electrical machining have achieved growing importance. New grinding wheel materials have transformed the grinding process and creep feed grinding, full form grinding and abrasive belt machining are starting to replace many of the conventional horizontal slab milling processes.

In addition, the more complex machining requirements of the tool and die business are being met increasingly by Electrical Discharge Machines (EDM), which are becoming increasingly sophisticated and replacing many of the conventional vertical milling processes.

Of particular importance has been the application of NC to the EDM process which has accelerated the market growth of both NC EDM and NC wirecut machines. In 1981 the growth of output of Japanese NC EDM machines alone was 186%.

The EDM process is particularly suitable for the toolroom application which is currently largely served by Bridgeport type milling machines. Continued growth in this area could therefore severely threaten the dominance of the conventional milling process.

1.8 SUMMARY

This chapter has described the effects on the world machine tool industry of increasing competition, slumping growth rates, high inflation and the business cycle.

A "Ratchet Effect" model was described to illustrate and explain how many western countries and individual businesses have suffered as a result of the business cycle and increased competition. The absolute and relative decline of the U.K. machine tool industry was examined and the decline was determined to be attributable to a number of factors.

The company's products were classified and several rapidly changing competitive patterns were identified, all of which were providing current or future threats to the company's existing range of products. These changing trends were:

1. The effect of the new micro-processor controls in reducing competitors prices and attracting new entrants into the market.

2. The rapidly increasing share that the Japanese have obtained in the U.K. and world machining centre market.

3. Increase in developing countries production of conventional milling machines (particularly Taiwan).

4. Alternative machining processes, particularly NC EDM and NC wirecut EDM which are threatening the milling process in certain applications.

CHAPTER 2

REVIEW OF TECHNIQUES

2.1 INTRODUCTION

The importance of new products to industrial goods manufacturers has been illustrated on a number of occasions (a good selection is given in ref. Choffray and Lilien 1980), and by the late 1970's the company was becoming aware that new products would play an increasingly important role in the future. This research project was consequently initiated to examine the process of new product development within the company.

The major difficulty with new product development is the exceptionally high rate of failure of new products (for example ref. Kotler 1980, Baker 1979), and the company already had experience of this problem with two or three recent new product failures.

The next generation of new products was going to be very important to the company since they would probably be taking advantage of the new technologies. In order that these new products were given a good chance of success it was decided to use a methodical marketing based approach to their development.

The decision to use such a methodology was supported by an accumulated weight of evidence which showed that the risk of failure could be substantially reduced if such an approach is adopted and conscientiously implemented (Ref. Cooper 1980 (New Prod Project), Twiss 1980, Baker 1979, Cooper and Little 1979, Little 1978, Little and Cooper 1977, Cooper 1975, Rothwell (SAPPHO Project) 1973).

This chapter will initially describe how practical considerations led to the development of a new methodology for new product development, and then proceed to review the individual techniques which can be employed at each stage in the process. The techniques which were used in practice will also be described and the reasons behind their selection will be explained.

2.2 THE METHODOLOGY

2.2.1 CONVENTIONAL APPROACH

Within the literature, there is a wide range of procedures for new product development, some of which have become highly elaborate and sophisticated (for example ref. Holt 1977).

It has been observed while surveying the relevant literature, that these procedures invariably include all or most of the stages originally developed in the 1960's by Booz, Allen and Hamilton. This is so widespread that the basic procedure has become adopted as a "textbook" approach to new product development (for example, ref. Kotler 1980, DeLozier & Woodside 1978).

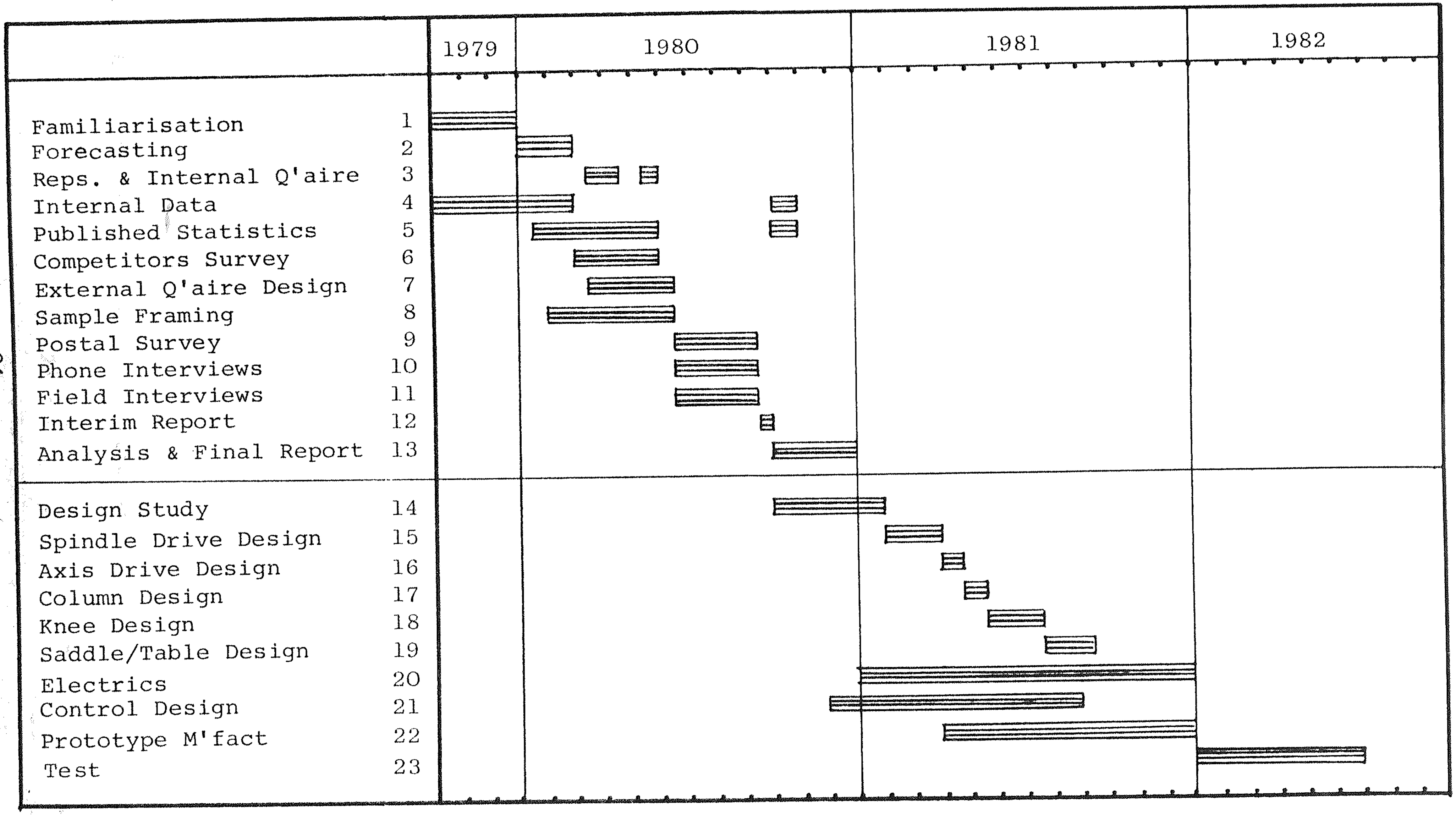
The principle steps in this procedure are:

1. Idea Generation
2. Screening of Ideas
3. Business Analysis
4. Product Development
5. Test Marketing
6. Commercialization

At the commencement of this research project a programme was developed along the lines of this conventional approach and this is shown in Figure 2.1.

From this figure it can be seen that "Idea Generation" consisted of items 1 - 3, and that "Screening" would have been accomplished in item 3 by the beginning of May 1980. The "Business Analysis", which would also include some refinement of the specification, included desk and field research in items 4 - 13. The next stage, "Product Development" would have taken all of 1980 with items 14 - 22. Finally, product and market testing was

FIGURE 2.1 NEW PRODUCT DEVELOPMENT PROGRAMME



planned for the first 6 months of 1980 in item 23 and "Commercialization" would have followed.

There is, in the literature, support for this "textbook" approach to the development of new machine tools specifically. In particular, a methodology proposed by Davies (ref. Davies 1975), covers in detail the first four steps of the above procedure and explains the need for "a methodical analysis of all relevant factors in the design of a new machine tool".

Further support of the philosophy is also provided by Johnson in his work on machine tool design (ref Johnson 1971).

The proposed programme was therefore based on sound principles and there were some indications that the methodology was applicable to the machine tool industry in particular.

2.2.2 PROBLEMS WITH FIELD RESEARCH

The programme in Figure 2.1 shows in item 3 how the "Idea Generation" stage was to have been supported by a field research questionnaire which was designed and drafted for circulation within the company. (A copy of this questionnaire is given in Appendix A).

This limited circulation was intended to maintain commercial security as the company did not want any information leaked to competitors. In this way this part of the research would have been identical to that performed by Evans (ref. Evans 1978), when in a similar situation for a new industrial product.

In addition to this, and at a later stage (items 7 - 11 in Figure 2.1), it was intended to use questionnaire, interview and telephone techniques on a much larger scale to help evaluate market parameters, such as size, growth, potential, company/customer factors, and to further refine the specification. Techniques of this sort are very well established, and have been documented in the machine tool industry (ref. Bursk 1962, Hummel 1954, Lester 1949).

Unfortunately, there was a problem in implementing these plans. There were, within the company, deeply held convictions that there was little or no value in field research or customer interrogation methods and that the results could be thoroughly misleading.

It is likely that these attitudes are common throughout the U.K. machine tool industry as two major surveys into the industry have shown that very little market research is performed (ref. NEDO 1970, EEF 1979).

Since there was no way that these attitudes could have been changed and because it was considered pointless to try and force these techniques on an unresponsive audience, it was decided to proceed without directly using these methods. (Use was made of some alternative methods such as interrogation of sales engineers and managers, and use of machine "guarantee" cards, lost order forms etc., and these will be discussed later. These methods provided some partial substitution of the techniques which were being denied).

2.2.3 THE NEED FOR STRATEGIC PLANNING

As a result of this constraint, it was apparent that the programme in Figure 2.1 would need to be changed. Also since customer requirements could not be established in a satisfactory manner, it was felt that concentration on a single new product would incur an unnecessarily high degree of risk.

It was therefore decided to look at new product development in a broader perspective, and to examine the role of new products within the company as a whole, and how they fitted in with the company's strategic plans.

At about the same time it was becoming apparent that much of the literature on new product development was also moving in this direction, and increasingly proposing the integration of new product planning with strategic planning (ref. Skinner 1972, Pessemier and Root 1973, DeLozier and Woodside 1978).

On the other hand, the discipline of organizational strategy had been developing concepts such as product/market strategy (ref. Ansoff 1965) and portfolio analysis (for example ref. Hedley 1977) which could provide framework strategies within which new products could be developed.

Some of these recent trends towards the coupling of strategic planning and new product development were identified and described by Buijs working at the Bureau for Product Development TNO in Holland (ref. Buijs 1979).

The above considerations led to the decision to use strategic planning as a precursor to new product development.

2.2.4 THE ROLE OF STRATEGIC MARKET PLANNING IN THE PLANNING PROCESS WITHIN THE COMPANY

Corporate strategic planning in the company is performed at two locations separately in the U.S.A. and the U.K. There is in addition a continuous dialogue between the two sites and the individual plans are formally amalgamated during the summer when a corporate five year plan is produced.

The planning generally follows a classic sequence of inward interrogation and is performed under the following headings:

1. What business are we in?
2. What business should we be in?
3. Review of strengths and weaknesses, opportunities and threats.
4. Set objectives
5. Develop strategies
6. Make plans
7. Evaluate

In the U.K., the advantages of localised planning can be readily witnessed. The high degree of immediacy and flexibility which is achieved is of considerable value in the modern rapidly changing world (ref. Ansoff 1981, Tavernier 1976).

In addition, the management structure provides the regulated flexibility advocated by Newman for this type of operation (ref. Newman 1972), and the chief executive is thereby in a position to devote time to the important aspect of long term strategic thinking (ref. Taylor 1979).

Much of the strategic planning input required for new product development was therefore already being performed in a satisfactory manner, and all that was required was the development of product/market strategies. Using the definition offered by Abell and Hammond (ref. Abell and Hammond 1979), this process will be called strategic market planning and treated as a distinct sub-strategy of the full corporate strategic planning process.

The idea of strategic market planning as a "sub-strategy" is not new and is used by McCarthy et al (ref. McCarthy et al 1975), and by Higgins who uses the term "program strategy" (ref. Higgins 1980).

2.2.5 THE PROPOSED METHODOLOGY

The major steps in the proposed methodology are now as follows:

1. Corporate Strategic Planning
2. Strategic Market Planning
3. Idea Generation
4. Screening of Ideas
5. Business Analysis
6. Product Development

7. Test Marketing

8. Commercialization

This research project fits into the company's organisation for new products by providing the interface between the (existing) stage 1 - corporate strategic planning and the (existing) stage 6 onwards.

The following sections will describe the individual techniques involved in the new stages 2 - 5 inclusive.

2.3 STRATEGIC MARKET PLANNING TECHNIQUES

2.3.1 INTRODUCTION

It is very difficult to draw the line between strategic planning techniques and strategic market planning techniques because many of the former can be applied to individual products or business segments to develop sub-strategies (see, for example, the WOTS technique and strategy profile method in Higgins and the strategic audit methods in Glueck, and Smith & Walsh) (ref. Glueck 1980, Smith & Walsh 1978).

This section will therefore be restricted to those techniques which provide market strategies in general and new product strategies in particular. For this reason, forecasting techniques will not be included in this section, although the value of forecasting in strategic market planning is appreciated and will be covered later. Technological forecasting will be covered in section 2.4 (Idea Generation) and sales/economic forecasting in section 2.6 (Business Analysis.)

2.3.2 GAP ANALYSIS

This is a fundamental technique which provides an interface between the corporate planning stage and strategic market planning. The technique was recognised and described by Kami in

1969 (ref. Kami 1969), who laid down some guidelines for its successful use.

A diagram of the technique is given in Figure 2.2, which shows how a gap can be observed between corporate goals and forecast performance. Two types of strategies are required to fill this gap. Firstly, new strategies can be adopted to improve the performance of existing products and secondly, any remaining gap would require completely new products.

This simple technique therefore provides the strategic requirements of new products and has become very widely used for this purpose.

2.3.3 THE PRODUCT/MARKET MATRIX

The product/market concept was developed by Ansoff in the 1960's (ref. Ansoff 1965) and Figure 2.3A shows his matrix in its simplest form.

Each of the four states on this matrix represents a range of alternative strategies under the four general headings given and all of these alternatives can be listed and appraised against criteria such as critical mass (minimum viable market share), resources available, synergy, competitive advantage etc. The effect of strategic change can also be seen by an examination of the alternative scope vectors.

This simple model has attracted a large number of variants. For example, Higgins (op cit) differentials between related and unrelated new products and markets (this produces a 3 x 3 matrix). Another example is Henry's differentiation between saturated and extensible present markets which result in a 2 x 3 matrix (ref. Henry 1978).

Another simple extension of the basic model is shown in Figure 2.3B (ref. Cundiff et al 1980), where each axis is shown divided into three levels. Some examples of possible alternative strategies are given at each product/market state on the matrix.

FIGURE 2.2

DIAGRAM OF GAP ANALYSIS

Shaded area represents size of gap which is to be filled from new product contribution.

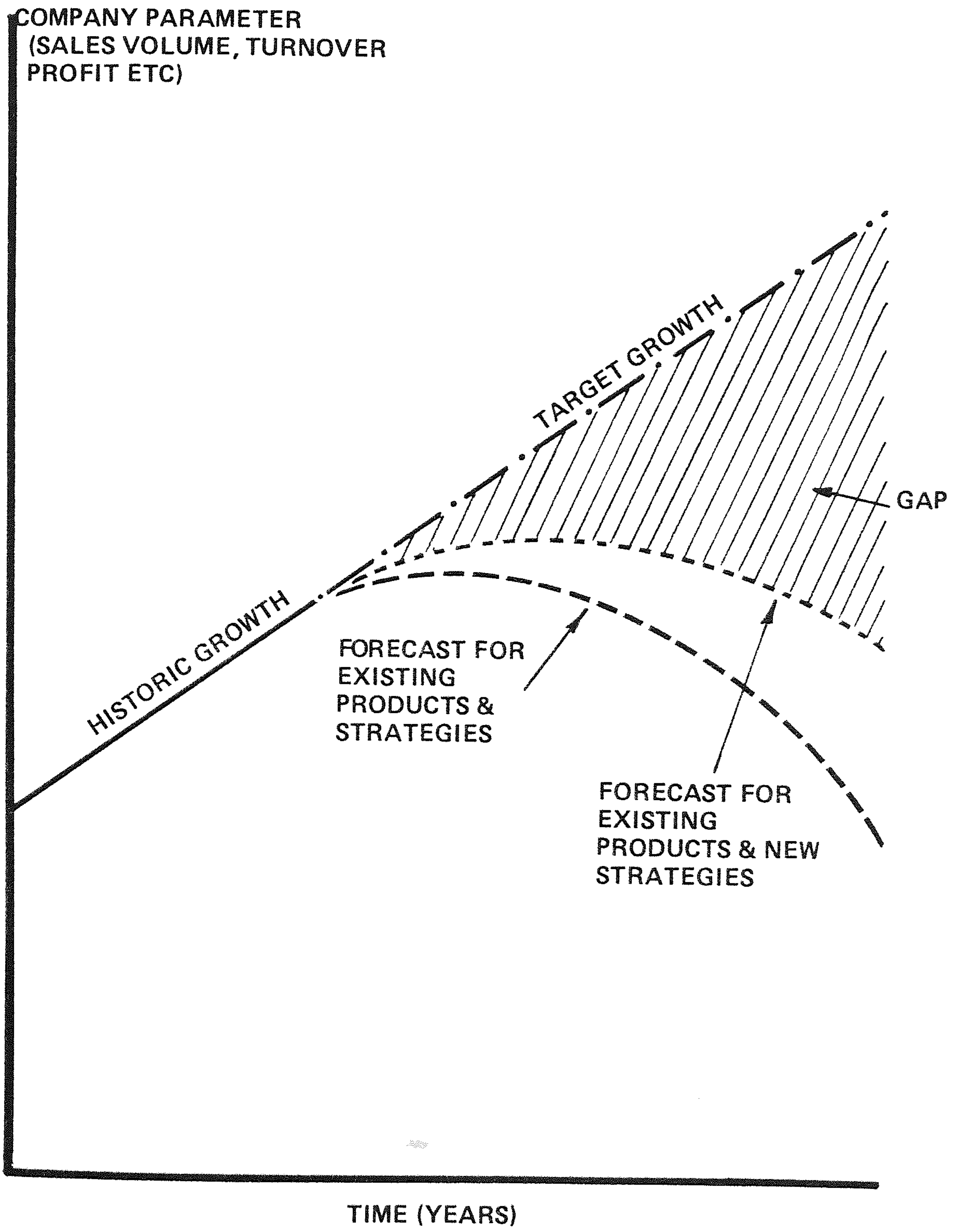


FIGURE 2.3 THE PRODUCT/MARKET MATRIX

MARKET \ PRODUCT	PRESENT	NEW
PRESENT	MARKET PENETRATION	MARKET DEVELOPMENT
NEW	PRODUCT DEVELOPMENT	DIVERSIFICATION

FIGURE 2.3A SIMPLE DIAGRAM

MARKET \ PRODUCT	NO PRODUCT CHANGE	PRODUCT CHANGE	NEW PRODUCT
NO MARKET CHANGE	DESIGN CHANGE CHANGE IN LEVEL OF INTEGRATION	PRODUCT LINE SIMPLIFICATION DISCONTINUE LINE NEW MODELS PLANNED OBSOLENCE	REPLACEMENT OF OLD PRODUCTS
IMPROVED MARKET	CHANGED NAME, PACKAGING ETC. RE-MERCHANDISING	PRODUCT CUSTOMIZING PROD SYSTEMS	PRODUCT LINE EXTENSION PARTIAL DIVERSIFICATION
NEW MARKET	NEW USES NEW USERS	MARKET EXTENSION TRADING UP OR TRADING DOWN	PRODUCT MIX DIVERSIFICATION

FIGURE 2.3B A MORE SOPHISTICATED MODEL

(Adapted from Cundiff et al 1980)

2.3.4 THE PRODUCT LIFE CYCLE

In the form that it is usually represented, the product life cycle (PLC) comprises the following stages:

a. Introduction

b. Growth

c. Maturity (or saturation)

d. Decline

e. Termination

At each stage in the PLC, characteristics have been established which include level of competition, average prices and profits, product quality etc. (ref. Smallwood 1973). These characteristics can be used for strategic market planning as the life of a product unfolds (for example ref. Cooper-Jones 1974).

There is some evidence which suggests that the PLC concept is more applicable to consumer products than to industrials (ref. Thorelli and Burnett 1981), but the general consensus is that the concept cannot be ignored, even in industrial markets (ref. Day 1981, Thorelli and Burnett 1981, Kotler 1980).

2.3.5 THE INVERTED PRODUCT LIFE CYCLE

This technique was described by Weber in 1976 (ref. Weber 1976) and offers a valuable tool for strategic planning. The technique combines concepts of partial penetration and ultimate potential with the PLC concept. Cross sections of the combined PLC's are taken at any given time in the life of the product and these are used to identify opportunities.

The areas of opportunity search which are presented are:

a. Product line gaps
b. Distribution gaps
c. Usage gaps
d. Competition share

The search area which this technique offers is not as wide as the Product/Market Matrix, but by being related to the PLC it provides a dynamic component which allows strategies to be assessed with time.

Weber points out that although the technique is straightforward to apply initially, it takes some years of experience to refine and develop accuracy and to maximise usefulness.

2.3.6 THE BOSTON GROWTH/SHARE MATRIX

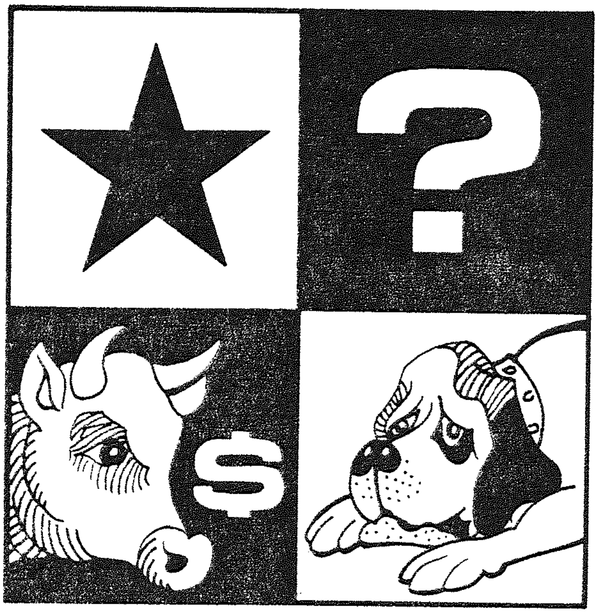
This technique (ref. Hedley 1977) was developed by the Boston Consulting Group and has become very well publicised. The basis of the method is a plot of "business growth rate" against "relative competitive position" and a matrix is generated by dividing these axes into High and Low.

Figure 2.4 shows the usual representation of the matrix. Each business segment in the company's portfolio can be plotted onto this matrix and will fall into one of the four quadrants, each with its distinctive name:

"STAR" (High - High) Indicates products which have a high market share of a high growth market. These products are often in cash equilibrium.

FIGURE 2.4

THE GROWTH/SHARE MATRIX



MARKET GROWTH

HIGH

LOW

HIGH

LOW

RELATIVE COMPETITIVE POSITION
(MARKET SHARE)

"CASH COW"	(High - Low)	Where a high market share is held in a low growth market. These products are often cash generators.
"DOG"	(Low - Low)	Where both the market share and market growth are low.
"QUESTION MARK"	(Low - High)	Where the market share is low but the market is growing rapidly. These products are often cash consuming.

When all business segments are plotted on the matrix the overall portfolio balance can be assessed and strategies developed. In addition to this each of the four quadrants has its own strategic implications and so strategies are suggested for individual segments.

There has been much criticism of this technique. The major allegation is that the matrix is over simplistic and can be misleading. This is based on two observations (ref. Lorenz 1981).

Firstly, market leadership does not always bring lower costs and high profits.

Secondly, what is the use of the matrix theory in today's environment of stagflation when "CASH COWS" and "STARS" are hard to find and most businesses fall squarely into the "DOG" category?

Michael Goold of the Boston Consulting Group has pointed out that the first criticism is often based on incorrect segment definition and that accurate business definition is a pre-condition for the successful use of the concept.

This difficulty of business definition has, in itself, been cited as a criticism by Glueck (op cit).

The second criticism, that there is now a disproportionate number of "DOGS", has been partially covered by the establishment of a new "CASH DOG" category. These businesses are close to parity with the market leader and can maintain a strong positive cash flow and stable competitive equilibrium.

For long periods of time, "CASH DOGS" can, under these conditions, provide a valuable contribution to the portfolio (ref. Goold 1981).

The matrix does not intrinsically provide time-based strategies but the Boston group have shown how the dynamic element can be obtained by creating a third axis for time and plotting matrices for 5 years past and hence.

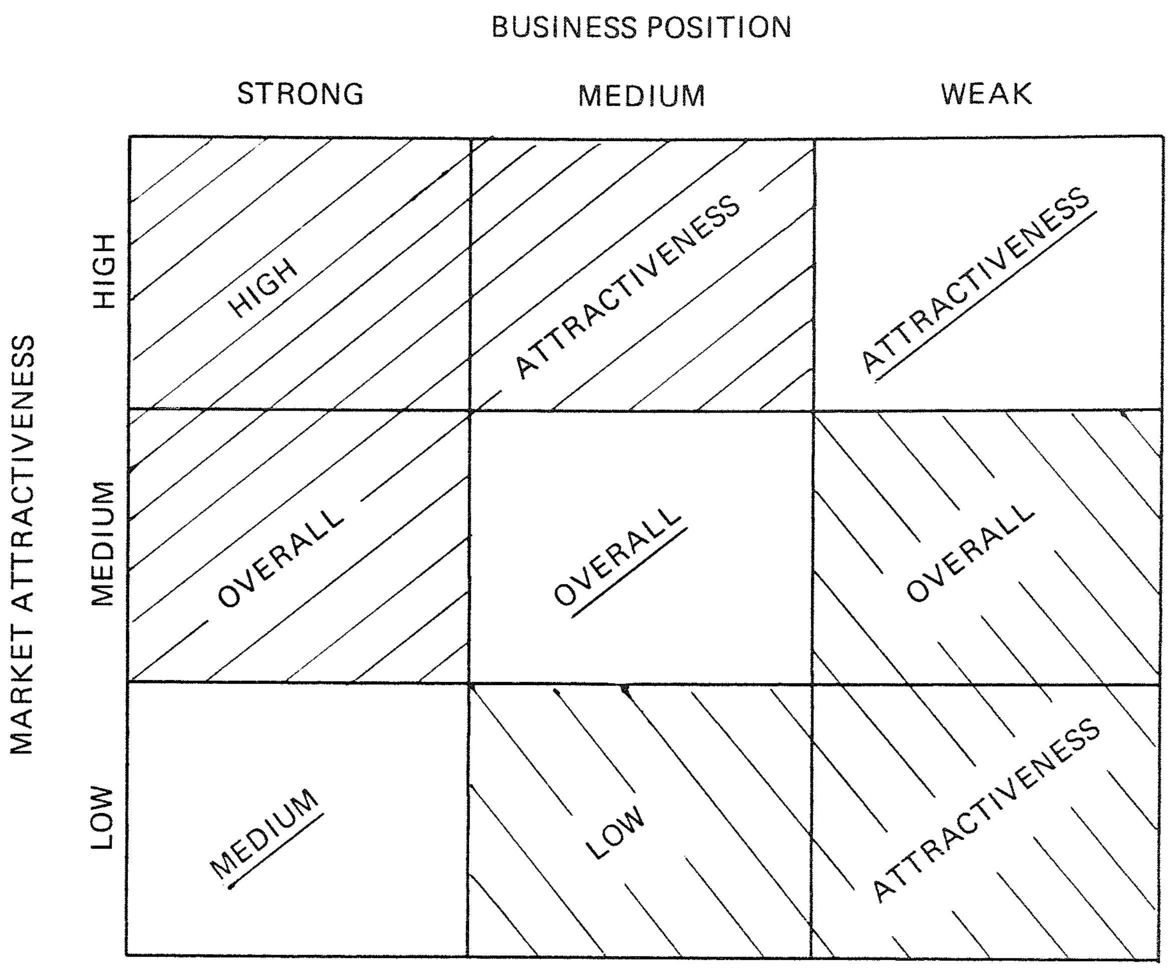
Another third axis modification has been presented by Kotler (op cit) who proposes using profitability as the additional parameter.

2.3.7 OTHER PORTFOLIO MATRICES

There has been considerable development around the basic growth/share matrix concept and several more sophisticated models have been developed. One of the most significant of these is the Market Attractiveness - Business Position Matrix which is described in Abell and Hammond (op cit). This matrix will be used here as the generic name of a number of similar techniques based on the same concept, such as The Directional Policy Matrix (ref. Robinson et al 1978), the General Electric "Stoplight" Matrix (Glueck 1980), the Business Sector Strategy Value (Dobson 1981).

The matrix is shown in Figure 2.5. The location of each business on the matrix is determined by using a scoring system based on a large number of contributing factors. These factors which contribute to market attractiveness and business position can be grouped into 5 sub-headings:

FIGURE 2.5 THE MARKET ATTRACTIVENESS - BUSINESS POSITION MATRIX



a. Market Factors

b. Competition Factors

c. Financial and Economic Factors

d. Technological Factors

e. Socio-Political and Environmental Factors

The use of a large number of contributing factors provides this technique with a considerable potential advantage over the Boston Matrix, in that factors other than simply market growth and competitive position can be used to determine overall attractiveness.

The technique also has the potential advantage of generating a high degree of differentiation between business areas.

An important constraint, identified by Abell and Hammond, is the high degree of skill required to perform the analysis. In particular they point to three problems in assessing either market attractiveness or business position.

a. Which factors are relevant in this PARTICULAR analysis?

b. What relation do these factors have? (e.g. what is an atractive market?)

c. What weightings should be used?

A further criticism which has been made by Hofer (quoted in Glueck op cit) is that the technique inadequately represents new businesses starting to grow. This led to the development of "Hofer's Analysis" in which a second matrix is constructed as well as the Market Attractiveness/Business Position Matrix.

This second matrix is shown in Figure 2.6 and uses the PLC concept to add a dynamic component to the technique.

FIGURE 2.6 THE COMPETITIVE POSITION/STAGE OF THE MARKET –

PRODUCT EVOLUTION MATRIX (HOFER'S ANALYSIS)

STAGE OF THE MARKET-PRODUCT EVOLUTION	STRONG	AVERAGE	WEAK
DEVELOPMENT			
GROWTH			
SHAKE-OUT			
MATURITY			
DECLINE			

COMPETITIVE POSITION

(BUSINESS POSITION)

2.3.8 PIMS

The basic idea behind PIMS (for Profit Impact of Marketing Strategies) (ref. Schoeffler et al 1974) is to provide insights and information on expected profit performance of different kinds of businesses under different competitive conditions.

Empirical data is taken from a large number of businesses and a computer model identifies the most important factors. It then shows how each factor is related to performance and "weights" them according to their relative importance in the total equation.

It is then possible to use this model on a "dummy" business to assess the effect of a strategic change. It can provide an indication of "PAR" for a given type of business and also illuminate promising directions for future exploration.

PIMS is therefore a very powerful strategic planning tool. Maximum benefit can, of course, only be enjoyed by participating firms but many "generalised relationships" have been published and these provide useful insights for the market planner. (See Schoeffler et al, Abell and Hammond).

The fact that PIMS first takes real business data and then develops a relationship, gives this technique a tremendous advantage over the market attractiveness matrix which relies on the skill and judgement of the planner to obtain the relationship.

2.3.9 THE SELECTED TECHNIQUES

Gap analysis was selected as a technique which was appropriate for this work. The analysis is a unique tool which is simple to use and yet very powerful. It would provide the interface between corporate planning statements (such as corporate goals, objectives and anticipated sales of existing products) and strategic market planning.

Among the strategy development matrices it can be observed that no technique intrinsically offers a dynamic planning perspective and that forecasts or state-of-the-cycle aspects must be considered separately. For example, in the methods which specialise in searching for strategies it can be seen how Weber's Inverted PLC offers this dimension in some measure to Ansoff's Product/Market Matrix. Similarly Hofer's Analysis provides the same function for the Market Attractiveness Matrix.

The need to add forecasts to the Boston Matrix has been identified by Abell (ref. Abell 1978) but the Boston method of drawing historic and future matrices is far from satisfactory. It has, however, been observed that the Boston Matrix concept implies a product life cycle as a business progresses from "QUESTION MARK" to "STAR" to "CASH COW" to "DOG".

It is therefore proposed that the strategic implications of the product life cycle concept are compatible with those of the Boston Matrix and so both tools can be used together.

There were additional reasons supporting the choice of the Boston Matrix. The first of these was that the Boston technique offered the ability to examine the entire product range simultaneously and then provide specific guidelines on portfolio management. As a tool for initial examination and for assessing priorities, this was of considerably more value than the product/market technique which would not offer the same total portfolio approach nor give any indication of preferred strategy.

Another reason for selecting the Boston Matrix and PLC was that they are both very simple to use and communicate. Since planning of this nature would involve a number of people many of whom has little or no experience of this type of exercise, it would be beneficial to use simple techniques.

This factor practically eliminated the use of the Market-Attractiveness type Matrix, and when combined with the difficulties of scoring and weighting, it was decided not to use this more sophisticated approach at this stage.

PIMS was not used since neither the U.K. company nor its American sister company were participating members of the scheme. Where appropriate, full advantage would be taken of the co-relationships and results which have been made available from the PIMS data base.

2.4 IDEA GENERATION TECHNIQUES

2.4.1 INTRODUCTION

Idea generation for a new machine tool takes place in two stages. It is first necessary to determine broad requirements (such as type of machine or type of diversified product). The second stage is to develop an outline specification of the machine. Davies identified these two stages which he calls "original proposals for a new machine design" and "refinement of the specification".

In the sections which follow idea generation techniques will be described, which are generally applicable to both these stages.

The techniques included in this section have been collected from a wide number of sources and are arranged under six convenient headings.

2.4.2 SURVEILLANCE OF INTERNAL SOURCES

The first source of new product ideas under this heading is from the results of corporate or strategic market planning. Other possible internal sources include:

a. Salesmen or Representatives

b. Dealers

c. Demonstrators

d. Research, Development and Design Departments

e. Suggestion Schemes

f. Production Department

g. Service Departments

Although Buggie maintains that people within the organisation are unlikely to provide new product ideas unaided (ref. Buggie 1981), the successful use of salesmen has been recorded by Evans (ref. Evans 1978), who used a formal questionnaire approach to obtain valuable information for a new industrial product.

2.4.3 SURVEILLANCE OF MARKET SOURCES

Another general source of ideas is from the market place where customers and/or potential users can be useful. These users may be simply observed to determine what is currently used or being performed and this can suggest new product ideas, or alternatively they may be approached directly.

The second source of new product ideas under this heading is competitors and competition. The ideas may be simply plagiarised, or else by a systematic search and evaluation of existing suppliers, market opportunities may be suggested.

Both these sources are quoted in most marketing books, but customer related sources are usually being considered to be slightly superior (e.g. ref. Shingleton 1981). An extensive review of market related techniques has been performed and published by Greenhalgh (ref. Greenhalgh 1971).

2.4.4 SURVEILLANCE OF OTHER SOURCES

The following list comprises some of the other sources which may provide new product ideas, or offer seeds which could stimulate further investigation.

a. Private Inventors

b. Patent Office

c. Private Laboratories and Publications

d. University Research and Publications

e. Government Research, Regulations and Publications

f. Technical and Trade Press and Media

g. Surveillance of Technology

2.4.5 GROUP CREATIVITY METHODS

These methods are based on the principle that given the correct environment, then creative thinking can be stimulated during group discussions. Around half a dozen participants are normally involved, and the sessions can continue for many hours. An experienced group leader maintains the momentum and direction of the discussion.

The sessions may be discreetly creative and involve customers (for example ref. Barnes 1980), or the more flamboyant brainstorming techniques may be employed where a rapid flow of (even outrageous) ideas is encouraged.

Alternatively, synectic methods may be adopted in which the creativity of the group is not constrained with a knowledge of the problem or historical solutions. External experts are used and their discussion is led in a generalised area of investigation.

These methods, like the one developed by Strategic Innovations Inc. (ref. Buggie 1981) have become quite sophisticated and have been found to work successfully.

The weakness in using all these techniques lies with the group leader. Holt (op cit) points out the need for experience coupled with formal training and many months of practice before a leader can perform satisfactorily. Shingleton (op cit) concludes that because of group leader problems, group discussion methods are rarely successful.

If an experienced leader is supplied through a consultantcy, many of these problems are resolved, but then this leader does not have a satisfactory level of specific knowledge and experience.

The methods are also costly and time consuming to run.

2.4.6 SYSTEMATIC SEARCH PROCEDURES

a. MORPHOLOGICAL ANALYSIS

The invention of this technique has been attributed to Fritz Zwicky of AeroJet Corpn. The method makes use of a two or three dimensional search matrix. Each axis of the matrix is constructed with a list of all conceivable component factors relating to the product under investigation. Each segment of the matrix provides an alternative combination of factors, any of which may yield a new product idea.

Recent proponents of this method are Carson and Rickards with their SCIMITAR approach. The three axes of their model are labelled "markets", "products" and "materials" (ref. Carson & Rickards 1979). Buijs (op cit) provides an example of the successful implementation of this technique.

b. ATTRIBUTE LISTING

This is the process of listing every attribute associated with the area of search. Trivial and desirable attributes should also be included. From a knowledge of the existing ways of achieving each attribute, a list is prepared of all conceivable "better" ways. This exercise then generates possible new product ideas.

c. FORCED RELATIONSHIPS

This method systematically examines all related products and functions to identify potential combinations. Holt explains how, in this way, an office equipment manufacturer may relate a desk with a bookcase and develop the idea of a desk with integral bookcase.

2.4.7 TECHNOLOGICAL FORECASTING

This is a very broad subject which has many functions, one of which is as a tool for generating new product ideas. Technological forecasting is of particular importance for new machine tools, not only because of the technological nature of these products, but also because of the lengthy development period and the relatively long anticipated product life.

This has been illustrated by Macgregor when describing his successful range of machine tools. He says, "Identification of market opportunities and technological trends has been an important factor in the healthy growth which has been achieved". (ref. Macgregor 1969). Similarly, Pessemier and Root have declard that "technological forecasting should be integrated into the search process" (op cit) (see also Jolson 1973).

It is therefore rather surprising that technological forecasting is omitted from some important works such as Davies and Kotler (op cit). It is used in this work and a review of techniques is appropriate.

Cooper and Jones (op cit) describe an OECD report which, as early as 1967, identified 20 basic techniques with over 100 variants, there are doubtless considerably more today. It is clearly outside the scope of this work to review all these techniques and so only the major methods will be covered.

a. TREND EXTRAPOLATION

This is a relatively straightforward technique which uses a forward projection of historic trends. There is a number of methods of mathematically performing this extrapolation which include straight line, semi-log and the various smoothing techniques.

The method has been successfully demonstrated and used for machine tool applications by Merchant of Cincinnati. (Cincinnati is the world's largest machine tool builder) (ref. Merchant 1969, 1971, 1973, 1975, 1976).

The selection of a parameter which is suitable for forecasting is very important, as illustrated by Cooper - Jones in their example of steam locomotives.

b. PRECURSOR TRENDS

This method relies on the ability to identify some leading indicator of technological change or development. The example that Jones & Twiss quote is the way that military aircraft development precedes commercial adoption (ref. Jones & Twiss 1978).

A related technique which uses the same concept is that of "historical analogy" and in some cases this could be of use.

c. TECHNOLOGICAL SUBSTITUTION

Technological substitution is said to occur when a new product or process replaces an existing one. Some historical analogies for this are: steam replacing sail in ships, auto washing machines replacing manual and colour TV replacing monochrome.

Fisher and Pry have developed an empirical relationship to describe this process (ref. Fisher and Pry 1971). The technique is based upon three assumptions.

1. Many technological advances can be considered as competitive substitutions of one method of satisfying a need for another.

2. If a substitution has progressed as far as a few percent of the total consumption, it will proceed to completion.

3. The fractional rate of fractional substitution of new for old is proportional to the remaining amount of the old left to be substituted.

d. THE DELPHI METHOD

Delphi was developed to overcome the limitations of "expert opinion" and "panel consensus" techniques. The method employs a panel of experts who never meet and are interrogated anonymously. The results of the first round are then analysed and fed back to the panel for re-examination. This cycle is repeated several times.

Jolson describes the two premises on which the method is founded:

1. With repeated measurement, the range of responses will decrease and converge towards the mid-range of the distribution.

2. The total group response or consensus will successfully move toward the "correct" or "true" answer.

The technique has enjoyed particular popularity for forecasting manufacturing technology, a task for which it appears to be applicable (ref. Smith 1979, I Prod E 1980).

The limitations of the technique include:

1. Time of execution can be excessive
2. Logistic problems
3. Difficulty in selecting panel personnel
4. Panel fees can be high
5. Some results can be hazy or imprecise (example quoted by Jolson)

e. RELEVANCE TREES

This is a method to determine and evaluate systematically the alternative paths by which an objective (or mission) could be achieved. Alternative means of achieving the objective are first listed, and then the functions required to achieve these solutions are developed. Following this, specific requirements can be identified which will solve the individual functions. In this way, a range of alternative ideas is generated.

Honeywell has developed its own PATTERN programme which is used on their military and aerospace activities. Programmes of this type are expensive. Twiss suggests a typical cost of \$250 - 300,000 set-up, plus an annual running cost of \$50,000 (ref. Twiss 1980). He also points out that the method could be simplified to be used at the company level.

f. TECHNOLOGY MONITORING

This is a long term methodical process in which information sources are monitored for relevant pieces of data. Technical competance is required to assess the possible impact of each piece of information as it is collected. Bright maintains that technological change can be foreseen by many years if this technique is adopted (ref. Bright 1970).

g. CROSS-IMPACT ANALYSIS

This heading covers a family of associated techniques. The basis of cross-impact analysis has been established by the Institute of the Future in the following steps:

1. Establish the principle events associated with the problem under consideration.

2. Assign individual probabilities to each of these (by using Delphi or trend extrapolation techniques).

3. Determine the interractions either enhancing (enabling or provoking an event) or inhibiting (restricting or preventing an event) and their relationship in time.

4. Enter the model into a computer, select a random event and process.

5. Repeat up to 1000 times.

Although a powerful technique, this method is rather complex and sophisticated, time consuming and costly to perform.

2.4.8 SELECTED IDEA GENERATION TECHNIQUES

Certain of the techniques which have been described were not used during the course of this research project. One general reason for eliminating many of the methods was that the high level of sophistication and investment in both time and money would be inappropriate for the function required. Techniques eliminated on this basis were:

a. Group Creativity Techniques
b. Systematic Search Procedures
c. Delphi
d. Relevance Trees
e. Cross Impact Analysis

In addition to the above consideration, it was felt that these more expansive techniques would be most suitable for identifying ideas for diversified products. Radical diversification was not likely to be necessary or desirable in this project.

Within the timescale of this research it was not practical to use the Technology Monitoring Technique, but it was decided to initiate systems so that this technique could be available for future new products.

The surveillance techniques were all selected for use in this work, but as explained in Section 2.2.2 systematic questionnnaire investigation of internal and customer sources could not be performed.

Instead, it was decided to investigate the internal and competitor information which would be available and try to identify some "market holes" from these sources.

The wealth of published information on workpiece and machining statistics made surveillance of these other sources particularly attractive in this instance.

The importance of using technological forecasting has already been covered and a most appropriate technique was considered to be substitution because of the substitution of conventional machines with numerically controlled machines.

The precursor technique could also provide some useful input, and one possibility may be that advanced markets (such as the U.S.A.) could offer a leading indicator to the situation in Europe.

There is a very wide range of published material which makes use of trend extrapolation, expert opinion and Delphi techniques. This material is very relevant to this project and so these techniques could also contribute indirectly.

In this way, a combination of techniques would be used to help generate future conscious new product ideas. The use of multiple methods is recommended by Jolson who says "Undoubtedly, no single technique for analysing the new product selection problem is as useful as a combination of several".

2.5 SCREENING TECHNIQUES

2.5.1 DECISION MAKING METHODS

These methods are largely borrowed from decision theory and use decision matrices, decision trees (venture analysis) or plain scoring methods. The basis of these techniques is to obtain a ranking of all the alternatives, based on a weighted score of a number of parameters. These parameters could include:

a. Market Appeal

b. Technical Feasibility Rating

c. Production Costs

d. Investment Required

e. Potential Return etc.

These techniques are applicable to computerisation and Toll has described four such methods (ref. Toll 1969).

2.5.2 RISK ANALYSIS

This concept is based on an estimation of the potential risk and selecting the idea with the lowest perceived risk.

The technique has its advocates, and has been used successfully at Rolls-Royce Motors with a risk matrix developed from the Directional Policy Matrix (ref. Hussey 1978).

A useful illustration of the principle of risk matrices is given by Deveruex who uses the Ansoff type product/market matrix to describe how risk increases with level of change. This is shown in Figure 2.7 (ref. Devereux 1977).

Severiens has developed a similar matrix which illustrates how risk increases with the level of technological change (ref. Severiens 1977).

2.5.3 PROFILING

Profiling is the process of matching the profile of each new product idea with the company profile and selecting the idea with the best match. This method is advocated by Buijs (op cit) in favour of ranking type procedures, and Kotler sees it as a preliminary screening technique.

Profile variables could be (ref. Baker):

a. Consistency with firm's production and marketing policies.

b. Utilisation of firm's existing skills and resources.

c. Contribution to long run profit expectations.

d. Satisfaction of clearly defined customers needs.

All three of these techniques could provide useful screening methods and any one could be selected for use in this work.

If the number of alternative ideas was low, then it may not be necessary to use any of the formal techniques.

FIGURE 2.7 MATRIX SHOWING NEW PRODUCT RISK FACTORS

PRODUCT CHARACTERISTICS

MARKET CHARACTERISTICS

	SAME PRODUCT	SLIGHTLY MODIFIED PRODUCT	CHANGED DESIGN	COMPLETELY NEW PRODUCT
SAME MARKET	1	2	4	8
EXTENDED MARKET	2	4	8	16
NEW BUT SIMILAR MARKET	4	8	16	32
COMPLETELY NEW MARKET	8	16	32	64

This illustrates how, the greater the departure from established products or markets, then the greater is the risk.

2.6 BUSINESS ANALYSIS

2.6.1 INTRODUCTION

The business analysis stage can conveniently be divided into four elements:

a. Market Analysis

b. Sales Forecasting

c. Technical Appraisal

d. Financial Analysis

As explained in Section 2.2.5, this work is providing a contribution to existing systems. The existing capabilities include a particularly strong technical department and a financial department competent in preparing product, project, investment and profitability analyses.

It is therefore only elements (a)and (b) which are required in this section.

2.6.2 MARKET ANALYSIS

The importance of adopting a marketing based approach to new product development was discussed in Section 2.1. The particular activity of market analysis is an important part of this type of approach and Robinson has shown how over 50% of new product failures are due to faults in this area alone (ref. Robinson 1973).

It is not strictly appropriate to discuss alternative techniques, since the normal method of performing market analysis is to use traditional desk and field researching methods to gain an understanding of relevant market factors. The list of market factors is very large. For example, the BOTB has modified Aubrey Wilson's checklist to develop a list of 420 parameters under 25 headings. (ref. BOTB 1979). The 25 main headings are given in Figure 2.8.

FIGURE 2.8 PRINCIPLE AREAS OF MARKETING RESEARCH

1.	MARKET SIZE
2.	MARKET STRUCTURE
3.	MARKET TRENDS
4.	MARKET SHARE
5.	THE FIRM
6.	MARKETING METHODS
7.	PERSONAL SELLING
8.	DISTRIBUTION METHODS
9.	SHIPMENT AND PACKING
10.	PROFIT
11.	COSTS AND PRICING
12.	THE PRODUCT
13.	SERVICES
14.	MARKETING RESEARCH
15.	OVERSEAS MARKETS
16.	NEW PRODUCTS
17.	COMPETITIVE CLIMATE
18.	COMPETITIVE PRICES
19.	COMPETITIVE PROCESSES
20.	COMPETITIVE PRODUCTS
21.	DEMAND
22.	USER ATTITUDES AND BEHAVIOUR
23.	GOVERNMENTAL FACTORS
24.	IMAGE
25.	MARKETING SYSTEMS AUDIT

(Source: "INDUSTRIAL MARKETING RESEARCHERS' CHECK LIST" BOTB (1979))

While it is obviously impractical and even unnecessary to fully research all 420 parameters, it is important to obtain an appreciation of most of them and investigate those which are most appropriate to the specific requirements.

2.6.3 SALES FORECASTING TECHNIQUES

The sales forecast for a new product is a most important analysis. This is because it is the basis of financial project evaluation and the GO or NO GO decision. It is however, a most difficult analysis (ref. Hague 1978). There is a very wide range of alternative techniques which can help and some of the most important will be described in this section.

Five of the methods previously described for technological forecasting are also applicable to sales forecasting, and are given in a - e below:

a. Trend Extrapolation

b. Precursor Methods

c. Delphi Technique

d. Cross-Impact Analysis

e. Substitution

Other techniques which are particularly suitable for sales forecasting include:

f. DECOMPOSITION

This is the process of separating out the various components of a forecast. For example, product growth can be examined separately from the effects of the business cycle before the two forecasts are superimposed.

Although decomposition is not strictly a forecasting technique, it does provide a very useful organisational function.

g. MARKET RESEARCH

Market research can be used to survey buyers' intentions and/or plans for future action. It can alternatively comprise a test marketing technique (see Kotler op cit). Davies suggests that an examination of the existing market may provide some guide if the new machine can be compared with an existing or previous machine by another manufacturer.

h. EXPERT OPINION

Expert opinion can include panel consensus, interrogating the salesforce or can be simply "visionary" by one person. Chambers et al have given some general idea of accuracy of forecasting methods and expert opinion is rated as "fair to poor" even in the short term. In the same work (ref. Chambers et al 1974), they do, however, provide some examples of human judgement being more accurate than analysts (for example: Xerox Machines and RCA with CTVs).

The methods can be refined with time and experience of previous performance.

i. CYCLES

Techniques which involve the business cycle should strictly be classified under trend extrapolation, but they will be considered seperately because of their importance to the machine tool industry and this work. A number of methods have been given by Abramson (ref. Abramson 1956).

The simplest method is the recurrent cycle technique, with which relatively long term projections can be made geometrically.

"Stage of cycle" and "rate of change" methods can provide very useful short to medium term forecasts without making assumptions or estimations about the period of the cycle.

Time series methods are more sophisticated and when computer assisted, can be most powerful tools.

j. REGRESSION

Regression is a casual type model in which a wide range of variables are identified which are related to level of sales. The ruling equation for each variable is identified using a least squares method and a forecasting model can be produced when the various relationships are analysed statistically.

The drawback of this method is finding relevant relationships (some of the data would not even be normally available to the company). It is also a relatively lengthy and expensive method. Computer assistance would normally be required.

k. ECONOMETRICS

Econometric models are also based on casual relationships and rely on the identification of influencing variables. Multiple correlation formulae or equations are generated from these variables and the resulting model is often very complex. For example, the Treasury model contains over 1000 variables and 650 equations (ref. Brittan 1982).

These methods are most often performed using aggregate data for a complete industry or national economy and are rated as very good to excellent for short term forecasts and good for medium/long term (Chambers et al).

A problem with these models is that they are frequently constructed around a particular economic viewpoint and so have distinct politico-economic theory overtones such as monetarism, Keynesianism etc. Other problems associated with slight variations have been reported by Brittan (op cit).

I. OTHER

This heading covers a wide range of informal future related techniques covering aspects which would indirectly effect sales forecasts. The areas of interest include an assessment of competitors reaction to the company's and other manufacturer's initiatives. This can be called strategic forecasting.

Also included under this heading is the range of socio-environmental and political considerations which could affect the industry, the company, or its products.

An element of comprehensive thinking in this manner is important in new product development so that the element of surprise is reduced (ref. Twiss, undated, Higgins, 1980, Wilson 1977).

2.6.4 TECHNIQUES SELECTED FOR BUSINESS ANALYSIS

a. MARKET ANALYSIS

The volume of evidence in support of performing a market analysis makes it essential that this be executed as thoroughly as the constraints of time and the lack of field research permit. All available techniques of desk and field research would be used to determine market and competitive factors.

b. SALES FORECASTING

Sales forecasts would certainly be required. One problem associated with sales forecasting in the machine tool industry is the wide variation resulting from the business cycle. The decomposition technique would therefore be of some considerable assistance in isolating sales growth from the effects of the business cycle. The two component elements would be called "economic forecasting" and "product sales forecasting".

c. ECONOMIC FORECASTING

The most applicable techniques for business cycle or economic forecasting would obviously be either "cycles" analysis or the causal methods such as regression or econometric analysis.

Although the latter methods are clearly appropriate they are outside the scope of this work, since they would entail considerable investment, both in money and time. The results of published work using these methods could, however, be profitably employed.

The technique selected for economic forecasting was therefore based on the recurrent cycle concept and with the aid of squared paper and smoothed data, estimates of turning points and amplitudes could be made geometrically.

d. PRODUCT SALES FORECASTING

Doyle and Fenwick have performed some work which shows that the accuracy of a sales forecast can be increased if a number of techniques are used and a weighted average forecast is taken (ref. Doyle and Fenwick 1976). It was consequently decided to adopt this approach wherever possible.

The more sophisticated techniques were, once again rejected on the grounds of being too expensive and time consuming.

Trend extrapolation and substitution methods could be used when historical data was available and the multi-technique approach could be achieved with the addition of expert opinion.

For completely new products where no historical data was available then different techniques would be required. Expert opinion could still provide one input, and could be extended by using published reports produced by external "experts". Another suitable method would be market research, but the limitation of no fieldwork would restrict this option. An examination of competitor sales levels as suggested by Davies offered a possible compromise and so a method of this type was selected.

e. SOCIO-POLITICAL AND STRATEGIC FORECASTING

It was apparent that the pressures of other parts of this work would limit the time available for this aspect of forecasting. Uncomplicated techniques such as literature searches and scenario writing were most appropriate and therefore chosen.

2.7 SUMMARY OF TECHNIQUES

A new product development methodology has been developed and integrated into the existing capabilities of the company.

Four new steps in the existing process have been proposed and these are (see Figure 2.9):

a. Strategic Market Planning

b. Idea Generation

c. Screening

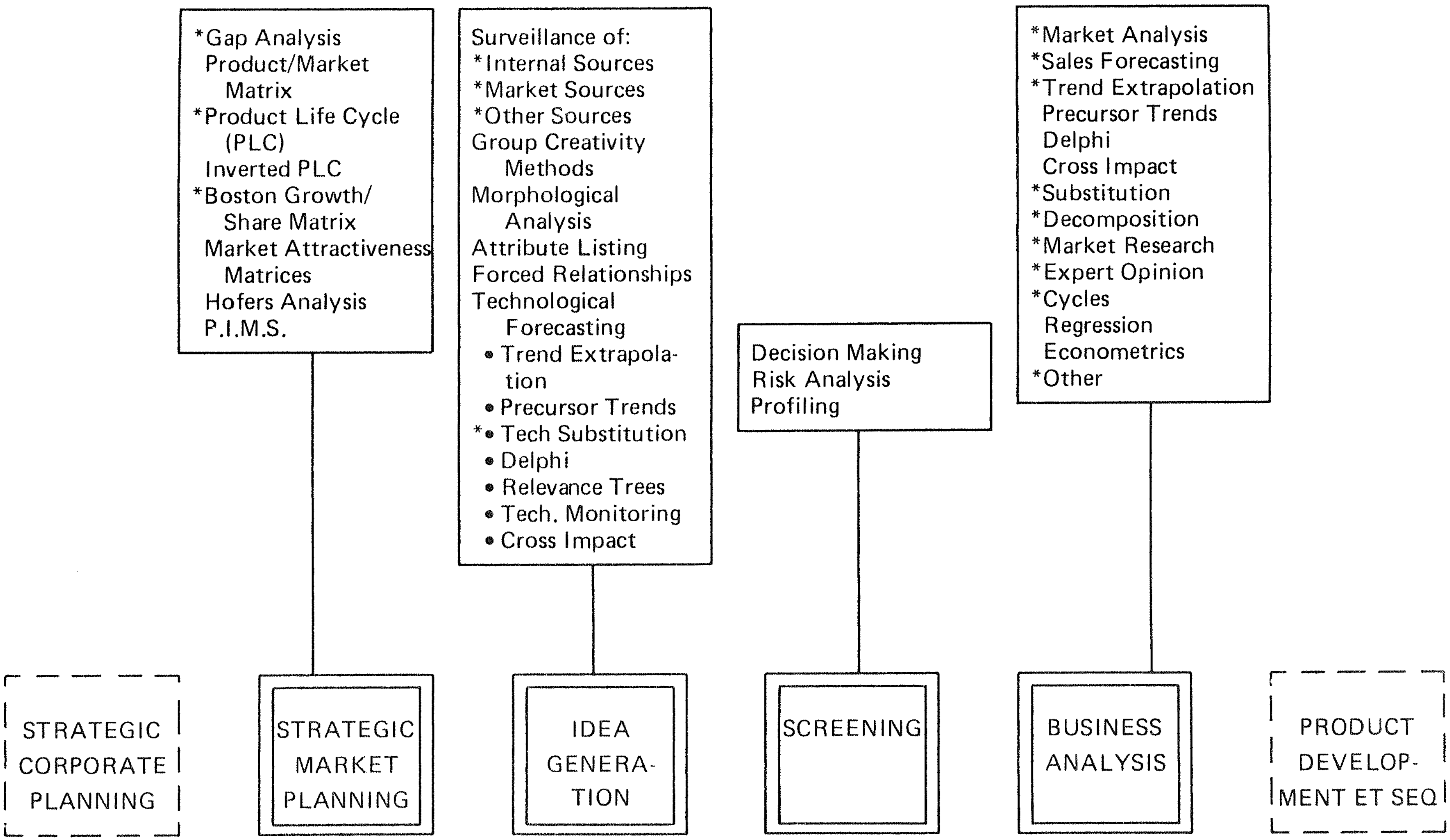
d. Business Analysis

For each of these four stages, a selection of appropriate techniques has been given together with a brief description of their relative merits and drawbacks. These techniques are summarised in Figure 2.9.

The techniques which were particularly suitable for immediate use have been selected, and in Figure 2.9 these are illustrated with an asterisk (*).

FIGURE 2.9 SIMPLIFIED NEW PRODUCT DEVELOPMENT FLOW DIAGRAM

(Showing summary of alternative techniques for each stage. Selected techniques are marked thus *)



2.8 COMPANY AND ENVIRONMENTAL FACTORS

There are a number of factors peculiar to this company and its environment which have had a direct influence on the development and implementation of the methodology and on the selection of the various individual techniques.

In Section 2.2 it was shown how the overall approach to the project was influenced largely as a result of two company factors (viz. the problems with field research and the difficulty in developing new products as an isolated activity).

In this section it will be shown how various factors have also influenced the selection and implementation of individual techniques.

Probably the most important company factor is that the company has been historically production orientated and had no previous experience in performing any of the proposed techniques. This had two effects:

Firstly, any technique which needed to be communicated had to be simple to use and easily understood. It was found that Gap Analysis and PLC techniques were very useful tools since these concepts, and their strategic implications, could be easily understood. Similarly, the relative straightforwardness of the Boston Matrix made this tool considerably more attractive than the more sophisticated alternatives.

The second consequence was that each of the proposed techniques had to be fully researched, assessed and implemented individually. As there was no possibility of assistance the author was forced to perform this work single handed. The magnitude of this task placed a practical limit on the depth into which any particular technique could be investigated.

It was therefore neither desirable nor practical to perform any in-depth analysis on individual elements, but rather to devise an overall set of techniques which would efficiently address the specific problems of this particular exercise.

A further factor which influenced this work was the rapid increase in competition, not only to the company's existing products directly, but also from machining centres and other processes.

The historic success of the company's products had led to a certain degree of complacency regarding competition and it was important that this tendency was corrected and that a detailed understanding of the competition was obtained.

Considerable emphasis had therefore, to be placed on the collection and analysis of competitor information. It was necessary to develop new methods of competitor research and to encourage company personnel to become more conscious of competition and to contribute to the total understanding of the changing competitive environment.

As a result of this concentrated effort, the company's competitor file grew in volume by a factor of four and now completely fills two three-drawer filing cabinets.

Another factor which had a major impact on this work was the recession which created the need for increasingly accurate forecasts. During the previous decade, the company had experienced continued growth and prosperity and the consequences of inaccurate forecasting were considerably less than during this recession when order volumes fell by up to 75%.

It became increasingly important to develop forecasting procedures which would be as realistic and accurate as possible.

An advantage of the technological bias of the company was that mathematical forecasting methods were readily comprehended and accepted and so the introduction of important techniques such as Fisher-Pry was relatively straightforward. The need for increasingly powerful and accurate forecasting techniques has continued to grow and plans are currently under progress to computerise a number of the techniques used in this work.

In summary then, it can be seen that company and environmental factors combined to affect the emphasis of this work, and that techniques had to be selected on the basis of their real practical value to this project.

CHAPTER 3

STRATEGIC MARKET PLANNING

3.1 INTRODUCTION

It was shown in Chapter 1 how three major developments within the five year period 1975 - 1980 had radically changed the outlook for the company. These developments were:

1. The technological revolution and its application to "mechatronics" enabling low cost controls and machines, N.C. E.D.M. and Machining Centres, thereby radically changing the competitive environment.

2. The dramatic entry of Japan into high technology machine tool market.

3. The rapid capability growth of the developing countries, in particular Taiwan.

In addition to these specific developments were the world changes experienced during the late 1970's of slumping growth rates and soaring inflation which culminated in the worst post war recession during the early 1980's.

It was therefore necessary to develop strategic plans for the future of the company, in order that market position, profitability and growth should be maintained.

This chapter explains the role of strategic market planning in the company and makes use of the Boston Consulting Group's strategic portfolio planning tool - The Boston Matrix.

The matrix will be used to develop strategies for each product segment of the portfolio. These strategies will be developed within the company's product policy of offering exceptional value for money. This policy has previously been achieved by first designing a high quality product and then by reducing costs with very large production volumes. (The company is the largest volume manufacturer of milling machines in the world).

3.2 THE BOSTON MATRIX

3.2.1 STRATEGIC IMPLICATIONS OF THE INDIVIDUAL MATRIX ELEMENTS

The Boston Matrix was described in Section 2.3.6 and illustrated in Figure 2.4. The strategic implications which have been developed for each of the four quadrants will be given below:

1. "STARS" are usually relatively new products which are in the growth phase of the product life cycles. They are market leaders and as such should generate large amounts of cash. The strategy for "STARS" is to maintain and consolidate the competitive position of these products. Since this generally involves injections of cash, these products are frequently in balance on net cash flow. If the competitive position is maintained these products will become "CASH COWS" when the market growth slows.

2. "CASH COWS" are usually established products which have reached the maturity stage of the product life cycle. As such, they should be high generators of cash, and since they require limited investment and financial support, profits are often high.

"CASH COWS" provide the company profits, and supply cash for reinvestment elsewhere in the portfolio.

The strategy should be to maintain market share and avoid excessive investment.

3. "DOGS" have the dual disadvantage of low growth and low market share. Prospects for "DOGS" are not good and a strong case for divestment exists. If "DOGS" are managed with low levels of investment, it is possible for them to generate a positive cash flow.

4. "QUESTION MARKS" have high cash needs because their growth is high but have low cash generation because of their low market share. This is the worst possible cash flow characteristic and there are only two alternative strategies for these products hence the title.

One strategy is to invest heavily to achieve a dominant market position and become a "STAR".

The only logical alternative is divestment.

The above classification of products and/or business segments into four areas is only used as a convenient notation. In reality businesses cover a smooth spectrum across both axes of the matrix, and the position within the quadrant provides essential qualification to any product status.

3.2.2 THE COMPANY'S PORTFOLIO

Figure 3.1 shows the Boston matrix of the company in 1979 at the start of the research programme. Six identifiable business segments have been plotted onto the matrix as shown in Figure 3.1. These segments are defined as:

1.	Auto toolchange CNC range	–	"QUESTION MARK"
2.	Manual toolchange CNC range	–	"STAR"
3.	Turret mill range	–	"CASH COW"
4.	2S range	–	"CASH COW"
5.	Horizontals	–	"DOG"

The most important machine in the company portfolio is a "CASH COW" and of the two machines in joint second place, one is a "STAR" and the other is a "CASH COW". Apart from a weakness in the "QUESTION MARK" sector, the overall picture is therefore one of a profitable, well balanced portfolio.

The matrix shown in Figure 3.1 has been presented in schematic form to protect confidential market share information. The information which is presented on it, however, is accurate and general relativities have been maintained.

FIGURE 3.1 THE COMPANY'S GROWTH/SHARE MATRIX IN 1979 (SCHEMATIC)

BUSINESS GROWTH RATE		"STAR"	"QUESTION MARK"
	HIGH	MANUAL TOOLCHANGE CNC RANGE	AUTO TOOLCHANGE CNC RANGE
		"CASH COW"	"DOG"
	LOW	2S TURRET MILL	HORIZONTALS
		HIGH	LOW

RELATIVE COMPETITIVE POSITION

(MARKET SHARE)

(Source: BOSTON CONSULTING GROUP)

3.3 SEGMENT STRATEGIES FOR THE COMPANY'S PORTFOLIO

The following sections make use of the Growth/Share Matrix concept to develop strategies for each identifiable segment of the portfolio.

3.3.1 STRATEGIES FOR THE AUTO TOOLCHANGE SEGMENT "QUESTION MARK"

There is only one model in this segment which is a No. 1 size knee and column machining centre. This machine has been subjected to extensive development work in the U.S.A. and the U.K. launch has been protracted. The U.K. market share is therefore near zero. The machine competes in the machining centre market which is the fastest growing of any segment on the matrix. The machine is therefore clearly a "QUESTION MARK".

The two alternative strategies for a "QUESTION MARK" are either heavy investment to reach the "STAR" position or else divestment. Being the only "QUESTION MARK" in the portfolio, much of the question is removed and so the favoured strategy must be heavy allocation of cash to this product to achieve a dominant market position. Investment into this segment could conceivably include a complete redesign of the knee and column machine if market dominance was not being achieved.

The shortage of "QUESTION MARK" products could be rectified in this segment by introducing bed-type machining centres. Although this type of machine is dominated by the Japanese, the total market size is probably larger than for the knee and column type, and future growth rates could be higher.

Potential new "QUESTION MARKS" could be:

1. Larger (No. 2 size) Vertical Machining Centre.
2. Small (No. 1 size) Horizontal Machining Centre.
3. Larger (No. 2 size) Horizontal Machining Centre.

The alternatives are limited to No. 1 and No. 2 size machines because the company currently manufactures only No. 1 and No. 2 size machines, and so the new products would be compatible with the existing range.

Proposals involving larger machines would incur unnecessary risk since the greater the departure from established products or markets the greater the risk of new product failure (ref. Devereux 1977). In the case of a large machining centre, both the market and the product would be new and so the risk factor would be multiplied.

The strategy would therefore be to offer one or more of the new machining centres to complement the small vertical machines. This strategy would offer the opportunity of growth by obtaining a share of a growing market from which the company would otherwise become totally excluded by the Japanese.

3.3.2 STRATEGIES FOR THE MANUAL TOOLCHANGE SEGMENT "STAR"

In 1979, this segment was almost wholly comprised of a No. 1 size CNC machine. The machine was introduced into this high growth market in 1976, and by 1979/80 had achieved around 60% market share. The machine was clearly established as a "STAR".

The broad strategy for a "STAR" product is that it should attract priority investment to consolidate market dominance ready for the "CASH COW" phase. Plans were already well advanced for further investment in this segment by commencing U.K. production of the larger No. 2 size CNC machine.

In view of the rapidly changing technological and competitive environment additional strategies were required to maintain market position in this important growth sector. The principle problems were the advent of the "retro" CNC package and also its application by OEM's to new machines. The alternative strategies are:

1. Manufacture and supply a retro-system which would be an "approved" product for fitting to conventional turret mills.

There is a problem with this strategy in that a retro-fitted machine can be technically very crude and there would be a real danger of a diminution of the perceived quality of the entire range.

2. Design a new CNC machine which would sell at a very low price and be competitive to retro-fitted machines, or develop a new machine based on the existing CNC machine but replacing the CNC control with one of the new low cost "retro" controls.

Certain design compromises would inevitably be required for cost reduction, but these new products would be totally compatible with the company's product strategy in being low priced and designed to sell in high volumes.

3.3.3 STRATEGIES FOR THE TURRET MILL SEGMENT "CASH COW"

The turret mills were launched in 1959 onto a U.K. market which was virtually ignorant of this type of machine. The growth of this business sector in the U.K. was therefore from zero. The market growth was high and the machines enjoyed a very high share of that market. The product range was initially a "STAR".

In recent years, the market growth rate for turret milling machines has fallen. This is due to two reasons:

1. The number of new users for the machine is decreasing, although this effect is compensated somewhat by the increase in the replacement market.

2. The steady increase in CNC machines, which are substituting for all types of manual machine.

Within this low growth market sector, the range has maintained dominance and currently holds a market share of around 70% in the U.K. The machine is therefore clearly established as a "CASH COW".

The turret mill range is suffering a slight but gradual loss in market share to "traditional" competitors and in addition there is the possibility of considerable future erosion of market share to new competitors such as Taiwanese and Korean manufacturers.

This is all happening within a low growth market, and the increase in CNC products could well turn this low growth into negative growth.

The concept of the Boston matrix indicates that the overall strategy for this range should be to maintain market share at minimum cost, and to avoid excessive investment.

This avoidance of excessive investment will inevitably result in a reduced rate of cost reduction on the experience curve effect. The competition, meanwhile, are moving along their experience curve, in some instances rapidly. Thus there is a conflict in which if costs are not reduced by further investment, additional loss of competitiveness will be the result.

There are two principle alternative solutions to this conflict:

1. <u>INCREASED VOLUME</u>

The first alternative is to increase the volume of production and move further along the experience curve, thus maintaining cost advantages over the competition. This strategy is compatible with the company's overall financial, marketing and technological criteria as a volume manufacturer of machine tools.

There are three possible methods of increasing production volume:

a. INCREASED INVESTMENT – This can take many forms such as price cutting, improved manufacturing plant, developing new models etc., but all of these methods are cash consuming and therefore not within the overall product strategy of avoiding excessive investment.

b. INCREASED MARKET SHARE – With the existing product and markets, this is only possible in export markets. Although international sales effort has been reasonably evenly spread over the whole world, some markets have performed better than others. Market research could be instigated to assess the suitability of current marketing strategies and product specifications in the weaker markets. Revisions in these areas could then result in improved market share.

The amount of investment, both in performing an indepth market research in each country, and in the cost of implementing findings may well prove too high for the increased volume achieved. The rewards, in terms of additional volume achieved, may also prove inadequate.

c. NEW MARKETS – The International Sales Department has almost 100% of the free world covered by distributors. There are, therefore virtually no totally new international markets to be found.

An alternative possibility is to find new market sectors for exploitation. There is possibly a very large additional market for a "down market" machine, with a greatly reduced specification and built down to a price, possibly in the order of two thirds the current prices. This machine would sell into very small manufacturing businesses and could sell in high volumes by substituting for drilling machines.

This strategy would need to be adopted very carefully because the company name is the generic term for turret milling machines worldwide (in the same way as Kleenex and Hoover for tissues and vacuum cleaners). Any such down market trend could easily damage the company's image.

Another consideration is that these machines would contribute less profit individually and so the need for additional production is compounded. In addition to these comments there is the more serious possibility of the modified product substituting for the full specification machine.

2. IMPROVED PRODUCT SPECIFICATION

The second alternative strategy to maintain turret mill profitability is to improve the specification of the product, rather than concentrating on volume increase. This strategy would result in a reduction in production volumes, and maintenance of profitability by sustaining a technical or novelty lead over the competition.

This strategy would require a re-structuring of the company as the programme develops because of the shift away from the philosophy of high volumes and low prices.

It is, however, not an unnatural progression for the product, since the existing machine is currently considered to be the "best" turret mill on the market. It is the machine which has set the standard and been copied by the competition. To maintain this superiority by improving the specification and keeping ahead of the competition is logical.

Another reason in favour of the adoption of this strategy is that even if market share is maintained, market volume will decrease with the technological substitution of manual machines by CNC. The consequential lower production volumes will demand an increased contribution per machine, and these lower model volumes throughout the range will inevitably result in the re-structuring mentioned above.

3.3.4 STRATEGIES FOR THE 2S SEGMENT "CASH COW"

The first 2S machine was launched in 1972 as a "QUESTION MARK" and slowly reached a relative competitive position of just over 1.0. The product life cycle reached the maturity stage in 1979 and a new Model 2S which was launched in 1980 used new technologies in an effort to extend this life cycle.

The market growth has gradually become slower during the life of the machine and is now virtually zero. The growth/share matrix concept would explain that this low market growth was a contributory reason for the marginal market leadership of the 2S, since the established competition would have proved difficult to displace.

The 2S segment is therefore just in the "CASH COW" category with the manual models in a lower growth market than MDI versions. Since the relative competitive position is so close to 1.0 the general strategies for the 2S segment are closer to those for "CASH DOGS". In other words, there is no immediate case for divestment, and properly managed as a "CASH DOG", should yield continuing positive cash flows.

Additionally, extra R & D, production or marketing investments in these machines cannot be justified as these investments would consume the limited potential that the 2S has for generating profit.

The only possible exception would be investment in the MDI version which is in a higher growth market. The machine has clear U.K. market leadership in this sub-segment, but it is still not clear at what rate the sub-segment market is growing.

3.3.5 STRATEGIES FOR HORIZONTALS SEGMENT "DOG"

"Horizontals" is the general name used here for the range of conventional horizontal spindle manual milling machines. Although principally of horizontal configuration, these machines have optional vertical milling attachments.

In 1979 the "horizontals" sector contained two ageing manual machines. At that time, a completely new machine was being designed to replace both these machines, and like the new 2S was incorporating recent advances in technology. Similar expectations for extending the product life cycle and increasing market share were held. The new machine was launched in 1980 and is currently a "DOG".

The general strategies for a "DOG" product dictated by the growth/share matrix technique indicate no further investment and a serious consideration for divestment.

The alternative strategies for this product are:

1. An MDI version could be offered to be generically compatible with the 2S MDI. Since the growth potential of this sub-segment is still in doubt, it is better to postpone this investment decision until market trends are more clear.

2. A cost reducing exercise could increase market share. It would also involve investment in R & D, production and marketing and would still only provide a machine in a near zero growth market. The marginal nature of this strategy excludes it from the alternatives.

3. Divestment. This is probably the most attractive strategy for a number of reasons. Firstly, the tactical divestment of a new up to date machine tool could achieve cash returns under a licencing agreement with another manufacturer, possibly in a developing country. The machine could become more profitable divested than it is currently. Secondly, it is now apparent that the company's portfolio will increase in the next few years and so the withdrawal of a marginal product would make administrative and financial sense.

3.3.6 STRATEGIES FOR DIVERSIFICATION

It is not within the scope of this work to consider radical diversification outside machine tool manufacture, but there are two important factors supporting the case for moderate diversification of the company's product range:

1. THE MACHINING COMPLEX

The strict delineation of machine tool types is slowly being eroded. Machining centres are performing milling, drilling and boring operations and with contouring facilities can also perform the external circular work previously restricted to lathes. On the other hand N.C. lathes are now available with milling capabilities (e.g. Yamazaki Slant-Turn 30 Mill Center) which can perform limited milling operations on cylindrical work.

The introduction of these machine types has provided considerable reductions in set-up and component transfer time. To make further reductions in time, a full machining complex is required.

A machining complex permits a variety of machining operations to be performed on a work-piece. This is achieved by transferring the work from one dedicated machining station to the next using a robot or pallet transfer mechanism. The entire complex is computer controlled with one master computer controlling smaller computers fitted to the individual machines. This operational method is known as DNC (Direct Numerical Control). In order to be able to participate in the DNC machining complex market, the machine tool manufacturer should have expertise in different machine types. This suggests that the company could diversify into other types of machine tool. Obvious initial choices would include NC lathes, robots and NC EDM.

2. COMPETITIVE PROCESSES

The long term effect of certain of the competitive processes described in Section 1.7 could seriously affect the market for milling machines. The strategy required to counter this threat is to monitor the growth of the market of each of the competitive processes and to diversify into one or more of these areas if continued growth and consequential erosion of milling machine markets becomes likely.

Since these machining processes can be considered to be simultaneously threats and opportunities, then new products could be launched into the NC EDM or "new technology type" grinding markets to exploit the opportunities.

3.4 SUMMARY OF STRATEGIES

The following is a summary of the alternative strategies which have been developed for each segment of the portfolio:

1. AUTO TOOLCHANGE SEGMENT

a. Invest heavily in the existing No. 1 size machine.

b. Launch new products in this segment.

2. MANUAL TOOLCHANGE SEGMENT

a. Launch a "retro" package

b. Enter the low cost market with a new machine.

3. TURRET MILL SEGMENT

a. Avoid radical developments or heavy investments.

b. Increase volume with lower price and specification.

c. Improve product specification to increase unit profitability.

4. 2S SEGMENT

a. Do not divest.

b. No additional investments can be justified.

c. If market growth is established, 2S MDI could offer opportunity for investment.

5. HORIZONTALS SEGMENT

a. Potential for divestment.

b. Future market growth could justify the launch of an MDI version.

6. DIVERSIFICATION

a. Enter the NC lathe market.

b. Enter the market for robots.

c. Enter the NC EDM market.

d. Enter the grinding market with the new technology type grinding machines.

CHAPTER 4

ASSESSMENT OF PRIORITIES

4.1 INTRODUCTION

This chapter will make use of the product life cycle (PLC) concept to add a dynamic perspective to the strategies already developed. The analysis will employ a modified PLC and will apply to the U.K. market only.

Each individual PLC will be examined to assess current performance and likely future developments. The relative urgency of action required will then be determined so that priorities can be assessed and further research optimised.

4.2 PRODUCT LIFE CYCLE MODIFICATION

In its simplest form, the PLC can be represented as a sales - volume curve passing through the four stages of introduction, growth, maturity and decline (ref. Kotler 1980).

The cyclical nature of the machine tool industry results in considerable distortion of this simple curve. In extreme cases, increasing sales volumes could be associated with a product in the declining stage of the PLC and visa versa.

To overcome this problem, a modified PLC has been developed. In this, sales volume has been replaced by sales relative to total machine tool consumption. Growth, maturity and decline are now represented as increasing, static and decreasing market share respectively.

4.3 DATA GENERATION

In order that market share can be determined it is first necessary to obtain total machine tool consumption statistics.

The best estimate of world consumption is given in the yearly NMTBA Economic Handbook (ref. NMTBA 1981) which provides an estimate of world demand based on a summation of world production figures.

There are difficulties associated with using this data which arise from varying exchange rates, incompatibility of definition of machine tools, highly approximate estimates of eastern bloc production and problems surrounding the inclusion or otherwise of spares and accessories.

In addition to this, the company's export sales figures, are highly dependent upon political considerations, variability in distributor patterns, large contracts etc. The resulting fluctuations make market share analysis on a worldwide basis insufficiently accurate to be worthwhile.

It is also doubtful if PLC factors could be interpreted from the aggregated total of over 75 export markets.

For all these reasons it was decided to restrict the PLC analysis to the domestic U.K. market where relatively steady state conditions exist and statistics are more thoroughly understood.

In this analysis total consumption will be expressed in terms of current values. The use of volume figures, although having some attractions, is not possible with U.K. statistics which include a large and totally distorting volume of small machine tools (such as hand held grinding machines etc.).

This analysis will make use of total consumption figures since this is a measure of the total amount of money spent in the U.K. on machine tools. Any market share variations relative to this omnibus measure will therefore more closely reflect PLC effects.

The total market consumption has been approximated to:

Total value of U.K. Machine Tool Production

LESS total value of U.K. Direct Export

PLUS total value of U.K. Imports

Figure 4.1 shows the data used for the estimation of total U.K. machine tool consumption (total market size) which was used for assessing market share of each individual product type.

4.4 RESULTS

From a knowledge of the company's actual current sales value of individual products, the modified PLC's can be drawn.

These are shown in Figure 4.2. The actual market share values are not given but the relativity between products has been maintained.

It is not possible to draw PLC's for either of the two product segments (Machining Centres, Horizontals) which comprise newly introduced models, because these machines are at the "introduction" stage of the cycle and no historical data is available.

Examination of the individual PLC's yield the following:

4.4.1 TURRET MILL

This product provides the major contribution to turnover and is still growing, although at a very slow rate. This indicates that the product has survived all the increased pressures of greater competition (especially Taiwanese) and the substitution forces of CNC products.

FIGURE 4.1 ESTIMATE OF TOTAL U.K. MACHINE TOOL CONSUMPTION 1968 - 80

(Units £000's)

YEAR	PRODUCTION P	EXPORTS E	IMPORTS I	CONSUMPTION (= P − E + I)
1968	153000	53291	46082	145908
1969	168000	65369	41780	145216
1970	201293	87749	56724	170268
1971	193543	97257	48926	145212
1972	188328	83543	50818	155603
1973	218397	83975	65528	199950
1974	255496	106841	99124	247779
1975	330115	164016	114663	280762
1976	356967	176723	142436	322680
1977	407904	184942	144397	367359
1978	513386	221191	207732	499927
1979	568325	222837	284886	630374
1980	612846	289815	267481	590512

(Sources: 1. PRODUCTION – H.M.S.O. BUSINESS MONITOR PQ332

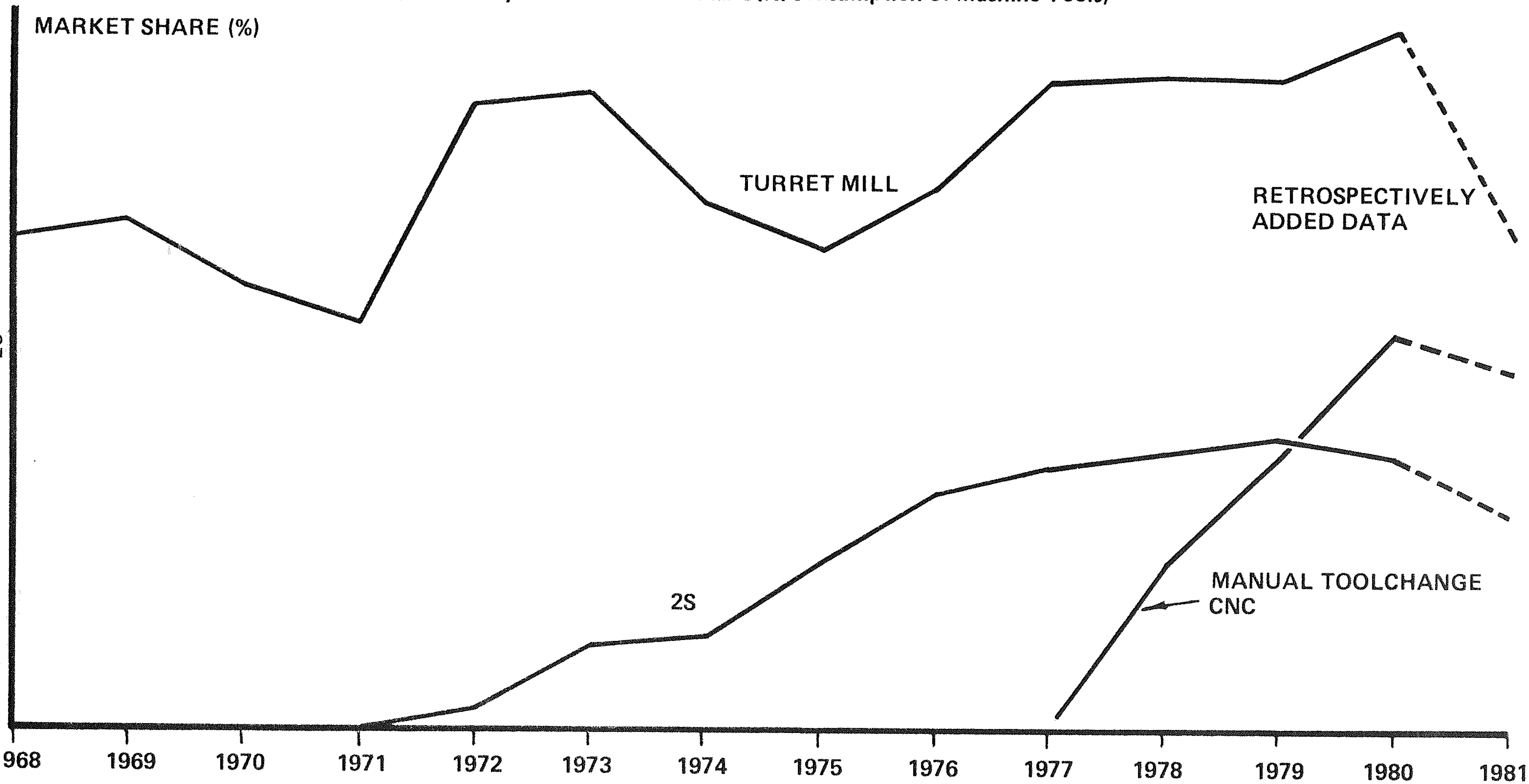
2. IMPORTS – H.M. CUSTOMS & EXCISE RECORDS (HMCI)

3. EXPORTS – H.M. CUSTOMS & EXCISE RECORDS (HMCI)

FIGURE 4.2

PRODUCT LIFE CYCLES OF VARIOUS MODELS

(Defined by Market share of total U.K. consumption of Machine Tools)



The product maturity phase would appear to have been reached or will be reached within a short number of years.

The underlying strength of this product would indicate that there is no immediate urgency for action but that new strategies will probably be appropriate in the not too distant future.

4.4.2 2S RANGE

The PLC for the 2S shows strong growth from 1972 to 1977. In 1978/9 the onset of maturity was apparent and subsequent to 1979, decline has been evident.

At its peak in 1979, this product provided around 20% contribution to U.K. turnover and is therefore a very important product in the range. The supportive action which was taken in 1980 with the launch of the new model 2S would not appear to have extended the product life cycle by a substantial amount.

Strategies clearly need to be implemented if this important sector of the company's portfolio is to be prevented from further decline.

4.4.3 MANUAL TOOLCHANGE CNC RANGE

The growth of these products is shown to be very strong until 1980 (when the analysis was performed). The products were in the growth phase of the product life cycle with no sign of the onset of maturity.

By 1980 these products were contributing almost 25% to turnover in the U.K. and had provided the greatest proportion of the total market share increase achieved by the whole company in the previous 3 years.

This rapid growth was not to be totally unexpected since strong growth was being experienced by all CNC products in the U.K. A preliminary substitution analysis performed at this time provided evidence for this fact. It was therefore necessary to examine the growth of these products in more depth.

If the growth of the CNC range is examined as a proportion of the total U.K. spend on CNC machines then, in much the same way as the modified PLC already explained, a new PLC should emerge.

Figure 4.3 shows the data and Figure 4.4 gives a plot of the PLC by this definition.

From Figure 4.4 it can be seen that by this measure, product maturity is imminent. Retrospectively added data for 1981 in Figure 4.2 illustrates how the decline did in fact commence in the latter part of 1981.

The significance of this is two fold:

Firstly, these products have provided a substantial contribution to the turnover and growth of the company. These are also in the high growth CNC sector and would therefore be expected to have good long term potential. Any indication of the onset of decline is of concern, particularly if the rate of decline is anywhere near the rate of growth already experienced.

Secondly, if product maturity is being reached after only 4 years, this would provide some evidence in support of the widely held view that PLC's are shortening in all markets (ref. Qualls et al 1981). If this is true, then new product planning and development will become increasingly more important in the future.

FIGURE 4.3 ESTIMATE OF TOTAL U.K. N.C. MACHINE TOOL CONSUMPTION 1974 - 1980

YEAR	PRODUCTION P	EXPORTS E	IMPORTS I	CONSUMPTION (= P – E + I)
1974	16010	6486	15184	24720
1975	23730	9405	22434	36720
1976	26980	9744	33271	50540
1977	33400	9935	26200	49670
1978	53320	15149	43888	82070
1979	65170	17211	73540	121500
1980	85540	23519	96300	158320

(Sources: 1. PRODUCTION – H.M.S.O. BUSINESS MONITOR PQ332 TABLE 1

2. EXPORTS – H.M.S.O. BUSINESS MONITOR PQ332 TABLE 2

3. IMPORTS – ESTIMATED FROM H.M. CUSTOMS & EXCISE RETURNS)

FIGURE 4.4

PRODUCT LIFE CYCLE OF MANUAL TOOLCHANGE CNC MACHINES

(Defined by share of total U.K. CNC market value)

4.5 CONCLUSIONS

1. A first general conclusion is that all three major products were at or near the product maturity stage by the end of 1980. This means that no real growth can be expected from these products and that future growth can only be achieved from new products.

2. The manual toolchange CNC range is in need of immediate investigations as the consequences of decline in this product would be most serious and the rate of decline could be most rapid.

3. The 2S range is in decline even after the recent launch of an updated version. Strategies need to be implemented to protect this business sector.

4. Longer term strategies will be required for the turret mill range as product maturity and decline occur within the next 5 years or so.

5. Some evidence of shortening PLC's has been found.

6. The conclusions of this analysis refer only to the U.K. market and are thereby limited.

CHAPTER 5

THE SPECIFICATION AND DEVELOPMENT OF

THE TWO MDI MACHINES

5.1 INTRODUCTION

Chapter 4 showed that by the end of 1980, first priority needed to be given to supporting the business sector comprising the manual toolchange CNC machines.

This chapter will provide a summary of the market factors existing at that time. It will be shown how the need for new products was identified and how this need was met with a range of two MDI machines.

Some specific work is also described, including a survey performed on the first MDI customers.

5.2 FACTORS LEADING TO DEVELOPMENT OF THE NO. 1 SIZE MDI

1. GROWTH OF RETROS

The market for the low cost retro packages was growing. The market size prior to 1980 was very small, but by 1981 there was evidence to suggest that one manufacturer alone was selling around 6 units per month (ref. Mach & Prod. Eng. August 1981).

The price of this equipment was so competitive that an existing turret mill could be retro-fitted complete with labour for half the price of a new CNC machine.

2. GROWTH OF COMPETITION

Other machine tool manufacturers had started fitting these low cost micro-processor based retro controls to their machines. One major competitor launched such a machine in November 1980 and was selling around 2 per month by the beginning of 1981.

These machines were of good quality and around 10 - 20% cheaper than the comparable CNC machine.

A similar move by Yeong Chin in 1981 was expected and later in the year, these machines were seen, at highly competitive prices, at the Australian AIEE Exhibition.

3. PRODUCT MATURITY

PLC analysis had shown that although the company's existing CNC machines were still in a growth phase, this growth was slowing and maturity could be imminent.

There was additional evidence to support this warning of product maturity, from the U.S.A. where the proportion of CNC machines at the parent company had ceased to increase about a year previously.

The U.S.A. was the birthplace of most retro controls and a technological time lag of around 12 - 18 months was anticipated on a precursor trend basis.

4. SUBSTITUTION FACTORS

This type of machine was seen to be replacing conventional turret mills on a technological substitution basis. Since the company had some 300,000 installations of conventional machines worldwide it was essential that suitable replacement machines were made available for these existing users.

It had been seen how many of these existing users were increasingly prepared to pay a premium for higher productivity machines. At the top end technological substitution was occurring with the purchase of CNC machines costing over 3 times the price of a standard turret mill of equivalent capacity. At the lower end there was an increasing demand for Digital Read Out Equipment (DRO) to be fitted to manual machines from new. By 1981 the proportion of machines fitted with DRO's had reached around 50%.

An estimate of the price/volume curve therefore suggested good potential for a controlled machine with a selling price of around twice the price of a manual turret mill.

5. STRATEGIC PLANNING CONSIDERATIONS

Chapter 3 showed how the manual toolchange CNC machines were in the "STAR" category. It was therefore an appropriate strategy to invest in this segment to maintain market leadership.

5.3 IMPLEMENTATION

The requirement for a new product was therefore identified. The specification of this machine was quite wide with the criteria of a No. 1 size vertical machine, having a numerical control and a selling price of less than two thirds that of the existing CNC machine. A target "psychological" selling price was set at under £10,000.

With the idea of attracting a maximum number of existing manual milling machine users, the machine was designed with handwheels for both manual operation and also "teach and learn" programming.

A low selling price was achieved in two ways:

1. CONTROLS

The very high volumes anticipated gave the company a strong position when negotiating purchase of controls. The least sophisticated and therefore least expensive MDI control in Heidenhain's range was selected and purchased at highly competitive prices.

2. MACHINE

The major mechanical components were taken directly from the existing CNC machine which was already being built in high volumes.

This allowed the new machine to be manufactured with a minimum of re-tooling.

Previous experience with the control unit, and use of some major assemblies of an existing machine enabled a low cost design and development programme and a smooth launch in September 1981.

In the first six months, up to the time of writing, sales of this machine have exceeded forecasts by over 30% (see results in Section 8.5). Market share for manual toolchange CNC machines for the whole of 1981 dropped to just over 50% and early indications suggest that the target of regaining 60% in 1982 will be achieved with the aid of these new machines.

5.4 USER SURVEY

The success of the No. 1 size MDI was such that an investigation was performed to determine the reasons behind the purchasing decision.

Questionnaires were distributed among the sales representatives who used their knowledge of the purchase of the first 38 machines ordered to fill in the forms. (Sample questionnaire is shown in Appendix B).

5.4.1 RESULTS OF SURVEY

Question No's 5 and 6 were asked to determine if the customer had intended to buy some other equipment and if so what.

As anticipated, sales were being won from the retro-fitters (in 13% of cases) and sales were being substituted from CNC machines (in 10% of cases) and customers were moving up market and buying an MDI instead of a standard turret mill (in 13% of cases).

A major reason for the success of the machine was determined to be the relatively high proportion of sales to customers with no prior intentions to purchase any machine (in 32% of cases).

Question No. 7 was asked to determine the reasons behind the purchase and these were identified as:

Price 89.5%

Ease of Programming 39.5%

Thus the importance of low price was confirmed. In addition it was clear that the ease of programming offered by the interactive control was also an important factor.

5.5 DEVELOPMENT OF THE NO. 2 SIZE MDI

Several factors contributed to the decision to develop the larger No. 2 size MDI machine.

1. Major sectors of the competition were offering larger size machines at relatively high prices. The competition environment was therefore very similar to that previously described for the No. 1 size machine.

2. The user survey had illustrated the popularity of the interactive MDI control and so it was logical to offer it on a larger machine.

3. Price-volume estimates indicated that once again a low price could be a deciding factor in obtaining high sales volumes.

4. Every No. 1 MDI "Lost Order Report" was examined and showed two major reasons for losing orders. These reasons were the lack of sophistication of the point-to-point control and the size (or capacity) of the machine.

The higher cost No. 2 MDI machine could accommodate a more expensive control and so the most sophisticated contouring control complete with a V.D.U. was specified.

A similarly short and relatively trouble free development resulted in a launch of the No. 2 MDI machine at the Metcut Exhibition in April 1982.

CHAPTER 6

MACHINING CENTRE MARKETING RESEARCH

6.1 INTRODUCTION

The two strategic market planning tools, Product Life Cycle and portfolio analysis have both shown that new products were required to provide future profits and to maintain company growth.

Portfolio analysis has identified several areas of potential new products which included machining centres and various diversification alternatives.

It was decided that new product research should, in the first instance, be concentrated on machining centres rather than on the diversification strategies, the reasons behind this decision being:

1. Machining centres offered a high growth opportunity.

2. Machining centres were substituting for both conventional and CNC machines and were being purchased by the company's existing customers.

3. An examination of the Devereux Risk Matrix (Figure 2.7) readily shows that machining centres offer the lower risk option by at least a factor of four.

Having once reached the outline decision to examine the market opportunities for machining centres, marketing research was necessary to further reduce the potential risk. It was clear that, unlike the case of the manual toolchange machines described in the previous chapter, these machines would not be merely replacement products entering a known market, but would constitute an extension to the product range and would therefore incur high levels of potential risk (ref. Severiens 1977, Skinner 1972, Devereux 1977, see also Figure 2.7).

This chapter describes the compilation of market information, the specific techniques used and the results obtained.

6.2 MARKET SIZE

The strict definition of market size is the total number of machining centres (M.C's) which are sold to end users worldwide in any particular year. It is impossible to determine this total number of sales and so a substitute measure of total world production was used. Production does not strictly equate to sales since manufacturers and distributors hold stocks and these stock levels are variable with the business cycle. This measure of market size can consequently be considered as being "smoothed".

An additional problem lies in the availability of statistics for Eastern bloc countries. Where these figures are available there are difficulties associated with classification and exaggeration. The NATO restrictions on high technology exports to the Eastern bloc result in very little trading between East and West in machining centres. Since each market is thereby substantially self-sufficient, it is a reasonable approximation to limit our investigations to the "free" world where statistics are more readily available.

The major producing countries publish production figures and the minor countries can be estimated without incurring large errors. The table in Figure 6.1 shows the world production of machining centres and the graph in Figure 6.2 illustrates this data graphically.

These figures show that by 1980, the total free world production of machining centres was over 10,000 units. The value of this production is over \$1.5bn (£700m).

6.3 MARKET GROWTH

Figures 6.1 and 6.2 show that the volume growth in free world production of machining centres has been tenfold between 1971 and 1980. This represents a very healthy growth rate of approaching 30% p.a.

FIGURE 6.1 KNOWN WORLD PRODUCTION OF MACHINING CENTRES

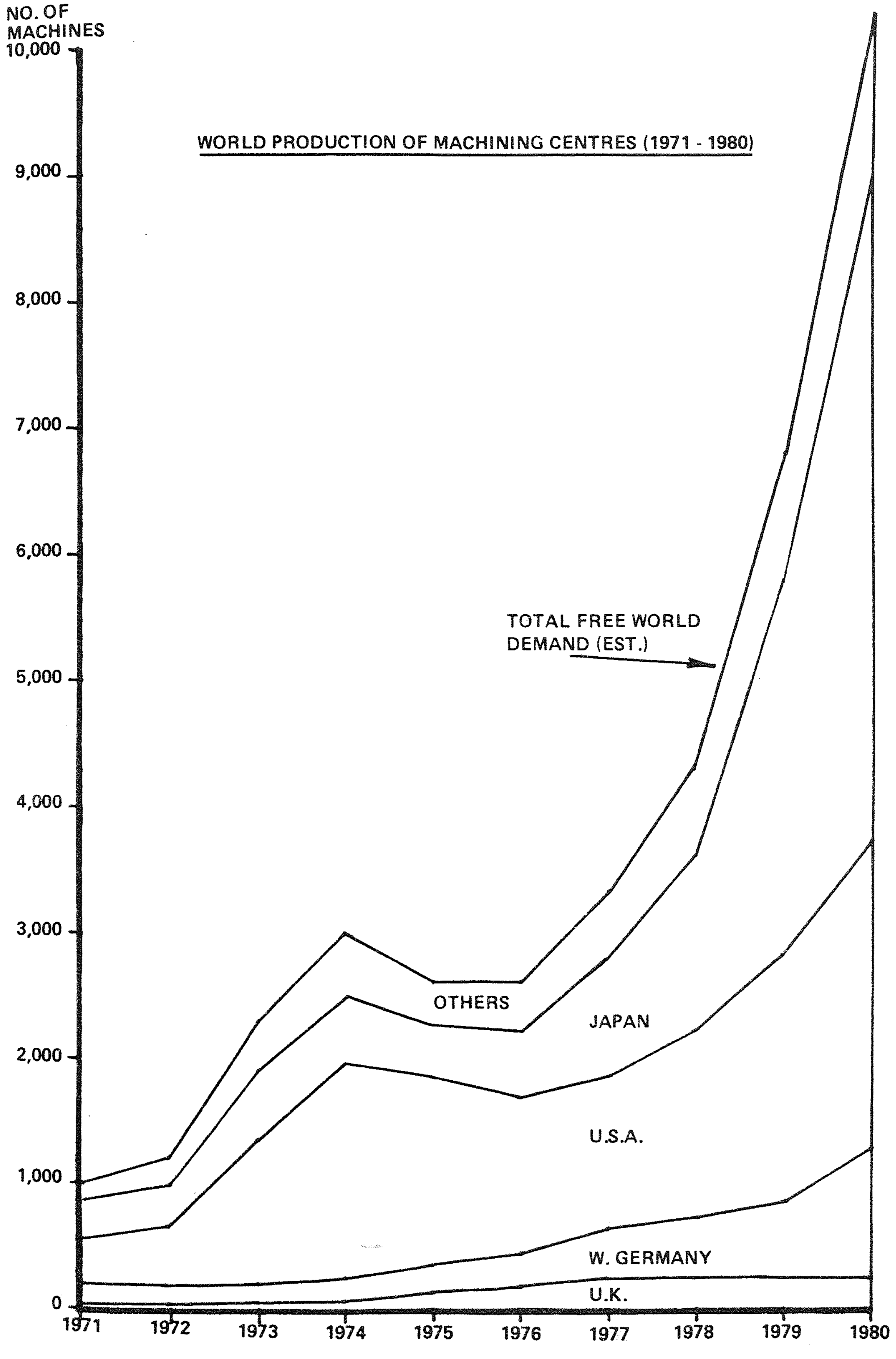
(Units)

YEAR	COUNTRY OF ORIGIN					TOTAL (EST.)
	U.S.A.*	JAPAN	WEST GERMANY	U.K.	OTHERS (EST.)	
1971	344	295	163	40	160	1000
1972	475	328	124	63	210	1200
1973	1162	564	162	67	350	2300
1974	1692	577	197	65	470	3000
1975	1460	401	217	130	390	2600
1976	1225	526	258	160	430	2600
1977	1201	926	396	230	550	3300
1978	1486	1371	490	210	750	4300
1979	1965	2936	651	220	1000	6800
1980	2401	5231	1041	230	1400	10300

*U.S.A. figures include MTC Machines

(Sources: U.S.A. - NMTBA, Japan - MITI, U.K. - PQ332, WEST GERMANY - VDW)

FIGURE 6.2



NO. OF MACHINES
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
WORLD PRODUCTION OF MACHINING CENTRES (1971 - 1980)
TOTAL FREE WORLD DEMAND (EST.)
OTHERS
JAPAN
U.S.A.
W. GERMANY
U.K.
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980

The highly cyclical nature of the world machine tool industry suggests that much of this growth is only apparent and could be due solely to the boom period in machine tools in 1978/9/80. It is therefore necessary to examine the machining centre relative to the world production of machine tools.

From the NMTBA Economic Handbook the free world production of machine tools for 1971 and 1979 can be compared with the free world production of machining centres developed in the previous section:

Thus in 1971:

Free world machine tool production = US$ 6114

Machining centre production = US$ 135

Equivalent to 2.2% of total production

In 1979:

Free world machine tool production = US$ 17154

Machining centre production = US$ 835

Equivalent to 5.7% of total production

In other words, machining centre production has increased by 260% in real terms over and above the world increase in the world machine tool industry.

6.4 MARKET SHARES

Figures 6.1 and 6.2 provide further evidence of the growth and dominance of the Japanese in the M.C. market. The following is a summary of the national market shares in 1980 compared with 1971 and it shows how all countries have lost share to Japan during this decade.

	Market Share in 1980	Market Share in 1971
Japan	51%	30%
U.S.A.	23% *	34% *
W. Germany	10%	16%
U.K.	2.2%	4%
Others	14%	16%

* These figures are over estimated by around 30% because the U.S. figures include manual toolchange machines.

6.5 SEGMENTATION

The basic concept of a machining centre is an automatic toolchanging multi-function (mill/drill/bore) machine tool. This description encompasses a wide range of machine configurations which are all classified as machining centres simply because they are equipped with auto toolchange equipment.

Although there is a growing number of purpose designed machines, most early machines and many current models owe their ancestry to conventional horizontal borers or to knee and column or bed type milling machines, turret mills/drills etc.

This diversity has led to the need for some kind of market segmentation. A dividing line at 10 h.p. spindle power is commonly used to differentiate between large and small machines, and the spindle orientation (horizontal or vertical) is also of fundamental relevance.

The five segments which have been found to be appropriate for our purposes are:

a. Vertical knee and column type under 10 h.p.

b. Vertical bed type under 10 h.p.

c. Horizontal bed type under 10 h.p.

d. Vertical machines over 10 h.p.

e. Horizontal machines over 10 h.p.

In order to determine the market size of these five segments it is necessary to ascertain how many machines are built at what value in each segment worldwide.

Achievement of this objective is virtually impossible because of the magnitude of the research project which would be required. The information has been obtained by using a substitute method.

In this substitute method, the segmentation of the U.K. market has been accurately determined and this has been compared with the segmentation of exhibits at Machine Tool Exhibitions in the U.K.

The segmentation of exhibits at exhibitions worldwide was then researched and when this information was compared with the U.K. experience and combined with some horizontal / vertical production data, total world segmentation could be estimated.

Further details of the specific stages in this process are given in the following sections.

6.6 THE U.K. MARKET

In April 1980, the international machine tool show MACH 80 was held in the National Exhibition Centre in Birmingham. This show provided an ideal opportunity to examine a large number of machining centres and every machine which was exhibited was studied. Catalogues, prices, options available and, where possible, production volumes and date of introduction were all collected and reported (a copy of this report is given in Appendix C). This provided a solid basis for a thorough investigation of the U.K. market in 1980.

In addition to the MACH 80 survey the following techniques were used to determine sales by volume, value and machine specification for each manufacturer in the U.K. in 1980.

1. To determine the extent of the competition, trade magazines were searched. The makes and models of all competing manufacturers were soon identified from the advertisements.

2. Trade magazines also provided news of new product launches and specific articles on U.K. manufacturers provided production, sales and turnover figures (ref. for example Holland 1980, 1981, 1982; Bennet 1981, Bowe 1982, Commline 1981, Eng. Today 1982, Mwkg Prod. 1981).

Total U.K. production and export figures are obtainable from Business Monitor PQ332 which segregates machining centre production and exports into horizontal and vertical spindle types. Although this information is only collected on a sampling basis, the sample size is fairly high (c 85%) and so provides a very useful guide to total U.K. production supplied to U.K. market.

4. One problem with PQ332 is that one major machining centre manufacturer is excluded due to a low number of employees. This manufacturers output and U.K. sales was determined by method (2) above and cross checked by examining the import statistics for

the Japanese built carcasses which he uses.

5. Import statistics for machining centres provide the key to link all the collected information together. The figures were first cross checked with the corresponding figures for the exporting countries where this was possible.

With this data it was possible to isolate some manufacturers completely where only one manufacturer or model was supplied from a given country (e.g. Holland, Denmark) and to provide sub totals, for example, for German or Japanese manufacturers.

6. The final method used can only be described as "other" information and consists of unpublished and confidential reports and intra-trade knowledge. After screening, much of this information provides a valuable perspective on the research subject.

6.6.1 SEGMENTATION OF U.K. MARKET

The results of the above research can be summarised under the five segment headings already developed. These results are given in Figure 6.3.

6.7 SEGMENTATION OF WORLD MARKET

The wide variety of machining centre types makes it necessary to have some indication of individual segment sizes. These can be estimated from the known U.K. segmentation and observed segmentations at machine tool exhibitions (Figure 6.4).

The information obtained at machine tool exhibitions is considered to be representative of the total demand because exhibitors will select best selling and/or best potential machines for show. There are certain problems with this assumption which lie particularly in the small/large breakdown. Large machines are usually built to individual order and are very expensive to exhibit. The smaller U.K. exhibitions therefore had a very low proportion of these machines, while the large EMO exhibition in Hannover had a relatively high

FIGURE 6.3 SEGMENTATION OF U.K. MACHINING CENTRE MARKET IN 1980

SEGMENT	DESCRIPTION	NUMBER OF COMPETITORS IN 1980	NUMBER OF MACHINES SOLD	VALUE OF SALES £m
A	VERTICAL KNEE & COLUMN UNDER 10 H.P.	6	190	7.5
B	VERTICAL BED TYPE UNDER 10 H.P.	13	135	8.5
C	HORIZONTAL BED TYPE UNDER 10 H.P.	13	130	13.5
D	VERTICAL MACHINES OVER 10 H.P.	8	50	4.5
E	HORIZONTAL MACHINES OVER 10 H.P.	10	65	8.5
	TOTAL	38	570	42.5

FIGURE 6.4 SEGMENTATION OF MACHINING CENTRE MARKET

SEGMENT	DESCRIPTION	U.K. CONSUMPTION 1980	MACHINE TOOL EXHIBITIONS			ESTIMATED WORLD BREAKDOWN	WORLD CONSUMPTION 1980
			MACH 80 EXHIBITION 1980	EMO 4 HANNOVER 1981	PEP PLUS METCUT 82 1982		
A	VERTICAL KNEE & COLUMN UNDER 10 H.P.	33%	15%	4%	14%	10%	1000
B	VERTICAL BED TYPE UNDER 10 H.P.	24%	29%	30%	42%	35%	3500
C	HORIZONTAL BED TYPE UNDER 10 H.P.	23%	35%	18%	21%	25%	2500
D	VERTICAL MACHINE OVER 10 H.P.	9%	10%	23%	17%	15%	1500
E	HORIZONTAL MACHINES OVER 10 H.P.	11%	11%	25%	6%	15%	1500
	TOTAL	100%	100%	100%	100%	100%	10000

proportion vis-à-vis total sales quantities.

The data for the 1982 exhibitions was obtained by combining the exhibits of the PEP show with those of the METCUT show three weeks later. Identical machines that were exhibited at both shows were only counted once.

Figure 6.4 shows how the 1980 world consumption of 10,000 machines can be disaggregated using this information.

The vertical knee and column machine represents a specific segmentation for the purposes of this work. Its appeal is not universal, being mainly restricted to those markets which have embraced the conventional turret mill. This is illustrated by the low (4%) proportion in Hannover (see Figure 6.4).

It is only manufactured in large quantities in the U.S.A. and U.K. with a small number coming from Spain, Italy and the developing countries. Production statistics in the U.K. and market intelligence from the sister organisation in the U.S.A. provides a cross check confirming the 1,000 machine p.a. total world consumption figure.

6.8 HORIZONTAL/VERTICAL MIX

It is very difficult to determine this mix accurately as most countries do not define machining centres under this sub-heading. Some evidence can be obtained from populations of machines, current sales levels and involvement at exhibitions, and this is given in the following table.

Additional problems arise from highly variable local preferences, for example, the Californian preference for Vertical machines (ref. American Machinist 1982).

SOURCE	%H	%V	TOTAL NO. OF MACHINES IN SAMPLE
U.K. Survey of M.C. (1976)	45	55	616
New Zealand M.C. (1981)	50	50	18
U.K. deliveries 1980			
N.E.D.O. sample	35	65	101
U.K. Market 1980	34	66	574
Mach 80	46	54	52
Jimt of 80 (Jap.)	41	59	98
Chicago 80 (Jap.)	33	66	44
EMO 81	43	57	169
PEP 82 & METCUT 82	21	73	78
U.K. Production (74 - 81)	41	59	679
Jap. Production 1979	36.5	63.5	2936
Jap. Production 1980	38.5	61.5	5231
Westec 1982	18.2	82.8	88
Weighted Average	38.1	61.9	10684

6.9 COMPETITION

The world market for machining centres is supplied by a large number of companies in a growing number of countries. The most comprehensive survey which was performed was at Hannover in September 1981 at the European Machine Tool Exhibition - the 4th EMO (Exposition Machine Outil).

Excluding special purpose machines there were 83 manufacturers exhibiting standard machining centres. These manufacturers represented the following 17 countries:

Denmark	Poland
France	Spain
E. Germany	Sweden
W. Germany	Switzerland
Holland	Taiwan
Hungary	U.K.
Italy	U.S.A.
Japan	U.S.S.R. (one machine only)
S. Korea	

Although 4th EMO was the largest machine tool show ever staged, it was largely aimed at the European market and consequently, although this sample is large, it is not comprehensive, since it excludes many Japanese and U.S. builders.

The Japanese Machine Tool Guide 1981 - 82 lists 40 builders of machining centres. One other manufacturer (Wado) is known to be exuded from this list making a total of 41. At 4th EMO there were 22 Japanese makes exhibited leaving a further 19 builders who were not represented.

In addition, there were five U.K. builders without machines at the show and if these rates of non-attendance were reflected in all non-Germanic countries worldwide, it is a reasonable estimate that there were in 1981, some 150 manufacturers of standard machining centres throughout the western world.

An increasing number of manufacturers are being attracted into the market, resulting in a rapid increase in this number. Taking the U.K. market as an example, the number of active competitors (i.e. those actually installing machines) has increased from 38 in 1980 to 67 in 1982 (an increase of 76%), and many of these competitors now serve more than one of the market segments.

6.10 DEVELOPMENT OF MACHINE SPECIFICATION (IDEA GENERATION)

There were three aspects to the idea generation process and selecting most suitable machine specifications:

Firstly, it was necessary to consolidate the company's current market position and be able to offer the higher technology machines to satisfy the requirements of existing customers.

Secondly, the total market requirements had to be investigated to identify optimum specifications to satisfy a majority of current and future metalworking requirements.

Thirdly, as the market was rapidly becoming established and many machines were already available, a certain element of opportunism was required to identify and exploit market niches into which new products could most easily gain a foothold.

The following sections describe how outline machine specifications were developed within this framework.

6.11 REQUIREMENTS OF EXISTING CUSTOMERS (CUSTOMER RESEARCH)

The requirements of the company's existing customers were identified using the "Surveillance of Internal Factors" technique. Three principle sources were used (see Appendix D).

1. The existing customer record file which is on computer and can be sorted by Kompass code, geographical location, number of employees, machines bought etc. This file contains nearly 30,000 records.

2. A "guarantee registration" card which supplies information such as reason for purchase and proposed use in addition to number of employees etc. Approximately one third of all machine despatches are covered by these completed cards.

3. Verbal and anecdotal evidence from within the company.

From these sources, it was found that there were two distinct markets which were being served by the product range with only a very small amount of overlap.

6.11.1 TURRET MILL USERS

Turret mills were being sold to small companies (78% to companies with less than 50 employees) for use in toolmaking or toolroom/maintenance applications (71% of users bought machines for this use).

The machines were only used in a very limited way for production (30% of users).

Two sizes of machine were offered, a smaller No. 1 size and a larger No. 2 size. There was an overwhelming preference for the No. 1 size with a sales ratio of almost thirteen to one.

Some further evidence of the technological change in this market was available by examining the CNC machines which offer similar power capacity and configuration. This showed a much higher proportion of machines in production use (56%) and a correspondingly lower proportion in toolrooms (19%). This was not entirely surprising and shows that production shops are early in implementing the higher productivity machines.

6.11.2 2S AND HORIZONTAL USERS

These machines were being sold to considerably larger companies (74% of all sales going to companies with over 100 employees).

The machines were also being used more in a production capacity. It has been estimated that 80% of all 2S machines are used in this way. This is illustrated by the non-governmental users profile in which the major customers were industries whose products include a large proportion of milled components. (65% of machines sold to Machinery and Metal Products Manufacturers).

It was also found that the sales ratio between No. 1 and No. 2 sizes was much closer to unity, resulting in a value ratio in favour of No. 2 size machines of nearly three to one.

6.11.3 MACHINE TYPES

It was therefore clear from these considerations that the existing requirements of the company's customers could only be satisfied with different machines.

Turret mill users would require a machine where the emphasis was on low cost combined with versatility. This would suggest a No. 1 size machine with the options of a large number of tools and multi axis operation. A high level part programming language would be required, and the programme must be capable of being entered at the machine.

The market which had been supplied by the 2S and horizontal type machines would demand a machine where the emphasis was on high productivity. This would suggest a horizontal spindle machine with auto-pallet change and swarf removal conveyor. The machine would be of No. 2 size to satisfy this type of customer and to make the high productivity options more cost effective.

6.12 INDUSTRIAL MACHINING REQUIREMENTS (WORKPIECE STATISTICS)

A convenient way of generating machine tool specifications is to look at the assembled knowledge of industrial workpiece statistics (ref. Optiz 1964, DDR Standard 1964, PERA 1969). In this work, the results of the PERA survey were used as being the most relevant and up-to-date, and the following guides to specification were obtained. (This method of generating ideas was described as "Surveillance of Other Sources" in Section 2.4.4).

6.12.1 MACHINE SIZE

The PERA figures were rearranged so that Figure 6.5 could be drawn. This figure is used to determine the proportion of all workpieces contained within a geometric envelope. The figure shows how relatively more components can be machined with cube and half cube configurations. It is also possible to see how many more workpieces can be accommodated on a larger machine. This is important since machine size and cost increases approximately to the third power of cube size.

For example, a No. 1 size machine with cube size 10 - 14 inches will accommodate 50% of all industrial workpieces, while the very much larger No. 2 size machine with cube size 16 - 20 inches only adds a further 13% to accommodate around 63% of all industrial components.

6.12.2 HORIZONTAL OR VERTICAL

Workpiece statistics can also provide some assistance in determining spindle orientation. This is because a vertical machine is of most use in machining the largest (top) face of a component as it is clamped onto the table. A horizontal spindle machine is more appropriate for machining the side faces of box-like components and when fitted with a rotary table (which is common practice) a horizontal machine can work on all four sides and also perform some operations on angled surfaces. Some work can also be performed on the top surface giving the machine the capability of multi-face work without resetting the component.

Figure 6.6 shows that the machining requirements are distributed fairly evenly over all faces of components and additionally, that 30% of all components are machined on at least one angled face. This indicates that where high productivity is important, a horizontal spindle machine would offer considerable benefits.

FIGURE 6.5

PROPORTION OF MACHINED WORKPIECES

CONTAINED WITHIN ENVELOPE

(Based on PERA Workpiece Statistics Data)

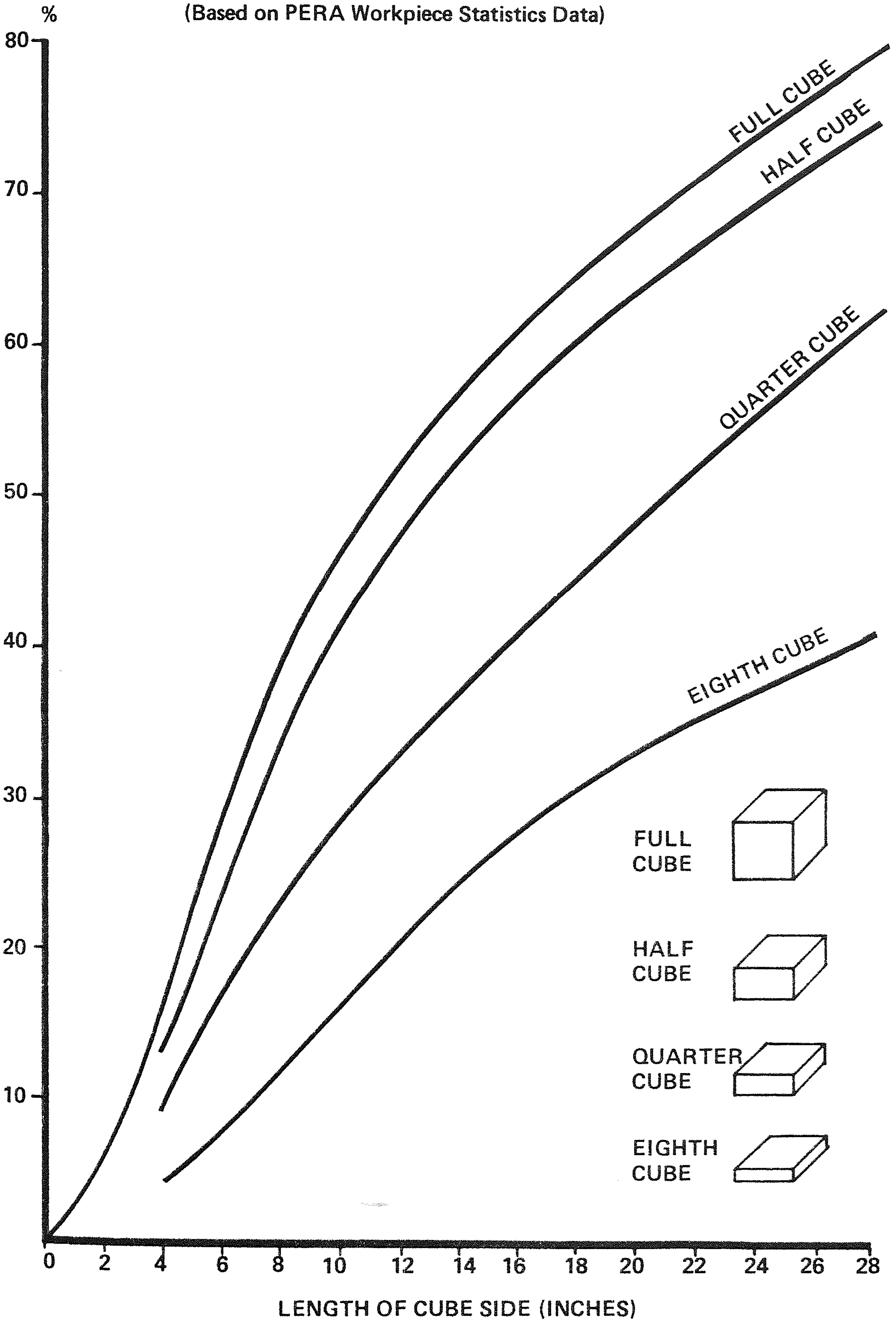
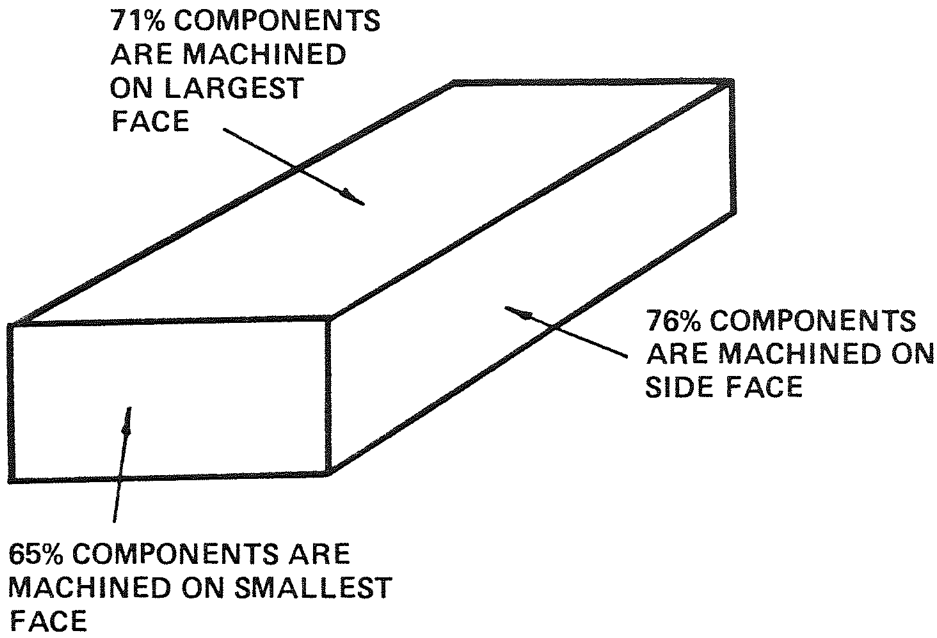
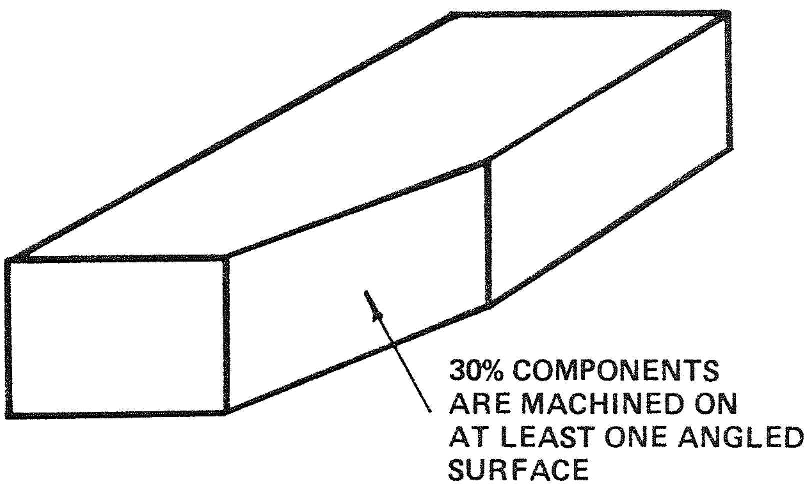


FIGURE 6.6

AVERAGE MACHINING ORIENTATIONS

(Source PERA Workpiece Statistics Data)





72% COMPONENTS ARE MACHINED ON 2 OR MORE FACES

6.12.3 THE AUTO TOOLCHANGER

Any machining centre must have drilling functions because there is 50% more drilling than milling performed on a component. The statistics also show that 95% of all workpieces can be fully drilled with no more than 16 tools.

Equivalent figures are not available for milling, but extrapolation would suggest that a thirty tool autochanger would be more than adequate to cover the largest proportion of machined work.

The maximum width of a milled surface on a 16 inch cube rarely exceeds 8 inches and so this suggests a maximum cutter diameter of 8 inches. Although this is physically possible on a 40 inch diameter carousel with 30 tools, this maximum cutter diameter is about twice that of existing machines and so the new machine would not lack competitiveness if this diameter was reduced.

6.12.4 MACHINE ACCURACY

90% of all work requires milled surfaces having an accuracy not better than 0.002 inch total, and so the positional accuracy must be better than 0.001 inches. The forecast increases in workpiece accuracies will be discussed in Chapter 7.

6.13 MARKET OPPORTUNITIES

From a knowledge of the range of competition it is possible to identify certain areas of the market which are not satisfied by existing products and provide opportunities. The wide and increasing range of competition offers machines which satisfy almost every specification, but two major market holes were discovered in 1980 and are still open in 1982.

These holes are each positioned at the bottom end of the ranges of horizontal and vertical spindle machines. In the case of the horizontal machine it was found that there was no machine offered under £60,000. In addition it was determined that there was no machine, horizontal or vertical, with auto-pallet change and selling below this price. (This hole has subsequently opened to £70,000, thereby increasing this opportunity).

The opportunity for the vertical configuration was for a low cost machine below £35,000.

As there had been a continous decrease in the relative price of these machines in recent years, it was probable that new machines, taking advantage of up-to-date technology and programmed for volume production, could be priced along the experience curve and achieve a considerable competitive advantage in these areas.

Such machines would be consistent with the company's policy of offering value-for-money achieved by high production volumes.

6.13.1 PRICE/VOLUME ENVELOPES

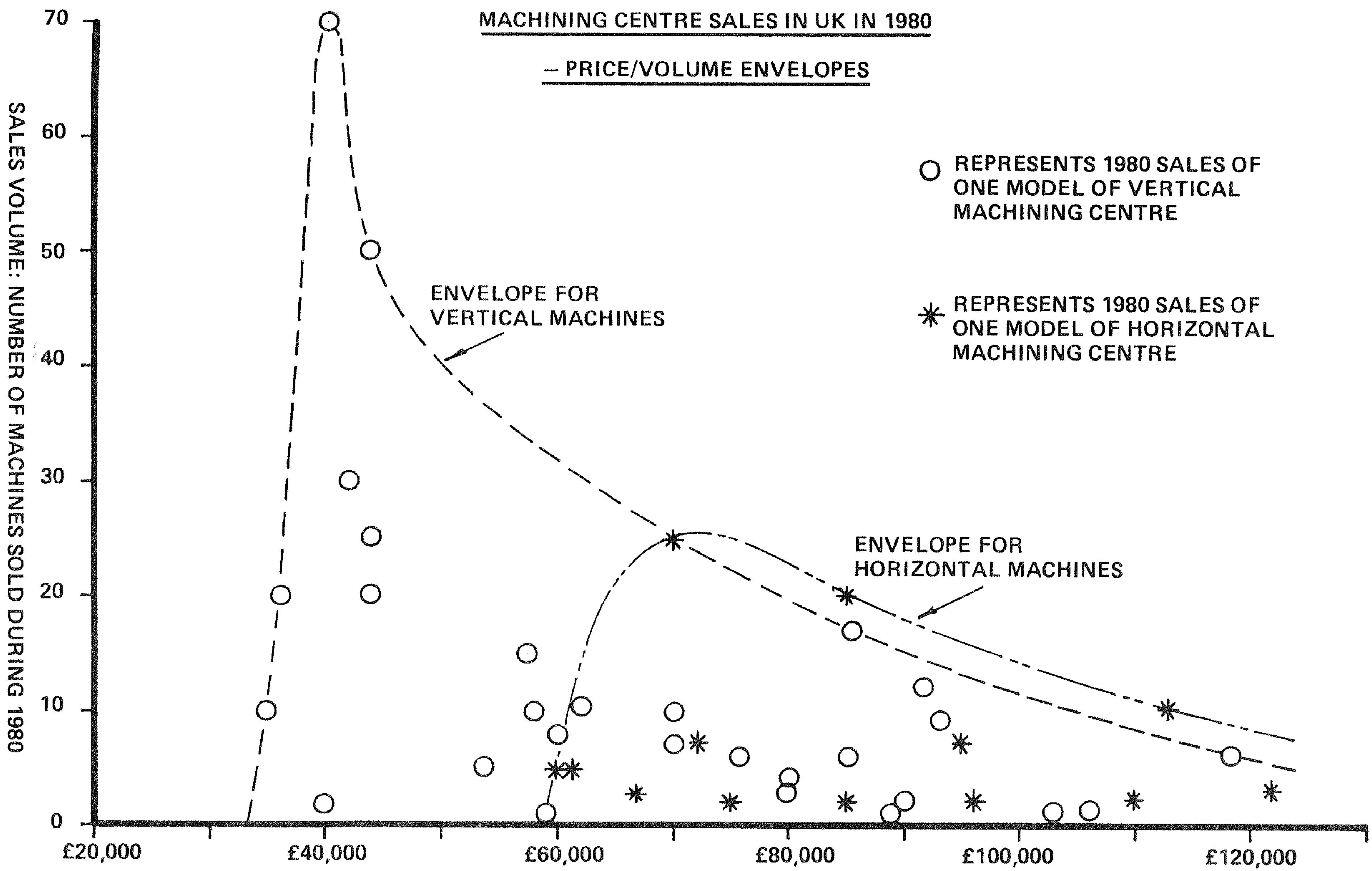
Past experience had taught the company that the smaller the machine, and hence the lower the price, then the greater the sales volume. It was necessary to determine if such a rule was true for machining centres so that high volumes were possible in order that advantage could be taken of the above opportunities.

Figure 6.7 shows that such a relationship does apply for vertical machines and there is no evidence to suggest that it would not apply to horizontals if the smaller/cheaper machines were made available. It can be seen from this graph that the major difference in sales volume between horizontals and verticals lies in the under £60,000 machines. This observation provides further incentive to enter this market hole.

FIGURE 6.7

MACHINING CENTRE SALES IN UK IN 1980

– PRICE/VOLUME ENVELOPES



6.14 PUBLISHED RESEARCH

The majority of marketing research which is performed is confidential and consequently remains unpublished. Certain organisations produce multi-client reports for the machine tool industry, but these usually suffer the drawback of being too general and sometimes inaccurate. In addition, they are usually fairly expensive, and for these reasons have not been used (for example, ref. Yano (1982) - £270, Larsen Sweeney (1980) - £795, Planning Research Systems (1981) - £900, Marketing Strategies International (1982) - £725, Frost and Sullivan (1979) - $875, (1980) - $975, (1981) - $1250, (1982) - $1150).

There are, however, two studies which have proved to be useful:

6.14.1 UNIVERSITY OF BIRMINGHAM/ALFRED HERBERT

A limited survey performed by Kelvin Warne in 1978 (ref. Grayson & Warne 1979) was particularly appropriate since it investigated the machine tool requirements of small engineering firms. The survey showed that the demand for milling machines from this sector was second only to that for lathes and that demand for N.C. milling machines was approximately 66% of the number of manual machines. There was also some evidence that demand patterns were geographically regional.

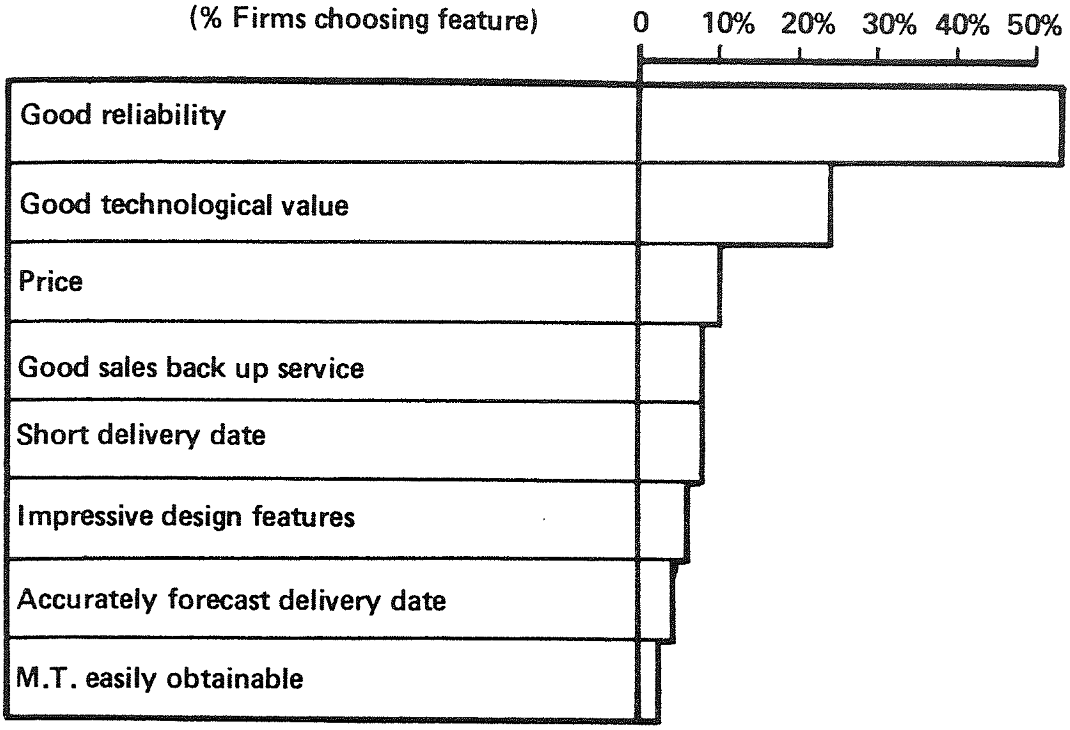
The survey provided some very useful additions to the specification generation and showed the importance of reliability, technological value, price and after sales back up service (see Figure 6.8).

An indication of the relative importance of advertising media was also given and the results of this are shown in Figure 6.9.

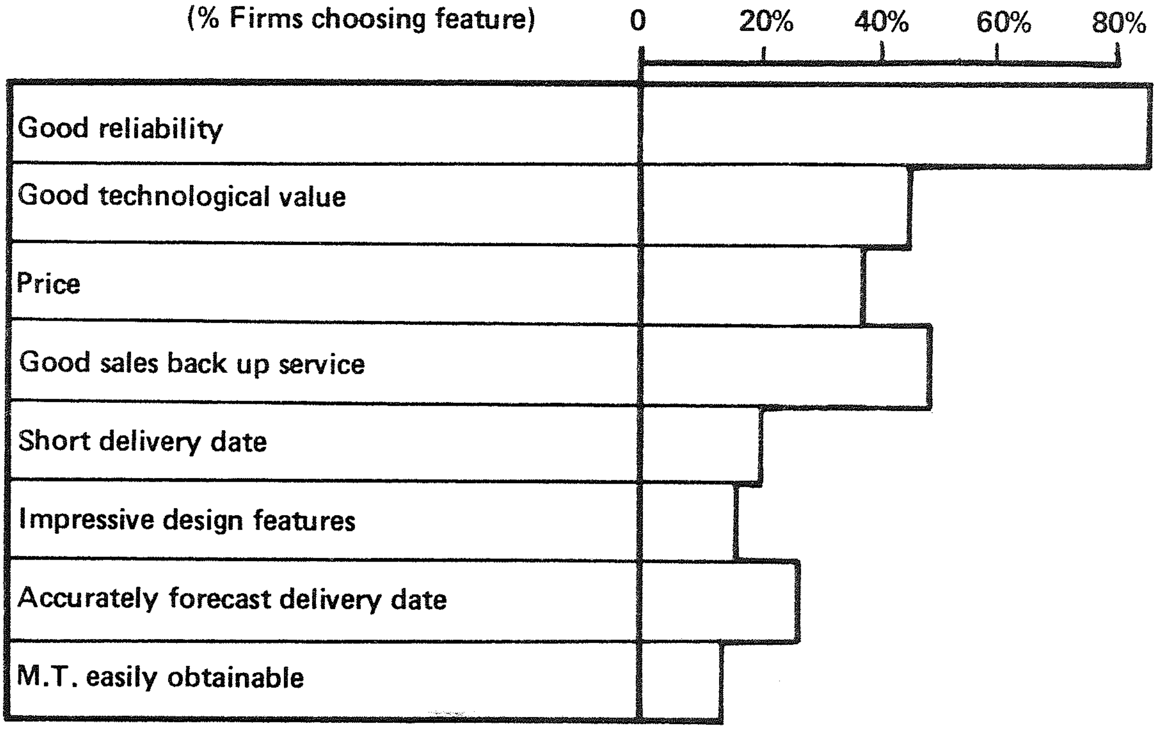
FIGURE 6.8

FEATURES OF MACHINE TOOLS CONSIDERED IMPORTANT

(Source Grayson & Warne (1979))



6.8A FEATURES OF A MACHINE TOOL CONSIDERED MOST IMPORTANT

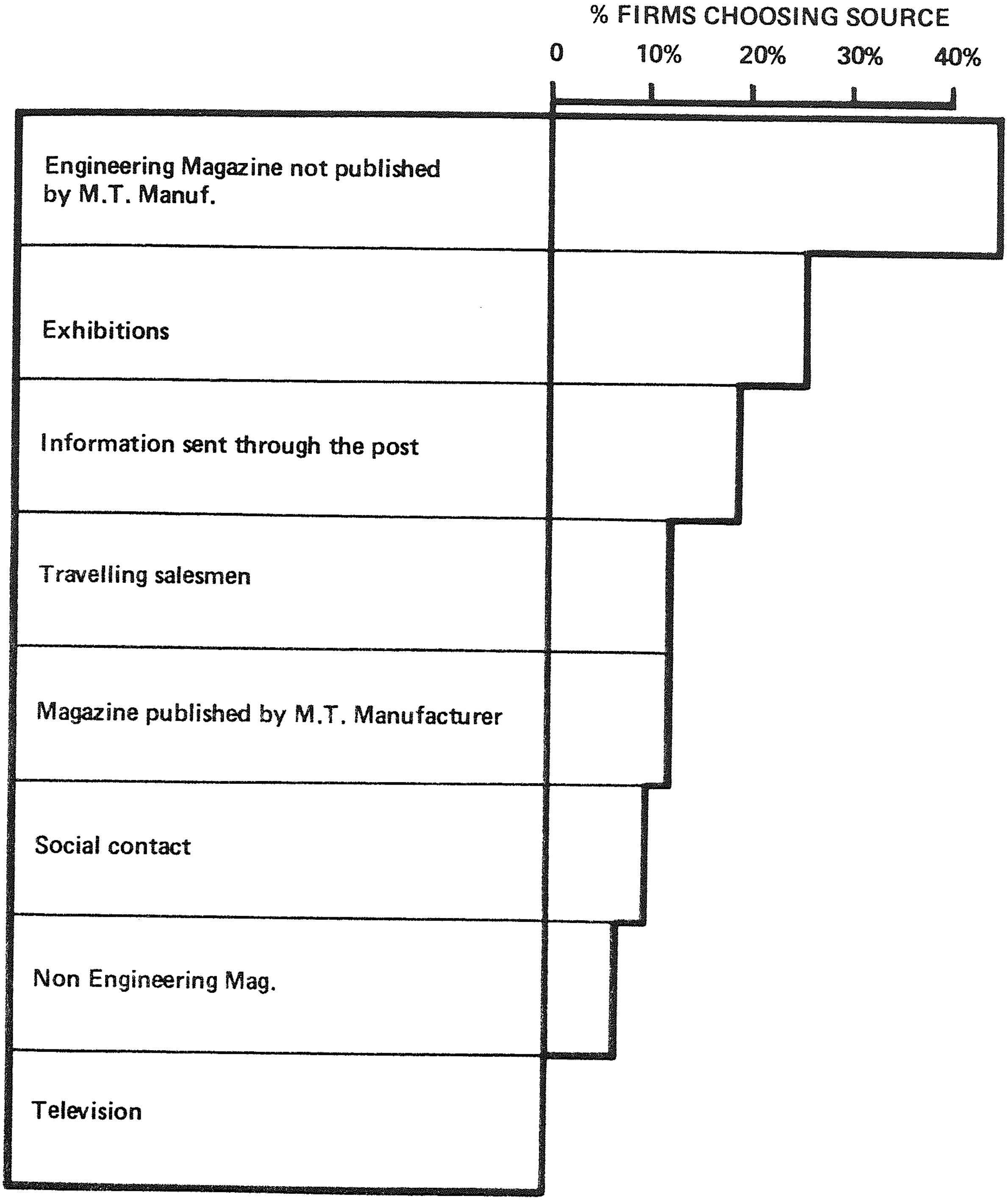


6.8B FEATURES OF A MACHINE TOOL CONSIDERED ONE OF THE THREE MOST IMPORTANT

FIGURE 6.9

SOURCES OF MACHINE TOOL INFORMATION

(Source Grayson & Warne (1969))



SOURCES OF INFORMATION ABOUT MACHINE TOOLS

CONSIDERED MOST USEFUL

6.14.2 N.E.D.O. REPORT

In 1980, the Machine Tools Economic Development Committee commissioned a report on machining centres. This report was prepared and issued by the National Economic Development Office (NEDO). The nine page report was unpublished and was based on an analysis of published information plus discussions within the U.K. machine tool industry.

The following summarises the principle conclusions which were drawn:

1. Machining centres are a fast growing albeit relatively small segment of U.K. demand for machine tools. This growth is likely to accelerate.

2. U.K. production is expanding but value of current production amounts at most to only 6% of the combined force of U.S.A., West Germany and Japan.

3. Import penetration is above average and export performance below norm to an extent that the U.K. is running a growing trade deficit in machining centres.

4. The Japanese are the most visibly thrustful and expansive and have now pushed well ahead in terms of share of U.K. import business.

5. The statistical evidence to date suggests that the U.K. runs the risk of becoming a disproportionately small producer in this very important sector and growing part of the business.

6. The facts presented point to the need for:

a. A move by two or three U.K. producers into high volume production of machining centres.

b. Maintenance of a major development effort at the advanced technology end of the product spectrum especially in relation to flexible machining systems.

6.15 SUMMARY OF RESULTS

1. MARKET SIZE

Free world production of machining centres (1980) was approximately 10,000 units worth £700m.

2. MARKET GROWTH

30% p.a. during 1970's representing a 260% increase over and above the increase in world machine tool production.

3. MARKET SHARE

Japan is clearly ahead with over 50% of free world share in 1980. This share has been increasing.

4. U.K. MARKET

In 1980 the U.K. market was 574 machines worth £42.5m.

5. SEGMENTATION

World production by segments has been estimated as (1980):

a. Vertical Knee and Column under 10 h.p. ....1000 units

b. Vertical Bed Type under 10 h.p. .... 3500 units

c. Horizontal Bed Type under 10 h.p. ....2500 units

d. Vertical Machine over 10 h.p. .... 1500 units

e. Horizontal Machine over 10 h.p. .... 1500 units

6. HORIZONTAL/VERTICAL MIX

This has been estimated at 38.1% horizontal and 61.9% vertical by volume.

7. COMPETITION

Estimated to be 150 competitors worldwide. Rate of growth of number of competitors in the U.K. has been 76% in two years.

8. EXISTING CUSTOMERS REQUIREMENTS

Indicate two machine types. A versatile No. 1 size machine is required for toolroom use, and a high productivity No. 2 size horizontal spindle machine is required for production shops.

9. INDUSTRIAL MACHINING REQUIREMENTS

Can illustrate the cost-benefit relationship of machine tool capacity, and can provide specification guides.

10. HORIZONTAL SPINDLE

These machines have certain potential benefits for a large proportion of workpieces.

11. AUTO TOOLCHANGER

The Autochanger has an optimum minimum of 30 tools with maximum tool diameter of 8 inches.

12. POSITIONAL ACCURACY

To be better than 0.001 inches (1969 data).

13. MARKET OPPORTUNITIES

These were identified for the following:

a. Horizontal machining centre under £60,000.

b. Any auto pallet change machine under £60,000.

c. Vertical (knee and column) machine under £35,000.

14. PRICE/VOLUME RELATIONSHIP

This showed that the lower the price (and the smaller the machine) then the higher is the potential sales volume.

15. RELIABILITY

Reliability of machine has been shown to be given No. 1 priority in a customer survey, followed by technological value and price.

16. ADVERTISING

This has been shown to be most effective in trade magazines, followed by exhibitions and direct mail.

17. RECOMMENDATIONS

Recommendations have been made by an independent authority for U.K. manufacturers to move into high volume machining centre production.

CHAPTER 7

FORECASTING

7.1 INTRODUCTION

This chapter describes the techniques and results of all the relevant forecasting which was conducted. The forecasts are classified under five main headings:

a. Technological Substitution

b. Technological Forecasting

c. Economic Forecasting

d. Sales Forecasting

e. Other Forecasts

7.2 TECHNOLOGICAL SUBSTITUTION

As explained in Chapter 2, technological substitution is said to occur when a new technical product or process replaces an existing one. Of interest in this work is the replacement of conventional manual machines with numerically controlled types.

Numerical Control was developed in the late 1940's/early 1950's (ref. Buzzel et al 1969) and expectations for its rapid growth were high. By the early 1960's there were already signs of disappointment (op cit) and in 1963 a U.S. Department of Commerce Report (ref. U.S. Dept. Comm. 1963) concluded that demand for numerical control had not grown as quickly as anticipated.

During the late 1960's forecasts for the growth of numerical control were still being over optimistic and at that time "it was being estimated by some observers that 1970's shipments of numerically control machine tools will reach 50% of the value of all machine tools shipped by the U.S. Machine Tool Industry" (ref. Merchant 1969 p. 574).

At the same time, in the U.K., stockbrokers Savory Millne were optimistically forecasting the 50% value substitution point would be reached in 1975 (ref. Savory, Millne & Co. 1970).

It was against this background of consistent historic unfulfillment of optimistic growth expectations of numerical control, that accurate forecasts were sought for the purposes of this project.

It was therefore not surprising that when optimistic growth forecasts were produced at the beginning of this project they were greeted with a certain degree of scepticism. It was not until the passage of time had confirmed some of the predictions, that the forecasting method gained some credibility and could be extended to other applications. The forecasting method used was the Fisher-Pry model for technological substitution.

7.2.1 FISHER-PRY SUBSTITUTION MODEL

This technique was described in Section 2.4.7. The mathematical expression for the 'S' shaped substitution curve is given by Fisher & Pry by the equation:

$$\frac{f}{(1 - f)} = \exp 2a\,(t - t_o)$$

where f = fraction substituted

a = half annual fractional growth in early years

t = time

t_o = the time at which $f = ½$

Thus, by plotting $f/(1 - f)$ as a function of time on semi-log paper, the closest fit straight line can be extrapolated to determine the continuation of the substitution process.

A useful reduction of the expression $f/(1 - f)$ is NEW/OLD, or in this case; numerical control divided by conventional non N.C.

7.2.2 WORLD DEMAND FOR NUMERICAL CONTROL

As was the case with market size estimations (Section 6.2), historical data is not available for all countries worldwide. Using the same sources as in 6.2, it was possible to determine the total production and N.C. production values for U.S.A., U.K., West Germany, France and Japan.

Assuming that there is no radical shift in the proportion of world production contributed by these countries, this data can be used for the Fisher-Pry substitution analysis.

The data is shown in Figure 7.1 and $\frac{f}{(1 - f)}$ is plotted against years in Figure 7.2.

Figure 7.3 shows the forecast rate of substitution expressed as a percentage of total value substituted. This forecast shows that in 1988/9, 50% of the free world value output of machine tools will be numerically controlled.

A second, and more important result which can be seen from this analysis is that the most rapid rate of growth of N.C. will occur during the next 10 - 15 years, when the substitution level increases from 30% to 70% and the slope of the 'S' curve is at its steepest.

7.2.3 U.K. DEMAND FOR NUMERICAL CONTROL

The data and substitution graph are shown in Figures 7.4 and 7.5 respectively for the U.K. market. This forecast shows that the 50% substitution point will be reached by 1986/7 which is a little earlier than the world average forecast in the previous section.

This result is consistent with the evidence given in the 4th Survey of Machine Tools (ref. Mwkg Prod 1979) which showed that the proportion of N.C. machines in the U.K. was the second highest after Japan.

FIGURE 7.1 DATA FOR WORLD N.C. DEMAND FORECAST

(All Values In U.S. $ Millions)

YEAR	PRODUCTION VALUE N.C. MACHINE TOOLS						TOTAL MACHINE TOOL PRODUCTION OF 6 COUNTRIES	$\frac{f}{(I - f)}$	N.C. EXPRESSED AS % TOTAL
	FRANCE	U.S.A.	JAPAN	W. GERMANY	U.K.	TOTAL			
1971	25.0	153.2	104.8	205.2	39.3	528	4726	0.126	11.1%
1972	27.8	170.1	103.0	183.5	24.2	508	5200	0.108	9.8%
1973	42.7	272.1	198.0	221.6	28.6	763	6698	0.128	11.4%
1974	51.0	378.7	243.6	268.6	34.4	976	7340	0.153	13.3%
1975	75.5	504.7	166.0	314.2	50.9	1111	79112	0.163	14.0%
1976	80.4	501.0	213.7	421.5	58.0	1275	7765	0.196	16.4%
1977	97.6	496.7	335.6	533.4	71.8	1535	8773	0.212	17.5%
1978	163.3	649.2	448.5	658.9	114.6	2034	11071	0.225	18.4%
1979	200 (E)	932.1	856.1	750.7	141.0	2880	13296	0.276	21.7%
1980	260 (E)	1256.5	1413.9	1092.9	183.9	4206	15380	0.376	27.3%

Note: (E) = Estimate

FIGURE 7.2

EXTRAPOLATION GRAPH FOR FORECASTING WORLD SUBSTITUTION OF N.C. FOR MANUAL

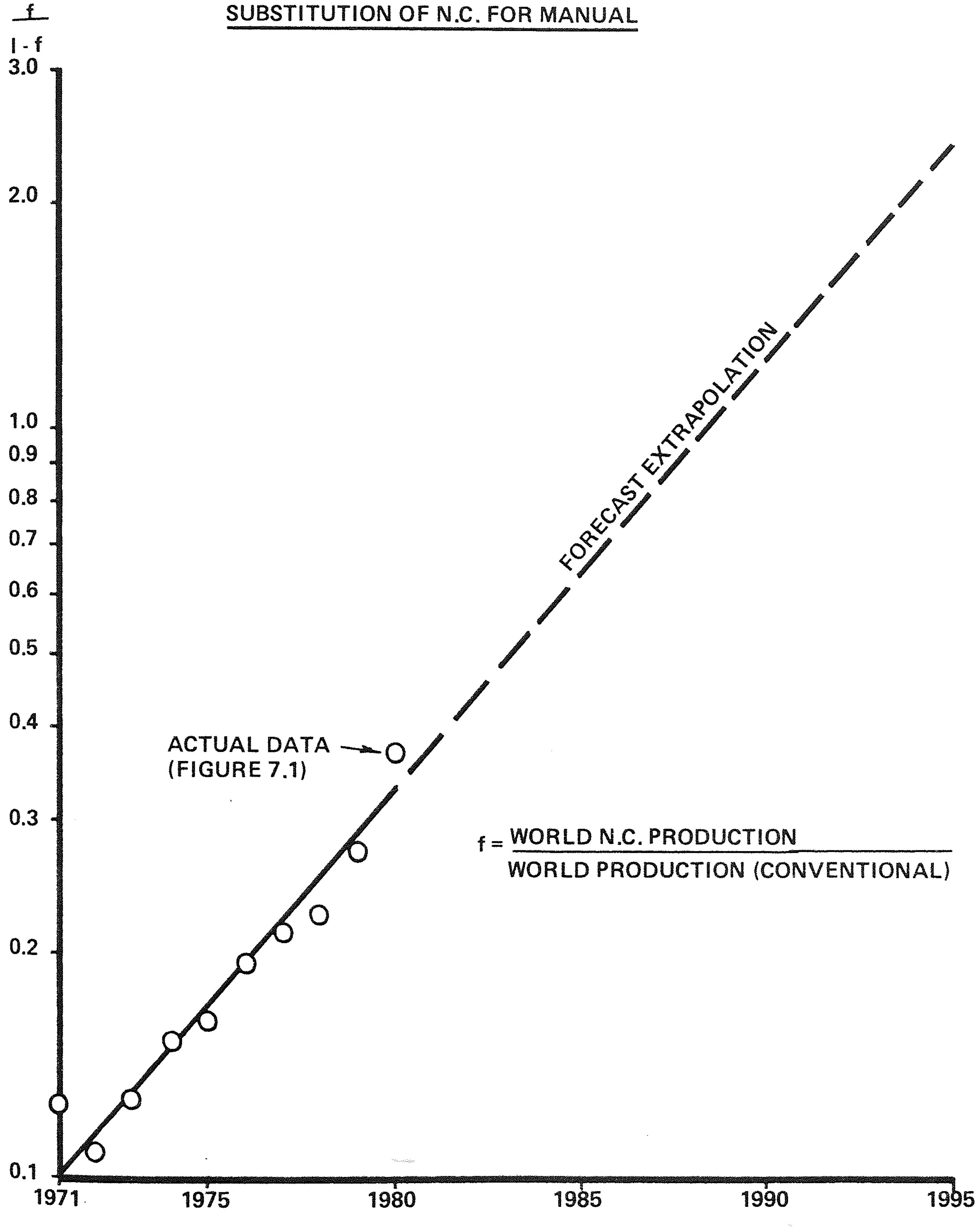


FIGURE 7.3

RATE OF SUBSTITUTION OF N.C. FOR MANUAL

(Based on Value Data From USA, W. Germany, Japan, UK and France)

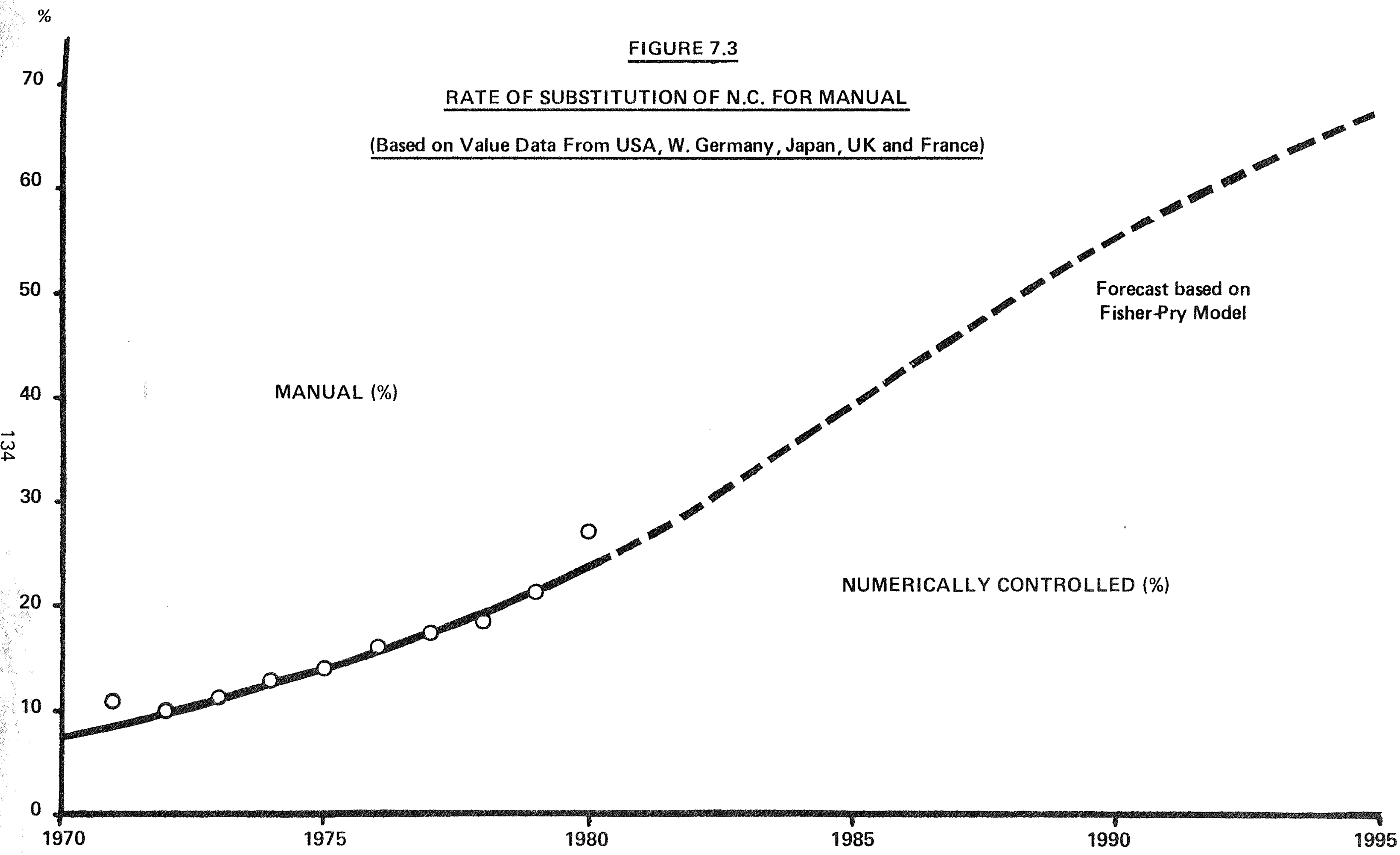


FIGURE 7.4 DATA FOR U.K. N.C. DEMAND FORECAST

(All Data In Units of £1000)

YEAR	IMPORTS OF N.C.	PRODUCTION OF N.C.	EXPORTS OF N.C.	CONSUMPTION OF N.C.	TOTAL U.K. MACHINE TOOL CONSUMPTION	$\frac{f}{(l - f)}$	N.C. AS % TOTAL
1974	15184	16010	6486	24720	247779	.111	10.0%
1975	22434	23730	9405	36720	280762	.150	13.1%
1976	33271	26980	9744	50540	322680	.185	15.7%
1977	26200	33400	9935	49670	367359	.156	13.5%
1978	43888	53320	15149	82070	499927	.196	16.4%
1979	73540	65170	17211	121500	630374	.239	19.3%
1980	96300	85540	23519	158320	590512	.366	26.8%

(Sources: IMPORTS FROM C & E DATA WITH N.C. FORMING (1974 - 1977) ESTIMATED

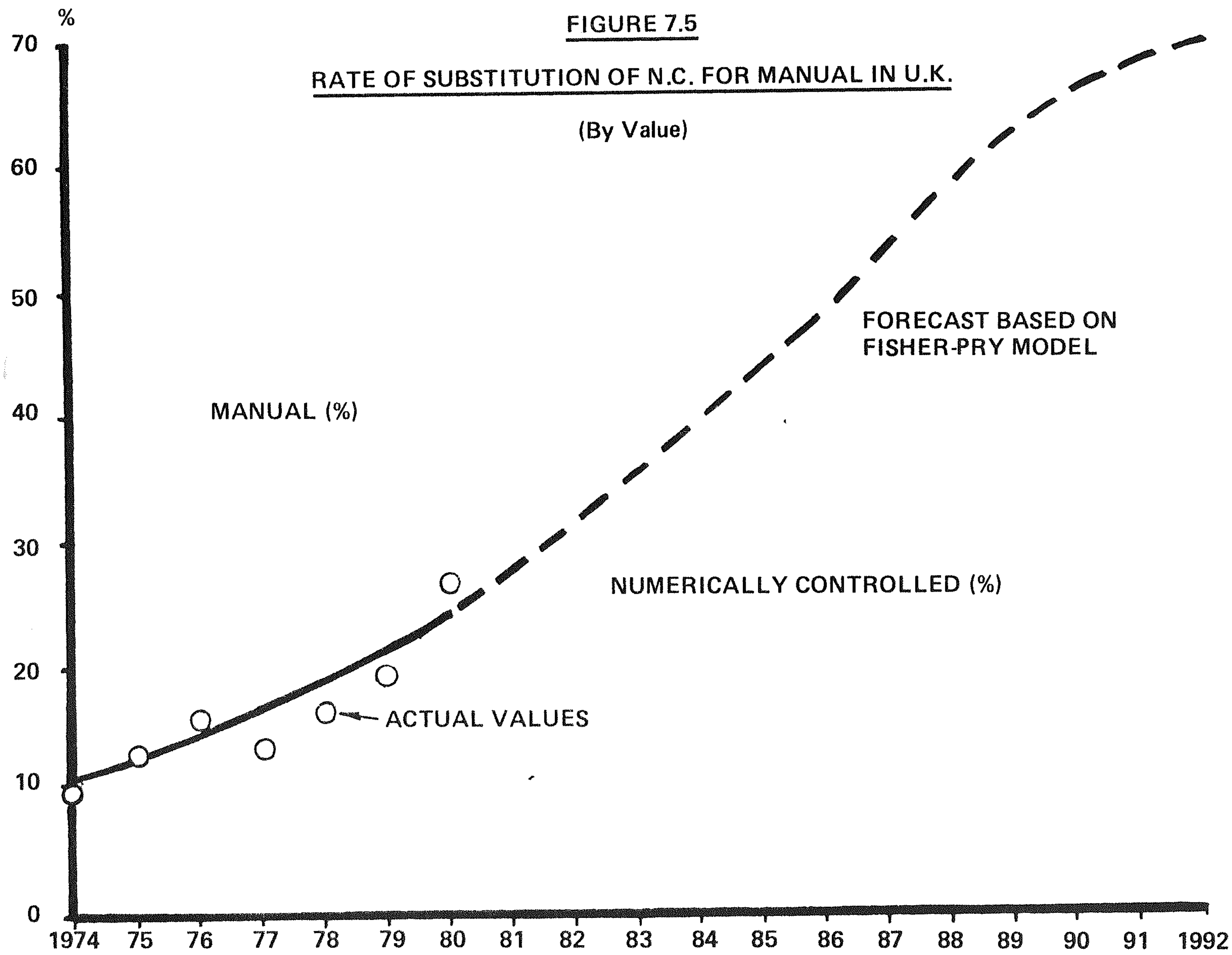
PRODUCTION TABLE 1 BUSINESS MONITOR PQ 332 HMSO

EXPORTS TABLE 1 BUSINESS MONITOR PQ 332 HMSO)

FIGURE 7.5

RATE OF SUBSTITUTION OF N.C. FOR MANUAL IN U.K.

(By Value)



The data which is used in Figure 7.4 suffers from a re-classification of the Customs and Excise (C + E) figures in 1978 when "Numerically Controlled" was replaced with "A.C.I. - Automated by Coded Information". In the same year an N.C. grinding section was lost and an A.C.I. Physico Chem section was created.

These breaks in the series renders this analysis of less value than the world analysis performed in the previous section, and underlines the difficulties of data collection even in the domestic market where statistics are more clearly understood and most experience has been accumulated.

7.2.4 VOLUME SUBSTITUTION

In the foregoing analyses, the data which has been used is expressed in money terms and the percent figures relate to the proportion of total spend. Analyses in volume terms, although highly desirable, have not been performed for a number of reasons. Firstly, volume figures are simply not available for many countries, and where they are available, problems with classification render them almost totally incompatible.

If it was possible to ascertain volume figures, there would be a second 'S' curve for volume of sales. Since the value of an N.C. machine is greater than that of a conventional machine, this second curve would lag behind the value curve already generated. If each N.C. machine was twice as expensive as its manual counterpart, then this lag would be around 5 years.

There is evidence to show that these two curves are gradually becoming closer together. A survey performed by MITI in Japan (ref. Ozaki 1980) showed that the price per ton of N.C. machines fell by 20% between 1970 and 1978, while the price per ton of non N.C. machines increased by 27% in the same period. Expressed in a different way, one ton of N.C. machine in 1970 cost 3.4 times more than a ton of non N.C. machine, but by 1978 this ratio had fallen to 1.6 times.

Experience curve effects on N.C. production, combined with increased costs of producing lower volume, increasingly sophisticated non N.C. machines will result in a continuation of this trend.

It can therefore be forecast, in a general manner, that the lag between volume and value substitution curves will decrease with time resulting in a rate of volume substitution which will be greater than the value rates shown in Figures 7.3 and 7.5.

7.2.5 SECTORAL FORECASTS

It would be extremely valuable if the Fisher-Pry technique could be used to forecast the substitution by N.C. milling machines plus machining centres for conventional milling machines and such a forecast was attempted.

In order that a sectoral forecast of this type can be performed, it is necessary to allow for all the intra-N.C. substititional forces which are at play. These forces include the replacement of milling and drilling machines by N.C. lathes which are fitted with milling heads, while machining centres are substituting, to a greater or lesser extent, for milling, drilling, boring, planing and even sawing machines.

Consistent data offering such a high level of detail is not available worldwide, but in the U.K. the 1976 Metalworking Production 4th Survey of Machine Tools (ref. Mwkg Prod 1979) was available.

This data provided an estimate of the total U.K. population of machine tools by model, broken down by age into 0 - 5 years, 6 - 9 years, 10 - 20 years. From this information it was therefore possible to determine the average rate of installation of each machine type.

Using this data required estimations of all the partial substitutions and this proved difficult. For example, it had to be estimated what proportion of drilling machines would ultimately be replaced by machining centres and what proportion by N.C. drilling machines.

Variations in this estimate alone resulted in forecasting errors of plus or minus 3 years, and similar accumulative errors were incurred for plano-millers, borers etc. When the forecast was performed, estimates of these partial ultimate substitutions were made using collective experience and a 50% volume substitution point was identified as 1992.

The conclusion was reached that this figure provided a very useful guide to the substitution process of N.C. milling machines and machining centres, but that it could not be used quantitatively. In addition to this constraint, was the limitation of the data itself, being based on a 1976 survey. The next survey, originally planned for 1980 will now be performed and published in late 1982 or early 1983 at which time the assumption in this forecast can be tested and updated.

The closeness of this 50% point to that forecast for the volume of all U.K. N.C. substitution given in Section 7.2.4 provides some evidence to suggest that the rate of substitution of machining centres is in phase with the total N.C. substitution process and is not in advance of or lag behind the general trend.

7.2.6 COLLABORATIVE FORECASTS

Although it has been shown how general opinion has historically over optimistically forecast the growth of N.C., it is of value to examine the results of published forecasts in comparison with the forecasts developed in this work.

1. RESULTS OF 7.2.2

World N.C. will be 50% by value in 1988/9.

2. RESULTS OF 7.2.3

U.K. N.C. will be 50% by value in 1986/87.

3. SME – UNIVERSITY MICHIGAN

U.S.A. N.C. will be 50% by value in 1986 (with an inter-quartile range of 1985 - 1990) (ref. Smith 1979).

This forecast used Delphi-type techniques.

4. SME – UNIVERSITY MICHIGAN

U.S.A. N.C. will be 50% by volume in 1995 (with an inter-quartile range of 1990 - 2000) (op cit).

5. HENLEY CENTRE FOR FORECASTING

U.K. N.C. will be 50% by value in 1986 (ref. Henley 1981).

This forecast was based upon a highly sophisticated computer assisted regression analysis econometric model.

This shows a very close agreement between forecasts using radically different techniques. Of particular interest is the close agreement between the econometric modelling technique of Henley and the Fisher-Pry method which has been used here.

It is also worth noting that the Delphi collective opinion forecast of the University of Michigan is also in close agreement with the mathematical techniques and yet this forecast was produced in 1978, some three years before the others.

7.3 TECHNOLOGICAL FORECASTING

The continuous improvement and changes in manufacturing systems and processes is of considerable interest to the machine tool manufacturer, since it is important to predict the future demands of manufacturing industry before proposing any new machine tool.

No formal original work was performed in this area, largely because of the wealth of published information from around the world. This information included the comprehensive five volume report by the Machine Tool Task Force which was published in 1980. This report (summary ref. Ashburn et al 1980) took thirty months to complete and involved almost 150 individual contributors. It reports upon current technology, future trends and directions for further research and development, and provides a qualitative review of future trends.

Further quantitative forecasts have been obtained from Delphi-type surveys which were performed by the Institution of Production Engineers in the U.K. (ref. I Prod E 1980) and by the Society of Manufacturing Engineers/University of Michigan in the U.S.A. (ref. Smith 1979). The older Delphi forecasts performed by CIRP (International Institution for Production Engineering Research) were also of value as most industrialised countries contributed to these forecasts (ref. Merchant 1971, 1975 and 1976).

Expert opinion was also sought and was collected from both verbal and written sources (for example ref. Hollingum 1980, Tamayo 1979).

A final source of forecast information which was of interest was the work performed by Merchant for Cincinnati Milacron during the 1960's. These forecasts were very long range and some of the general findings are still of use today (ref. Merchant 1969 and 1973, Cetron and Ralph 1971).

These various sources have provided a wealth of information which is being utilised by the Research, Design and Development department to provide guidelines and assistance in making decisions regarding specific design details. The more general trends which are of interest in this work are summarised in the following sections.

7.3.1 PRODUCTIVITY

It is generally agreed by all sources that machine tool productivity will increase and that machining time per part will continue to decrease.

The growth of N.C. which we have already examined will be partly contributory to these improvements, but productivity will also be improved from expected future improvements in metal cutting rates. SME predict that cutting speeds would reach 20 - 30 metres per second by 1985.

This higher performance is forecast to make demands on the machine tool for higher dynamic stiffness and more power. This combination will demand more rigid spindle and bearing assemblies.

In parallel with these developments will be improvements in adaptive control of machines. The major restriction in the implementation of these systems have historically been the availability of sensors but these are forecast to have become widely available by 1985 (SME). The I Prod E survey forecasts a 20% availability of adaptive control systems by 1990, while in the U.S. it is forecast that in process adaptive control of surface roughness will be widely used in 1988. Facilities for automatic sensing and replacement of broken or worn tools will be possible by 1984.

It is also generally agreed that machine tool down-time will be reduced by an increase in diagnostic systems. The SME forecast quantifies this application as 20% of machines having diagnostics in 1982 and 38% in 1987.

7.3.2 AUTOMATION

Without exception, all sources agree that the trend towards higher levels of automation will continue. The theoretical limit of these trends is the fully automatic computer controlled factory and Merchant clearly sees this as the ultimate goal, and achievable by the year 2000, while the SME forecast predicts that it will never happen, although it is now a near-reality in Japan.

Group technology is expected to be used for 10% of all machining by 1990 in the U.K. (I Prod E survey) while in the U.S. this point will be reached by 1987 (SME survey).

The number of FMS installations is confidently expected to increase and this will place demands on individual machine tools for increased automation as well as mechanical handling and part conveying, robots and computer systems (ref. Kellock 1981).

The SME forecasts suggested that in 1982, 12% of all equipment costs will go on auto handling and this will increase to 20% by 1987.

The demands for higher automation on individual machine tools will result in an increase in the use of dedicated parts loading robots and pallet change mechanisms to reduce loading and unloading time and to eliminate machine idle time during part setting. The use of automatic toolchangers will increase and tool change times are forecast to reduce.

The U.S. forecasts predicted that automatic fixturing, pallet shuttle systems and robots will be used on over 25% of stand alone N.C. machines by 1987. In the U.K., the forecast is for these systems to be fitted on 20% of all installed machines by 1990. Also between 10,000 and 15,000 programmable robots will be used in this country by 1990 (ref. Hollingum 1980).

Other aspects of machine tool design will need to reflect this trend towards higher automation and in particular automatic swarf clearance and removal will be more important in the future. The machine tool task force has forecast a continued growth in this area.

Improvements in machine controls are also forecast to contribute to increased productivity, and in particular CIRP and SME show considerable growth in remote (down-line) loading of part programmes and the use of control computers (60% and 25% use by 1987 respectively). The growing use of floppy disks is shown to supersede paper tapes in the I Prod E Survey and all sources predict software improvements on and off the machine, with an increasing use of computer simulations and interactive controls.

7.3.3 FLEXIBILITY

Increased flexibility of production is generally regarded by all sources as being of increasing importance. The argument is that as product life cycles reduce, then an increasing majority of a company's metalworking facilities will last longer than any individual product run, and thus the more flexible the production equipment, the shorter and less expensive becomes the changeover to a new product line.

In addition to these PLC effects in the increasing variety of options which manufacturers are offering and this is resulting in a continuous reduction of batch sizes, as shown by the Task Force, Merchant and others (for example ref. Otto 1981).

It has been reported that the Toyota Motor Co. Ltd in Japan has decided to introduce full scale N.C. production to provide 20% parts machining capability (ref. Metalworking 1982). The reason behind this decision is the necessity for the company to switchover to small-lot large-variety production and N.C. offers the flexibility for this type of production.

The effect that these factors will have on machine tool design is twofold. Firstly, there will be an increasing demand for versatile machines with powerful controls so that a wide variety of workpieces can be accommodated, and secondly, the growth of flexible machining systems is reinforced, even into areas, like the car industry which have traditionally used special purpose custom built production flow lines.

7.3.4 QUALITY

All the published forecasts agree that quality of the workpiece and/or machine tool will improve with time. The SME predict a 25% improvement by 1987. The machine tool Task Force produced a complete volume on the subject with over fifty key recommendations for achieving the increases in workpiece accuracy which will be required.

Automatic workpiece sizing is discussed by Hollingham and in the U.K. 10% of all manufacturing industry in the U.K. is forecast to have a considerable amount of on-line automatic inspection and a corresponding diminishing of post manufacture inspection.

The SME survey in the U.S. forecasts that 24% of all machines will be fitted with in process gauging by 1987, also that non contact in process gauging will be widely used by 1989. The consequence of these improvements will be a reduction of scrap in 1987 by 30%.

7.3.5 WORKPIECES

A general conclusion which can be drawn from all the forecasts is that there will be an increasing variety of workpiece materials. The Task Force highlights the increasing use of sophisticated materials and aluminium and plastics, and this is confirmed by the I Prod E Survey, Merchant and Hollingum. The Task Force also identifies the trend towards greater use of composite materials.

It is also suggested that the increasing costs of materials and energy will result in workpieces being pre-formed or cast into near finished shape.

The changes in workpiece materials have two effects on machine tool design which have been identified by the Task Force.

Firstly, the more sophisticated materials (for example Aerospace materials) will demand increasing machine tool power with consequential rigidity increases in bearings, spindle, motors and drives.

Secondly, the softer materials and the near finished workpieces will require increasing high machining speeds and spindle speeds and feeds will consequently increase with time.

7.3.6 PROCESSES

The potential growth of ultra high speed machining is discussed by the Task Force, Tamayo and Merchant. It is generally considered that this will be seen initially for machining aluminium.

The performance requirements of a machine tool for this process are high and feeds would have to be about twice those of a conventional machine and spindle power around four times as great. Spindle speeds would be required in the range 10,000 - 30,000 r.p.m.

The new competitive processes of high speed grinding, abrasive belt grinding and electrical machining are also of interest in this work. The growth of these processes are discussed by Hollingham and Merchant and the following theoretical limits were forecast by SME.

1. Grinding will be unlikely to replace 25% of work now done by machining by the end of the century.

2. Grinding will be unlikely to constitute 50% of finishing operations after forming before the end of the century.

3. Electrical machining methods will never take over 30% of conventional machining.

Although these processes do constitute a threat to the company's products, it is only forecast to be a slow growing threat.

7.3.7 ENVIRONMENTAL

1. A legal maximum noise level of 85 dB is predicted for the U.K. while SME forecasts a 50% reduction by 1985 and CIRP proposes "an average exposure level of below 90 dB or even possibly 85 dB".

2. Continued improvements in machine tool safety are discussed by the Task Force, Tamayo and in the CIRP forecasts which use forecasts of social incentives as a driving force behind machine tool development and the computer integrated automatic factory.

3. There are a number of forecasts for the continued reduction of workforce in manufacturing industry and CIRP (ref. Merchant 1976) presents some forecasts showing only 2 - 10% of the workforce in this sector by the end of the century.

4. It is forecast by the I Prod E in the U.K. that the working week will shorten to 32 hours by 1990 but that it is unlikely that a four day week will ever be adopted.

5. The need to conserve and economise on energy is emphasised by the Task Force although machine tool energy utilisation is shown to be only ½ - 2% of total plant consumption.

The possibility of rationing of energy or materials is expected by the I Prod E Survey.

7.4 ECONOMIC FORECASTING

As explained in Chapter 2, economic forecasting is the name which will be given to methods devised for forecasting the amplitude and turning points of the economic (or business) cycle.

7.4.1 EXTRAPOLATION OF ORDER INTAKE DATA

The company's order intake data was a logical choice for initial examination, since it would accurately reflect the interaction between the company and the outside world. In June 1980 a forecast was made based on this data and the forecasts for both home and export cycles are shown in Figures 7.6 and 7.7. The graphs were generated from historical order intake data smoothed with a moving annual total (MAT) and the forecasts were constructed using the recurrent cycles method which was described in Section 2.6.3.

These forecasts predicted the following:

1. The recession on the home market would bottom in November 1981 at a level higher than the bottom of the 1975 recession.

2. Home order levels would rise rapidly to reach a new peak in August 1985.

3. Export orders would act similarly but with a time lag of some 6 months.

Since these forecasts were in reasonable agreement with the expectations of many professional forecasters, they were used at that time for sales forecasting and new product planning.

FIGURE 7.6 FORECAST HOME ORDERS

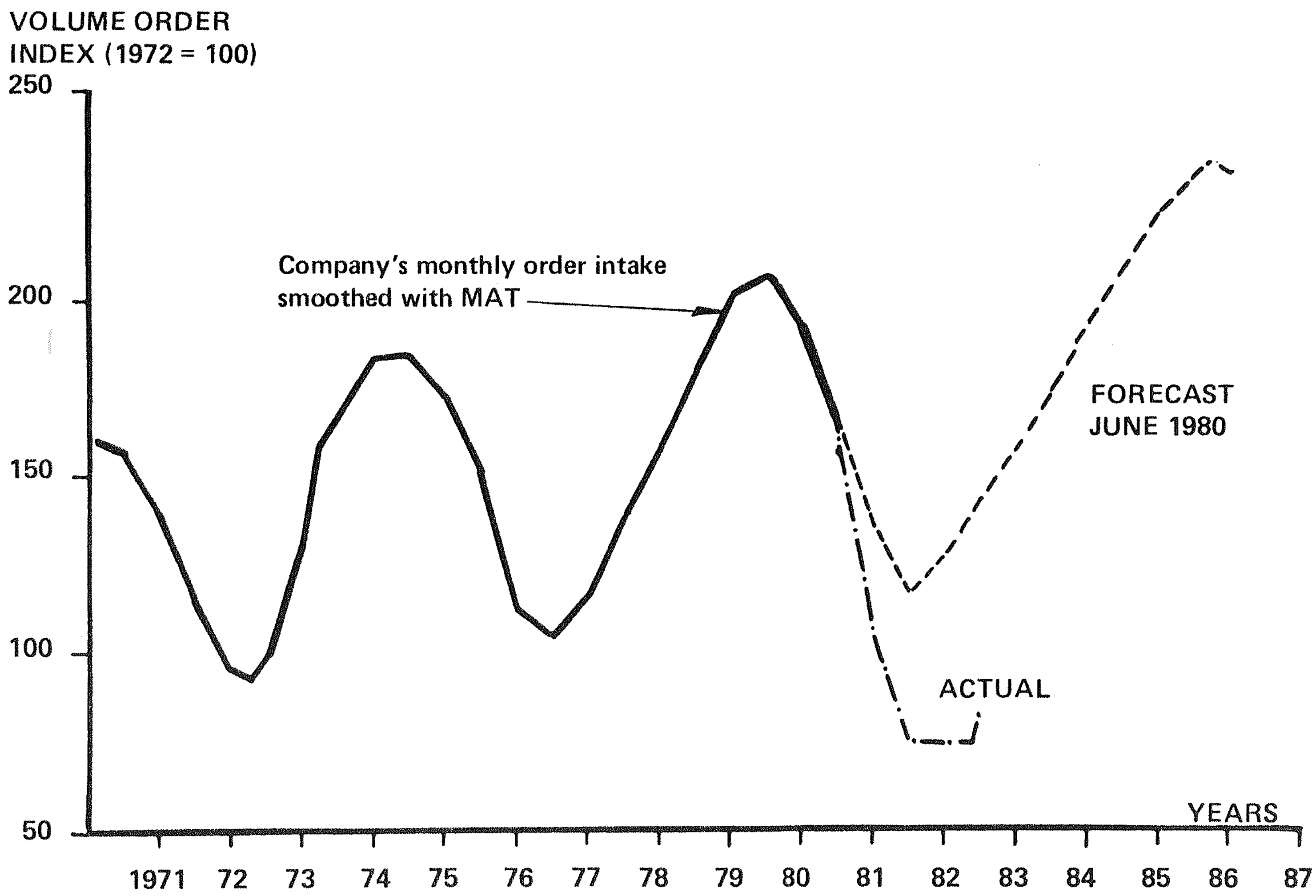
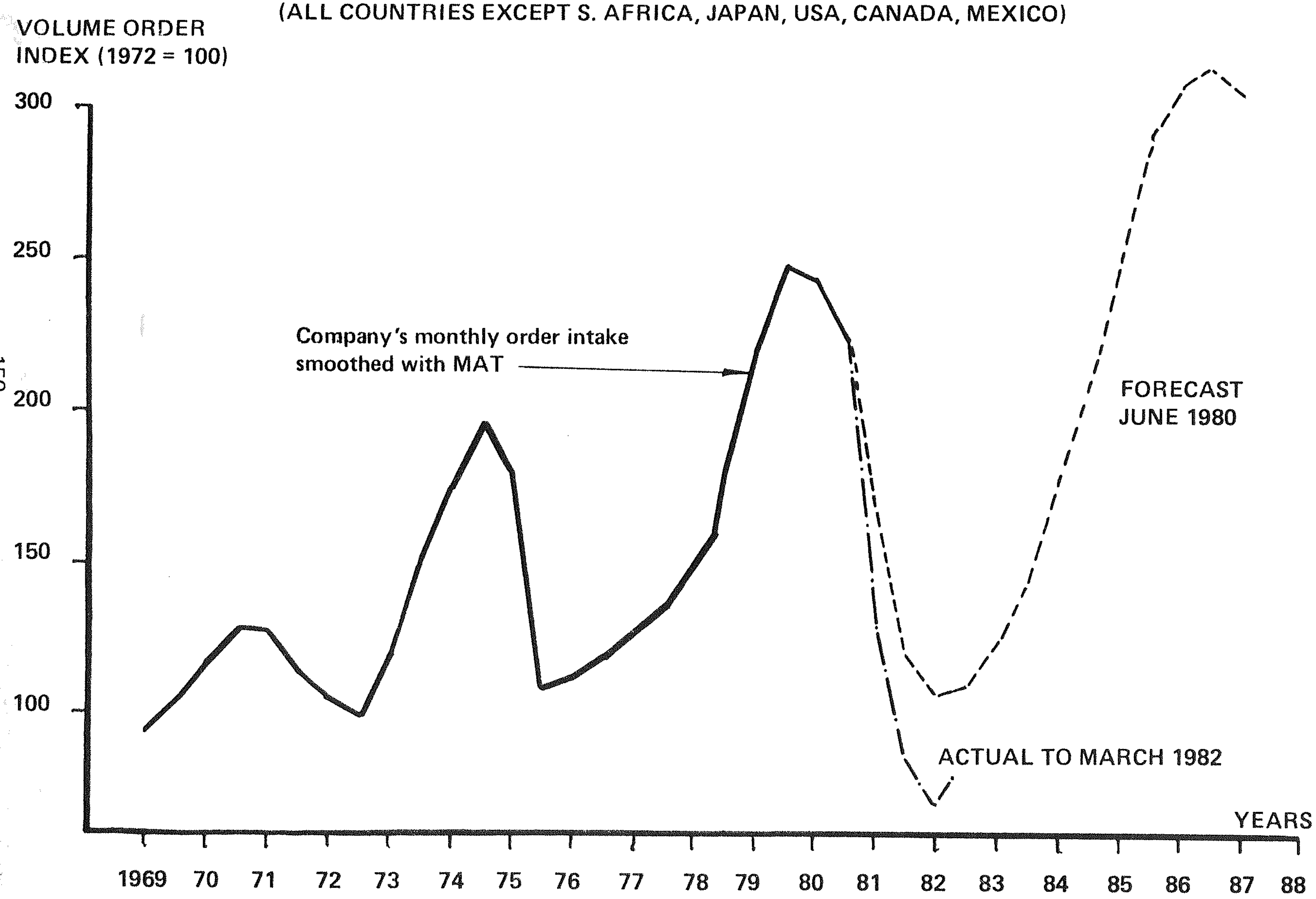


FIGURE 7.7 FORECAST EXPORT ORDERS

(ALL COUNTRIES EXCEPT S. AFRICA, JAPAN, USA, CANADA, MEXICO)



7.4.2 THE WORLD RECESSION IN 1981

Figure 7.7 provides an illustration of the world recession since it is a combination of order intake figures from around seventy five countries. This graph shows that the turning point was predicted to a reasonable degree of accuracy using the recurrent cycles method, but that the depth of the recession was not accurately forecast and turned out to be around 40% lower than anticipated.

Professional forecasters also failed to predict the severity of the recession in 1981, and as an example, the figures for world growth predicted by the Henley Centre for forecasting were:

Date	Forecast World Growth in 1981*
November 1978	4.0%
November 1979	2.5%
November 1980	2.2%
November 1981	1.1%

*OECD GDP growth over previous year.

This increased severity of the international recession resulted in the company's distributors taking a proportionately longer time to de-stock, thus resulting in the severely depressed export order intake shown in Figure 7.7.

In addition to these factors was the effect of product substitution and declining volumes of the turret mills which combined to reduce total order volumes during this period.

It is very difficult to predict the rate of growth out of this world recession since no forecasts of world machine tool demand are published. The best independent indication comes from OECD (ref. OECD 1981) which offers short term forecasts of the rate of growth of industrial production for OECD countries and this is given overleaf:

Year	Rate of Growth of Industrial Production for all OECD Countries
1969 - 1979 (Average)	3.4%
1980	-0.8%
1981	¾%
1982 (1st half)	2%
1982 (2nd half)	4½%
1983 (1st half)	4¾%

This forecast predicts strong growth out of the recession and by the second half of 1982 the world (OECD) growth of industrial production is forecast to exceed the average 1970's growth rate.

A broadly similar growth expectation can therefore be assumed for the machine tool industry.

7.4.3 THE U.K. RECESSION

The situation in the U.K. has been rather different. As can be seen from Figure 7.6, the turning point was once again, predicted reasonably accurately but the amplitude was again very poorly forecast and the actual was only just over one half of the forecast levels. Moreover, in the U.K. there was not the recovery that the cyclic techniques predicted. (The apparent upturn in February/March 1982 was due to two months high order intake resulting from a special offer on one model and does not represent an underlying cyclic increase).

This difficulty in predicting economic conditions in the U.K. was shared by the professional forecasters. In the Summer of 1980 it was generally agreed by these forecasters that recovery would begin in 1981 (ref. Marsh 1980), but four months later further decline was being forecast for 1981 (ref. Riddle 1980).

Four months later again, even more pessimistic projections were being made (ref. Riddle February 1981), and there was still no agreement on the timing of the low point.

When it became apparent that the low point had in fact been reached, the debate turned to the expected rate of recovery, but once again a very wide range of opinion was observed (for example ref. Hogg 1981 - pessimistic; Staniland and Hall 1981 - pessimistic, Wilkinson January 1982 - optimistic).

At the time of writing there is a growing volume of opinion (including Figure 7.6) supporting the view that the U.K. manufacturing sector has physically contracted in size and that normal cyclic recovery will be weak and will not regain 1979 levels (ref. Riddle, March 1981, Elliott & Smith 1981, Mauthner 1981, Marsh 1981 , CBI 1982, MTTA 1982, Anon (Engrg Today) 1982, Marsh 1982, Wilkinson April 1982, E.E.F. 1982).

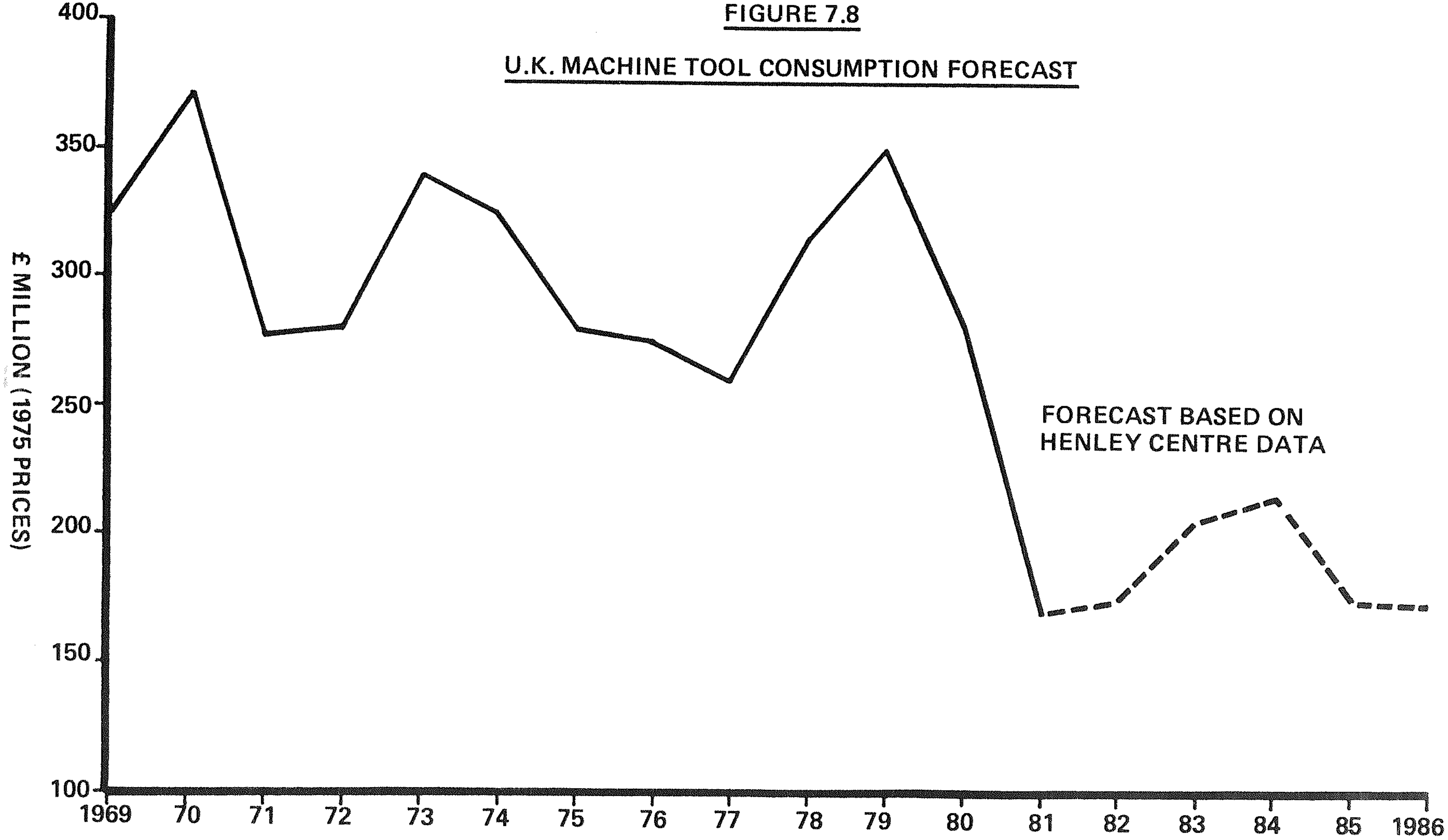
Additional, and more relevant, support comes from the Henley Centre forecasts for the U.K. machine tool industry (ref. Henley 1981). It is possible from these forecasts to produce a forecast for the total U.K. demand for machine tools up to 1986. This is shown in Figure 7.8 which clearly shows how the demand for machine tools will still be cyclic but with a very much smaller amplitude. This considerably weakened demand for machine tools over the next five years reflects the new, contracted, size of the U.K. manufacturing base.

Shortell (Head of Statistics, MTTA) observed at the 4th MTTA forecasting seminar that the Henley model was good at predicting turning points but not so good at amplitude forecasts, and that there was a tendency towards amplitude suppression and flattening out with time.

The conclusion that can be drawn from Figure 7.8 is that three years of growth can be expected until a peak is reached in 1984. It is unlikely that this peak will return to the same levels as prevailed in the 1970's, but that the peak could well be higher than that suggested in Figure 7.8.

FIGURE 7.8

U.K. MACHINE TOOL CONSUMPTION FORECAST



7.4.4 STRATEGIC IMPLICATIONS

There are two very important implications which can be drawn from the foregoing economic forecasts.

Firstly, while growth and recession will be relatively "normal" for the rest of the world, the growth in the U.K. is likely to be rather sluggish. The implications of this is that to maintain turnover growth, the company will need to concentrate an increasing proportion of effort into export markets and improve the existing export ratio.

The second point relates to the effect of this market growth on the introduction of the new machining centres. Substitution analysis showed that the greatest rate of numerical control substititution would occur between 1982 and 1995 (Figure 7.3). The high and increasing rate of growth of N.C. will be in addition to the cyclic growth during the next three years resulting in very high short term volume growth rates.

These very high growth rates provide an excellent opportunity to enter and to gain a large and defendable market share in the machining centre market. This opportunity is probably unique since competitive pressure in the mid 80's will increase as recession arrives again, and the next period of high growth will probably occur at or around the point when 50% substitution has been reached.

By the time these high levels of substitution have been reached at the end of the decade, market leaders will have become established, experience curve effects will begin to tell, uncompetitive manufacturers will start to withdraw from the market, and general levels of competition will increase significantly.

The implication of these points is that if the machining centre market is to be entered, then it must be done by the end of 1982 and with a range of products which can be successfully sold on overseas markets.

7.5 SALES FORECASTING

For our purposes, it is convenient to consider three types of sales forecast, that for existing products, replacement products and completely new products.

7.5.1 FORECASTING SALES OF EXISTING PRODUCTS

This is a relatively straightforward process and once the economic climate forecast has been obtained (for example from Henley) then normal extrapolation of historic data will provide a reasonable short term forecast. The major difficulty with this type of forecasting is the uncertainty surrounding the economic forecast (Figure 7.6 and 7.7) which is made worse by the accelerated business cycle in the machine tool industry.

This demands frequent forecast updating, particularly during the periods around the turning points.

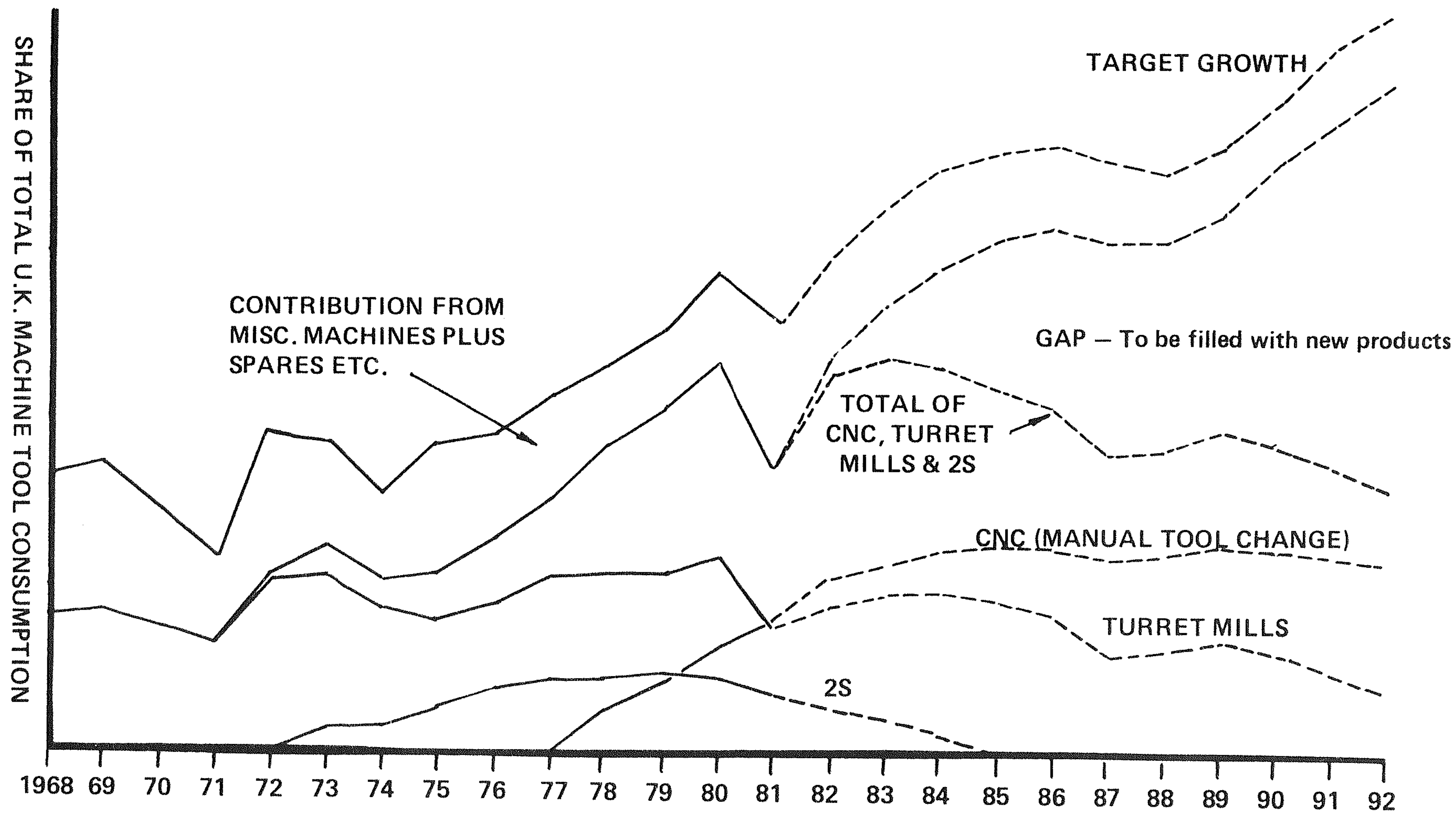
The forecasting method which has been developed for existing products uses the decomposition concept where the business cycle forecast is separated from the product growth forecast.

Individual product growth projections can be made based on extrapolations of the PLC and these are shown in Figure 7.9. The broken lines effectively provide a forecast of market share over the next 5 - 10 years.

The business cycle component is provided by the total market forecast which was shown in Figure 7.8, and sales forecasts can be obtained by combining Figures 7.8 and 7.9.

This method has been found to be a most effective way of obtaining a sense of realism in forecasting and preventing excessive optimism or pessimism.

FIGURE 7.9 PRODUCT LIFE CYCLES EXTRAPOLATED OVER NEXT 10 YEARS



The method also supplies a form of gap analysis where the gap between the existing products and the target market share can be identified. The size of this gap is equal to the market share which new products must achieve.

7.5.2 FORECASTING SALES OF REPLACEMENT PRODUCTS

Although the new MDI machines were not 100% direct replacements for the existing CNC range, for purposes of forecasting they can be considered as such in that they satisfy broadly the same markets and can be classified together under the general heading of manual tool-change CNC machines.

Under normal circumstances a replacement (new) product can be treated in much the same way as an existing product and the PLC can be suitably modified and/or extended and forecasts generated as described in the previous section.

In this particular instance, however, some forecast was required to illustrate the growth of the manual toolchange machine as a substitute product for the standard turret mill. This was because there were some opinions that manual toolchange CNC machines had no future against the rapid growth of machining centres.

Some specific forecasting was therefore required and this was performed using the Fisher-Pry analysis on the CNC/turret mill substitution process.

Since the company held the largest U.K. market share in both turret mills and CNC mills, it was reasonable to use the order intake data in this forecast. The only source of significant error would occur if there were any radical changes in market share of either product.

The first objective was to clearly identify the technological substitution process and this was performed using Product Moment Correlation Tests. This work is fully described in Appendix E.

The data for the Fisher-Pry model is given in Figure 7.10 and the log-linear graph which was produced is shown in Figure 7.11. The best fit of the straight line in this graph was weighted towards the data after January 1979 when market share of the CNC was fully established.

The forecast rate of continued substitution is given in Figure 7.12 which shows a 50% volume substitution point around August 1983.

At the time of forecasting (December 1980) this rapid changeover was found to be a very difficult forecast to get accepted but the experience of the following 18 months proved it to be fairly accurate in general terms.

Each of the deviations from the forecast line can be explained. The initial fall to the low point in middle of 1981 represented the decline in the CNC machine and the subsequent rapid increase followed the introduction of the first MDI machine in June 1981. The next low point in February 1982 resulted from the distorting influence of a successful sales drive on the turret mill which increased the sales volume of this product and thus effectively reduced the substitution percentage.

With the information obtained from this forecast plus the use of cyclic extrapolation it was therefore possible to quantify the sales forecast for manual toolchange machines over the forthcoming years.

FIGURE 7.10 DATA FOR CNC/TURRET MILL SUBSTITUTION

Note that the expression $\frac{f}{(1 - f)}$ reduces to $\frac{NEW}{OLD}$

The values given below are therefore $\frac{\text{monthly CNC order volume}}{\text{monthly turret mill order volume}}$

The figures are smoothed with a 3 month moving average and CNC includes all manual toolchange CNC orders. 1981 and 1982 are actual outcome.

MONTH	1977	1978	1979	1980	1981	1982
JAN	–	.044	.141	.248	.264	.460
FEB	–	.049	.113	.232	.295	.288
MAR	–	.043	.126	.119	.265	.360
APR	–	.034	.133	.132	.224	.453
MAY	–	.027	.146	.136	.160	–
JUNE	–	.030	.168	.146	.130	–
JULY	–	.028	.209	.156	.177	–
AUGUST	–	.047	.200	.257	.292	–
SEPT	.040	.069	.175	.299	.430	–
OCT	.046	.100	.118	.319	.660	–
NOV	.042	.142	.130	.256	.827	–
DEC	.037	.142	.234	.258	.744	–

FIGURE 7.11 EXTRAPOLATION GRAPH FOR FORECASTING RATE OF SUBSTITUTION OF CNC

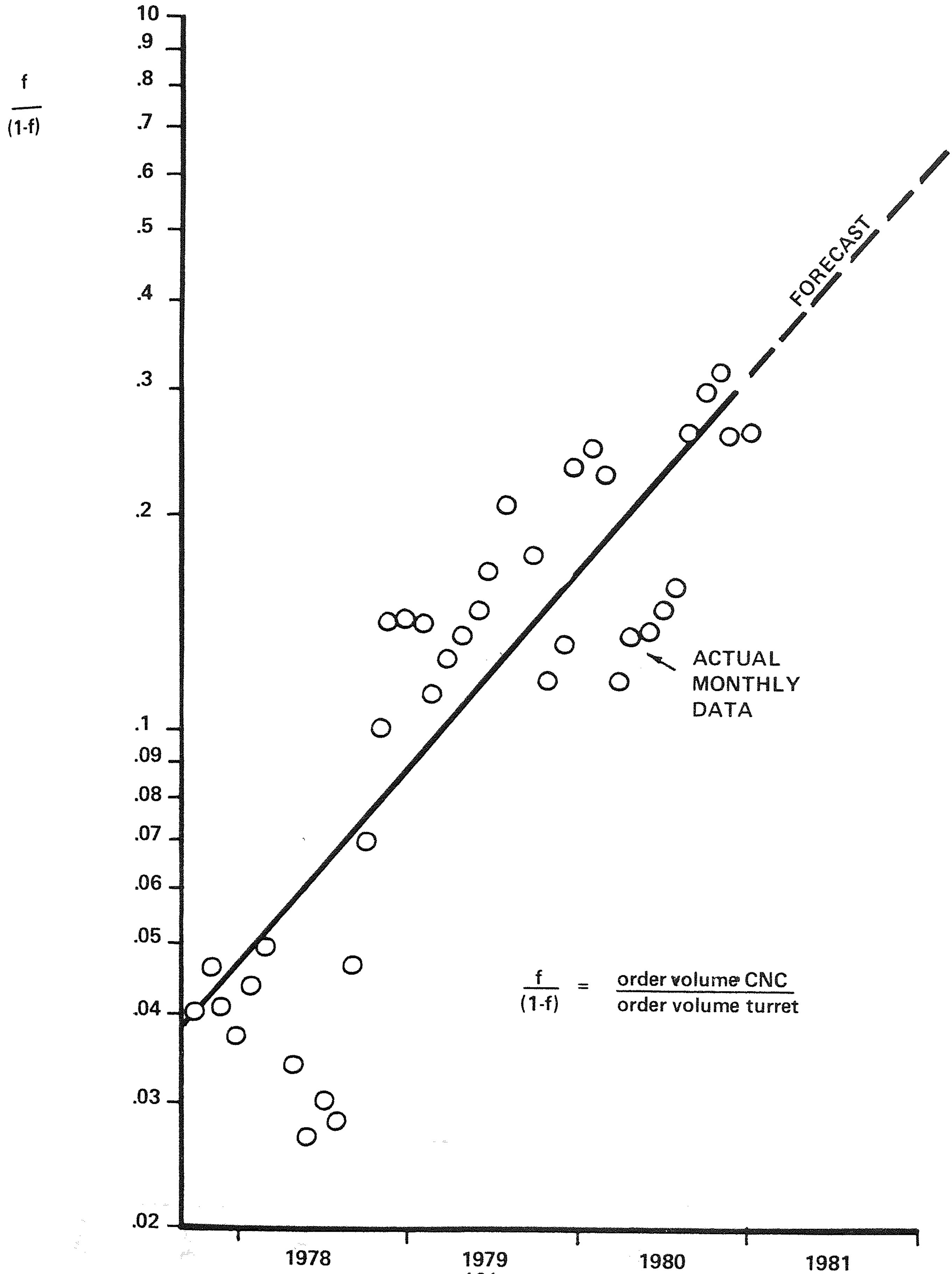
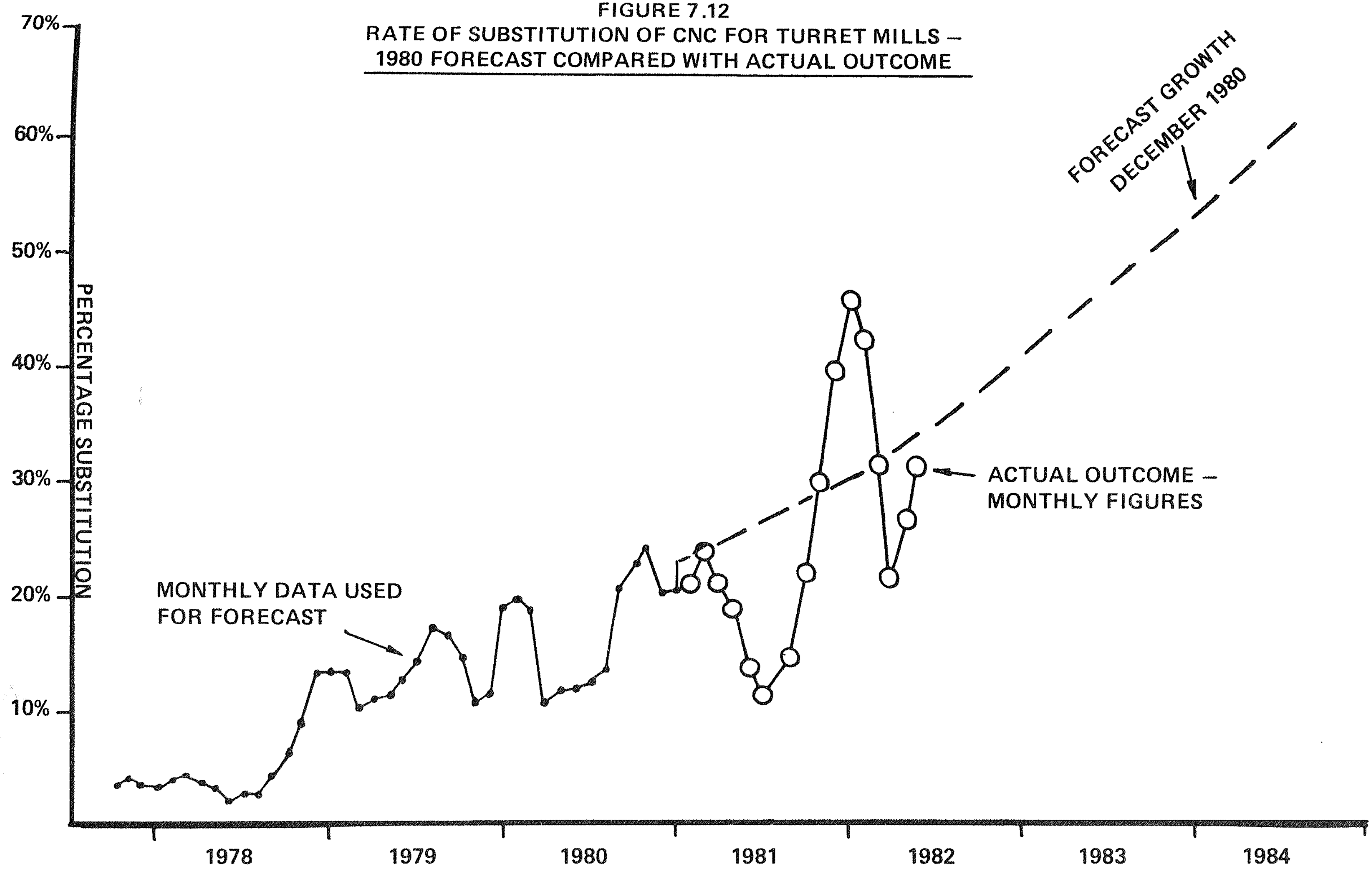


FIGURE 7.12
RATE OF SUBSTITUTION OF CNC FOR TURRET MILLS –
1980 FORECAST COMPARED WITH ACTUAL OUTCOME



7.5.3 FORECASTING SALES OF NEW PRODUCTS

New products are defined here as being products for which there is no historical company data available for forecasting. In addition since these products are, in nature, new to the company, there is no direct relevant experience available.

The lack of data and experience makes this particular type of forecasting rather more difficult than that described in the previous sections. This difficulty is especially accentuated since forecasts for new products are particularly important for the following reasons:

1. The future growth of the company depends upon being able to fill the gap (in this case shown in Figure 7.9).

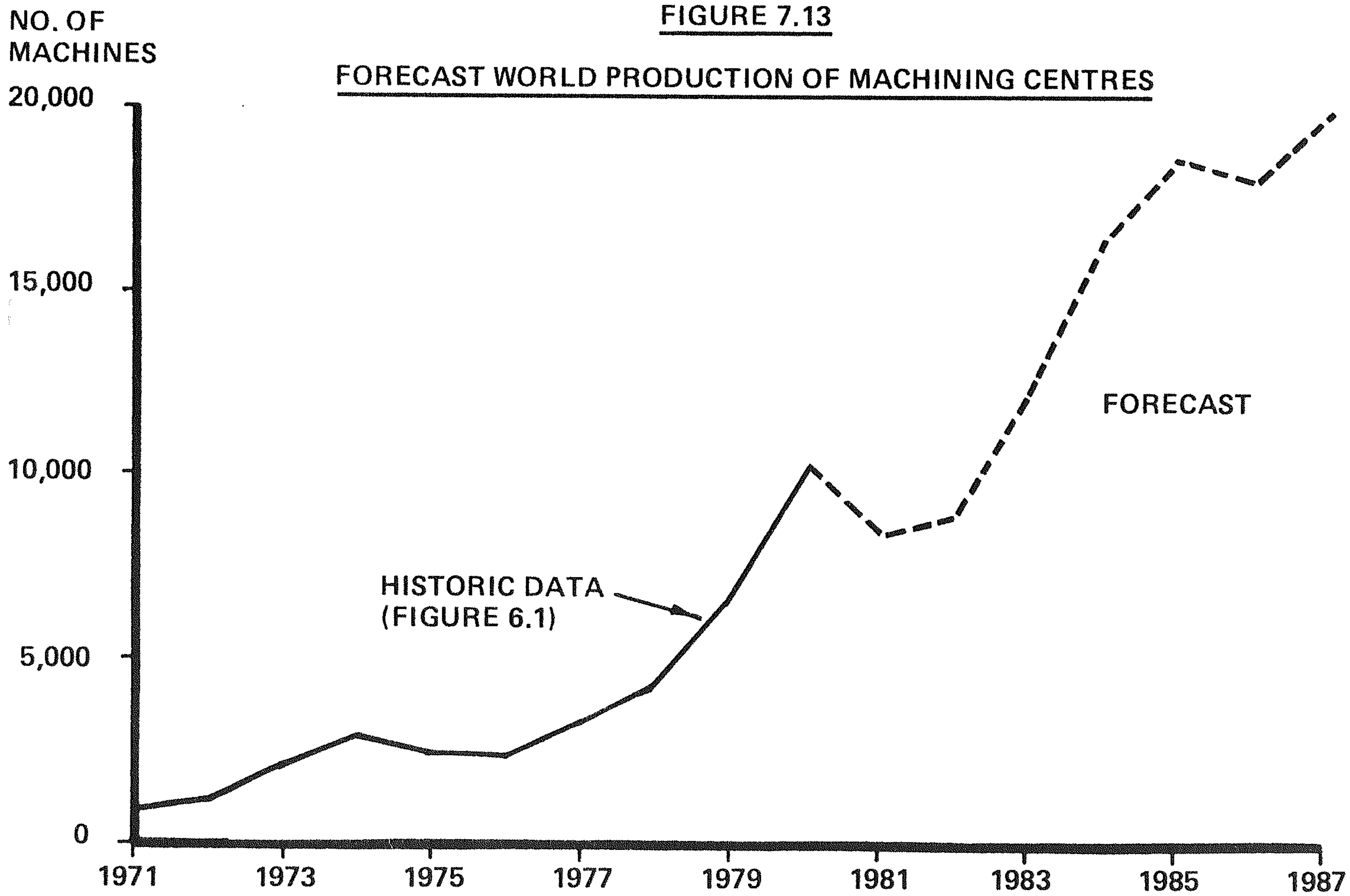
2. Any new product venture of this nature is likely to involve considerable amounts of technical and capital expenditure, and so reasonable accurate product performance expectations are required.

The above considerations justify the use of as many forecasting techniques as possible in order that some form of consensus can be reached in the manner proposed by Doyle and Fenwick (see Section 2.6.4). To this end two techniques have been used to provide sales forecasts for the proposed machining centres. Unfortunately, as explained in Chapter 2, field marketing research involving potential customers was not performed and so this powerful technique was not available to help with this problem. It was therefore necessary to devise other methods.

The first task was to estimate future growth of total world demand. This was done by taking the historic growth already developed (Figure 6.2), and project forward by 5 years. This projection is shown in Figure 7.13 and makes allowance for the current and the 1986 recessions. The growth rate in the intervening years is shown as being greater than during

FIGURE 7.13

FORECAST WORLD PRODUCTION OF MACHINING CENTRES



1978 and 1979 by the same ratio as the rate of increase of substitution shown in Figure 7.3.

Although this forecast is a simple and unsophisticated extrapolation, it does provide a representation of the likely future potential of this market. With forecasting errors as high as 30% p.a. (Section 7.4) generation of more sophisticated forecasts cannot really be justified.

With the information given in Figure 7.13 the following methods were used to generate numerical forecasts of sales volumes:

1. EXPERT OPINION

From historic experience of launching new products and making a critical appraisal of potential it is possible to estimate potential market share and growth of penetration in each major market worldwide. This information yields sales by country, the sum of which provides a total sales forecast.

Experience with this "summing up" technique has shown that forecasts generated this way are usually optimistic, sometimes highly. This method can therefore be used to set the upper limit.

2. PRICE-VOLUME ENVELOPES

This method is a form of the Market Research method and uses a form of the analogous product comparison proposed by Davies.

A price-volume envelope for machining centres was developed in the previous chapter and illustrated in Figure 6.5. This can be used in some measure to estimate potential sales volumes in the U.K. since the boundary represented by the envelope represents the limit of all the highest selling machines in 1980.

It is therefore possible to say that the maximum achievable sales in 1980 of, say, a £55,000 machine would have been around 35 p.a. While it is clear that this argument cannot be continued indefinitely (since the shape of the envelope would change), it does give a starting point for a U.K. sales volume forecast. This starting point can then be projected forward using a growth rate which is calculated in the following way:

a. In Section 6.3 the historic growth rate was shown to average 30% p.a. over the last 10 years. The results of the substitution analysis which were given in Figure 7.3 show that the rate of substitution over the next 10 years will be twice that of the previous 10.

Allowing for volume reductions resulting from the high productivity of machinining centres, and taking into consideration the continuing low level of U.K. manufacturing output, it is a reasonable estimate that the annual average volume growth rates would be around 40% p.a. in the U.K. and 50% p.a. worldwide.

b. Some support for these estimates can be obtained from published work although there is very little on this specific subject.

In 1980, Planning Research and Systems forecast a growth of 20% p.a. in U.K. machining centre consumption up to 1983, comprising a 25% growth of imports and 9% growth of U.K. manufactured machines (ref. JBNCS 1980).

Although this growth was not achieved, it is interesting to see strong growth predicted in the face of the imminent economic slump.

Total sales forecasts were then generated using the estimated 1980 start point, the predicted growth rates and an estimation of export ratios based on work performed in Section 7.4.

7.6 OTHER FORECASTS

As explained in Chapter 2, this is the process of lateral thinking which is used to maintain a wide perspective on new product development. The list of influencing parameters is considerable and in this Section we shall examine some of the most relevant and important factors.

7.6.1 POLITICAL

Probably the most important factor under this heading is war since it has two effects. Firstly, war between third parties often results in formal or informal loss of valuable export markets (for example Iran/Iraq). This has the effect of reducing total export potential. Conversely, war involving Britain or its close allies would result in an increase in sales potential as production of armaments and associated products increases (for example the effects of Korea and Vietnam in the U.S.A.).

It is therefore useful to examine all potential areas of conflict and assess the subsequent consequences.

There are, additionally, an increasing number of countries against whom trade sanctions are imposed and if this list were to include some of the more important export markets then, once again, future export potential would be restricted. On the other hand, as the EEC increases in size, the potential could tend to increase from countries previously protected with trade barriers.

Another political factor is the position of Japan which currently supplies over half the world demand for machining centres. The reaction of the western world to the increasing trade imbalance with Japan is currently straining the GATT treaty.

The technology, quality and value-for-money of Japanese products is such that it is counter-productive to erect trade barriers and so the most likely solution to satisfy both parties is a dramatic increase in the current trend of local manufacture by Japanese companies.

When this happens, and if experience is transferred, then highly competitive machines, free of duty and transportation costs, will appear on the domestic market in Europe and U.S.A., thereby increasing the competition to the existing indigenous manufacturers.

7.6.2 STRATEGIC

It is inconceivable that the launch of a major new range of products by a world leading company would not have considerable effect on the competition. It is therefore valuable to speculate the likely competitor reaction to this initiative.

In addition to this, each competitor has been considered individually and historic growth rates extrapolated forward to predict future growth potential.

It is also necessary to consider the likely new product developments of competitors, for example one possibility is that all major manufacturers of vertical machines could launch horizontal versions within the next five years. This would effectively increase the competition in this sector by over 30% and each of these new entrants would be already experienced machining centre manufacturers. Another serious possibility would be if one or two Japanese volume manufacturers entered the vertical knee and column machining centre market (possibility at a U.K. or U.S.A. facility?).

The one single outstanding conclusion which has been reached from this type of forecasting is that competition will get increasingly stiffer over the next five or ten years, and so plans must be made to constantly improve competitiveness.

7.6.3 SOCIOLOGICAL

Merchant (ref. Merchant 1976) points to a number of social incentives contributing strongly towards the prospects for early realisation of factory automation. Among these trends, he highlights the increasing shortage of manufacturing workers and the coming of the post-industrial society. Other factors include the attitude of employers in providing greater job satisfaction and the actions taken by Governments towards freeing workers from unsafe or unhealthy working conditions.

Since his work was written there have been some dramatic changes in the levels of employment which have somewhat changed these more positive social attitudes. More pessimistic scenarios can now be painted which include civil disorder, "machine bashing", socialistic "work making" schemes, and organised worker resistance to working with new technology.

As the unemployment problem becomes more acute (see OECD forecasts below), the probability of the realisation of these events increases. It is unlikely that in current free market conditions all of these problems would arise within the next five years or so but long term contingency plans (such as not abandoning manual machines) must be made.

Year	OECD Forecast of Unemployment in the OECD Area (December 1981)
1980	21.4 million
1981	25.0 million
1982	28.25 million
1983	28.5 million

CHAPTER 8

RESULTS

8.1 INTRODUCTION

This work has resulted in the development of a methodology with which the company may, at any time, assess its current position and determine future product requirements. This methodology will be broadly described in the first section of this chapter.

This methodology has also been applied in the company over the last three years, and so some specific results can be given. These will be presented in the second section.

The third section will summarise the outline specification of the proposed new products. Since some of these new products have already been launched, the early results of these new machines can be given and these will be described in the last section of this chapter.

8.2 THE SYSTEMATIC METHODOLOGY

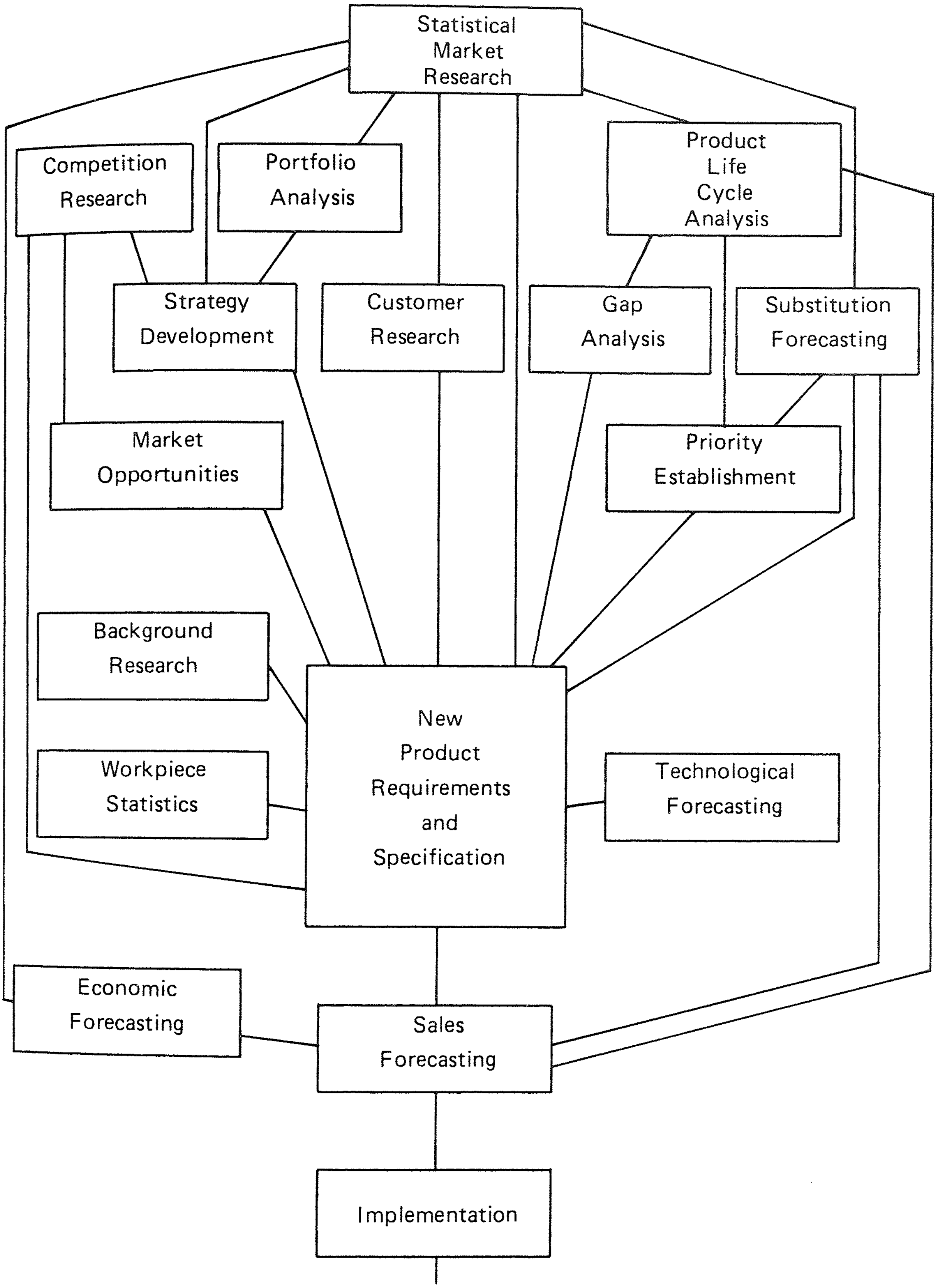
Figure 8.1 is a flow chart of the methodology for developing new product strategies which has resulted from this research project. The chart shows how the various elements of marketing research and forecasting have been linked together with techniques.

In practice there were many more minor connections between the various stages, but for simplicity only the major links have been shown in Figure 8.1.

The chart shows that the process was complex with a large number of interrelated elements combining to provide the end result. Full description and amplification of each of these elements is given elsewhere in the body of this work.

The following section will provide a summary description of each element of the methodology with particular reference to its interrelationship with the other elements. Reference to the relevant section in the text will be made in parenthesis.

FIGURE 8.1 DEVELOPING NEW PRODUCT STRATEGIES – A METHOD FLOWCHART



8.2.1 THE INDIVIDUAL ELEMENTS

STATISTICAL MARKET RESEARCH (2.4, 2.5, 4.3, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.11, 7.2, 7.4, 7.5) This is the largest single input element of Figure 8.1 and comprises the collection, analysis and interpretation of published statistics and company data. The sources of this data are given in Appendix D.

This statistical work provides fundamental background data on market size, growth, segmentation etc, and is therefore of considerable value in developing strategies and in determining new product requirements.

In addition, Statistical Analysis provides data input to the other techniques used and which are described in this thesis. In particular, both company and market data is used for the portfolio and product life cycle analyses. Data on existing customers is the input to customer research and historic data is the starting point for substitution, economic and sales forecasting.

COMPETITION RESEARCH (1.5, 1.6, 1.7, 2.5, 6.4, 6.9, 6.13) This is another major input and the results of this work provide an understanding of how the current and historic market requirements have been satisfied. Trends can be identified for forecasting purposes and market opportunities can be located. Competition Research is a fundamental prerequisite to the development of new product strategies and also provides a valuable input to the process of product design.

PORTFOLIO ANALYSIS (2.3, 3.3) provides a method of examining the complete product range for the purpose of generating broad strategies for each segment. It helps to achieve a balanced perspective of short term profitability and long term potential of the whole product range.

PRODUCT LIFE CYCLE ANALYSIS (2.4, 4.1, 4.2, 4.3, 4.4, 4.5, 7.5) provides a dynamic and complementary component to Portfolio Analysis by monitoring the changing market share of individual products with time. As such it is an extremely useful tool for sales forecasting and can be used to readily identify problem areas in the product portfolio.

STRATEGY DEVELOPMENT (3.4, 3.5) Broad generalised segment strategies can be developed from portfolio analysis, and with a knowledge of competitive pressures and world conditions, individual product strategies can be developed.

CUSTOMER RESEARCH (2.5, 5.4, 6.11, E.1) is used to identify the current and future needs of the company's customers for purposes of idea generation. Techniques include the use of guarantee registration cards, user lists, user surveys and interviews.

GAP ANALYSIS (7.5) is the method of determining the sales required from new products. It is simply the gap between target growth and anticipated growth of existing products and is obtained from Product Life Cycle Analysis.

SUBSTITUTION FORECASTING (2.6, 7.2, 7.5) This is the method of establishing the rate at which N.C. is replacing conventional machine tools. This information is of considerable value in assessing priorities and establishing new product requirements. A method has been developed which uses substitution forecasting as a tool for forecasting sales of replacement type new products.

MARKET OPPORTUNITIES (6.13) One result of thorough and comprehensive competitor analysis is the identification of holes in the market which provide opportunities for new product entry, free from direct competition.

PRIORITY ESTABLISHMENT (4.1, 4.4, 4.5) This is a result of Product Life Cycle Analysis which, when used as a monitoring tool, illustrates those segments of the portfolio which are in most need of attention. It has also been found that forecasting in general, and substitution forecasting in particular, can help establish priorities.

BACKGROUND RESEARCH (1.2, 1.3, 1.4, 2.6, 6.14, 7.6) This is the collection and accumulation of general knowledge. It includes an understanding of the history, politics, technicalities and sources of information in the machine tool industry. Also included under this heading are the more formalised thinking processes of strategic and sociological forecasting, and the seeking out of relevant published research. In this way, Background Research provides a valuable contribution to the methodology.

WORKPIECE STATISTICS (2.5, 6.12) Analysis of the universe of potential workpieces has been shown to make a substantial contribution to the development and refinement of a new machine specification.

TECHNOLOGICAL FORECASTING (2.6, 7.3) Since a machine tool has a life expectancy of many years, it has been found essential that Technological Forecasting plays an important role in the development of the specification.

NEW PRODUCT REQUIREMENTS AND SPECIFICATION (5.1, 5.2, 5.3, 5.5, 8.3) This part of the methodology brings together the results of all the elements described above. It is divided into three parts.

Firstly, it is necessary to determine whether new products are required at all, and if they are what contribution they are expected to make to the product range. The strategic planning tools "Portfolio Analysis", "Product Life Cycle Analysis", and "Gap Analysis" provide this information.

Secondly, the type of new product must be determined (i.e. what sort of machine or diversified product is required?) This information is obtained from "Strategy Development", "Statistical Market Research", "Priority Establishment", "Workpiece Statistics" and the three types of forecasting ("Substitution", "Technological", and "Other").

Thirdly, an outline specification must be obtained to act as a design brief. This requirement is provided by "Customer Research", "Market Opportunities", "Workpiece Statistics", "Technological Forecasting", "Competition Research", and "Statistical Market Research".

ECONOMIC FORECASTING (2.6, 7.4) uses internal data, external data and published research to predict the total levels of machine tool demand over a five year period for both U.K. and world markets.

SALES FORECASTING (2.6, 7.5) applies the results of a range of forecasts to predict potential sales levels of proposed new products.

IMPLEMENTATION (5.3, 9.2, 9.3, 9.4) The method of implementation will be dependent upon the nature of the new product proposal and the particular circumstances, but the first important stage of implementation is budgeting. It has been found preferable that budgeting should be performed by the accounts department. This department is most familiar with the mechanics of overhead apportionment, cost determination etc., and also offers a relatively impartial appraisal of the proposal.

8.3 RESULTS LEADING TO THE DEVELOPMENT OF NEW PRODUCTS

This section will show how the elements of the methodology shown in Figure 8.1 influenced the development of new products in practice, during this research project. Summary results only will be given and the relevant section of the text will be indicated in parenthesis.

8.3.1 THE NEED FOR NEW PRODUCTS

It was first necessary to identify whether new product development is appropriate. The first indication of the need for new products was given by the weakness of "Question Marks" in the Portfolio Analysis (Section 3.3.1). It was observed that if new products were launched into high growth markets then a more balanced portfolio could be obtained.

Secondly, Product Life Cycle Analysis showed that all existing products were at or near the product maturity phase (Section 4.5) and thus continued growth would only be achieved with new products.

This was quantified by Gap Analysis (Section 7.5) which showed that new products would need to supply 50% of total turnover by 1990, if growth rates were to be maintained.

8.3.2 TYPE OF NEW PRODUCT REQUIRED

Alternatives which were developed from Portfolio Analysis showed that potential new products could be manual toolchange or auto toolchange CNC machines or other types of high technology metalworking machine tools (Section 3.4.1).

Priority Establishment identified the following order of priorities (Section 4.4):

a. Support for manual toolchange CNC machines (Section 4.4.3)

b. Developments in support of 2S machines (Section 4.4.2)

c. Longer term support of turret mill range (Section 4.4.1)

Portfolio Analysis suggested that new products should be launched into high growth markets and Substitution Forecasting showed that numerical control in general was a high growth market worldwide (Section 7.2.2), and in the U.K. (Section 7.2.3). This result was supported by Technological and other forecasts (Section 7.3 and 7.2.6).

It was therefore clear from these results that the first priority new product should be a manual toolchange CNC machine.

The second and third priorities had indicated support for conventional manual milling machines. However, Substitution Analysis had shown that manual machines were being rapidly replaced by N.C. machines in general and machining centres in particular (Section 7.2.5). This was strongly confirmed by Technological Forecasting (Section 7.3).

It was therefore apparent that machining centres would provide the new product opportunity that had been shown necessary in Strategy Development (Section 3.4).

The prerequisite that new products should be launched into high growth markets was satisfied using Statistical Market Research. From this, it was calculated that the real growth rate over the previous ten years was around 30% p.a. (Section 6.3). The total market size was estimated to be 10,000 units p.a. in 1980 (Section 6.2).

Future growth was given by Substitution Forecasting which showed that growth rates over the next 10 - 15 years would be greater than those already experienced (Section 7.2.2), and that the substitution of machining centres for conventional machines was closely parallel to that for all machine tools (Section 7.2.5).

Substitution Forecasting also showed that timing was critical and that new machining centres would need to be launched with minimum delay. This result was reinforced by Economic Forecasting (Section 7.4.4).

Strategies for diversification were not pursued at this stage since the requirements for new manual toolchange machines and machining centres filled the "gap" and hence provided sufficient opportunity for new product development. It was also shown that other types of machine tools would incur an unnecessarily high level of risk (Section 6.1).

8.3.3 OUTLINE SPECIFICATION OF MANUAL TOOLCHANGE CNC MACHINES

The outline specification of the manual toolchange CNC machines was developed in the following way using the methodology:

Competition Research identified the growth of the low cost micro-processor based 'retro' type controls on this type of machine (Section 1.5 and 5.2). This suggested that the full computer controlled machines would soon become replaced in the volume market. This was confirmed using a precursor technique which showed that this was already happening in the U.S.A. (Section 5.2).

Since the 'retro' type controls are cheaper than the full CNC type, prices would also come down. A user survey (Section 5.4) showed that low price was the single most important factor behind the purchasing decision for this type of machine.

It was identified from further Competitor Research (Section 5.5) and from Statistical Market Research (Section 5.5) that competitive advantage could be achieved by developing both No. 1 and No. 2 sized machines and that the No. 2 size machine could incorporate a more sophisticated control.

8.3.4 OUTLINE SPECIFICATION OF MACHINING CENTRES

Customer Research (Section 6.11) showed that two machine types would be required. These were a high productivity No. 2 size machine with horizontal spindle and a No. 1 size machine offering a high degree of versatility.

Workpiece statistics (Section 6.12) were found to be of help when specifying a machine which would be capable of accommodating a maximum number of workpieces. This feature was obviously most appropriate for the larger No. 2 size machine which was found to have an optimum machining capacity of 16 - 20" cube. It was also found that the auto tool-changer should accommodate at least thirty tools with a maximum tool diameter of 8".

Positional accuracy should be better than 0.001″.

A further guide to machine specifications was obtained from an analysis of Market Opportunities (Section 6.13). This identified three market holes open to exploitation in 1980:

a. Horizontal machining centre under £60,000

b. Auto pallet change machining centre under £60,000

c. Vertical machining centre under £35,000

The low target selling price of these opportunities suggested that these specifications were most appropriate for the No. 1 size machines.

The same analysis yielded the characteristic price/sales volume curve for machining centres. From this curve (Figure 6.5) it can be seen that machining centre sales volumes increase greadually as price decreases to about £60,000. As price reduces below this figure sales volumes can be observed to increase considerably more rapidly (Section 6.13.1).

The segmentation of the U.K. (Section 6.6) and world (Section 6.7) machining centre markets was determined to be, in 1980:

		Number of machines	
		U.K.	World
a.	Vertical knee and column under 10 h.p.	190	1,000
b.	Vertical bed under 10 h.p.	135	3,500
c.	Horizontal bed under 10 h.p.	130	2,500
d.	Vertical over 10 h.p.	50	1,500
e.	Horizontal over 10 h.p.	65	1,500
	TOTAL	570	10,000

This indicates that the most attractive volume markets are for the smaller machines under 10 h.p. Fortunately, this type of machine, being generally No. 1 or No. 2 size is well suited to the company's distinctive manufacturing, technological and marketing competencies.

The share and growth of individual manufacturing countries was determined (Section 6.4) and this showed how in the last ten years Japan had achieved dominance with a total world share of around 51% in 1980.

Competition Research (Section 6.9) had found no Japanese machine in the vertical knee and column segment and so for this reason this segment was particularly attractive. This helped to confirm the strategy of obtaining high market share in this segment, and if the existing machine could not provide the required penetration then a new machine would need to be launched into this sector.

Competition Research had shown that for the other two segments of interest (horizontal and vertical machines under 10 h.p.), the number of competitors in the U.K. had increased by 76% between 1980 and 1982 (Section 6.9) and that the total number of competitors worldwide had increased to well over 100. Background Research had included forecasts which showed that this competition would continue to increase substantially in total (Section 7.6) and from all parts of the world (Section 1.5 and 1.6).

Technological Forecasting (Section 7.3) established the trends towards increased productivity (Section 7.3.1) high automation (Section 7.3.2) and increased flexibility (Section 7.3.3). These trends were illustrated by the growth of computer control, auto toolchange systems, auto pallet change mechanisms, automatic swarf removal, automatic handling (including robots) and flexible machining systems (FMS). Most of these features will be readily accomplished with horizontal spindle configuration machines.

Technological Forecasting also provided a number of detail guidelines for refining the specification of the new machines. These are all future trends, and if machines designed today are to remain competitive in the future they must move part way towards satisfying these requirements or else be capable of having them incorporated at a later date. The major requirements are (Section 7.3):

a. Higher machining accuracy

b. Improved dynamic stiffness

c. Higher feeds and speeds

d. Increased spindle power

e. Reduced noise levels

f. High levels of safety

g. More energy efficient

h. In-process gauging capability

i. Adaptive control capability

j. Greater use of: diagnostics, downline loading, computer simulations, interactive controls.

In addition to these, Background Research identified a strong need for increased reliability (Section 6.14).

The following Japanese segment shares have been estimated from Section 6.8 and 6.7.

		Total	No of Japanese Machines	Japanese Share
a.	Knee and column machines	1,000	0	0%
b.	Vertical bed under 10 h.p.	3,500	2,250	64%
c.	Horizontal bed under 10 h.p.	2,500	1,250	50%
d.	Vertical machines over 10 h.p.	1,500	950	63%
e.	Horizontal machines over 10 h.p.	1,500	750	50%
	TOTAL	10,000	5,231	51%

This illustrates the relative attractiveness of segment a. and also shows that on this criteria the horizontal segments are more attractive markets than the verticals. The company does have a history of manufacturing vertical machines and so these should also be represented in the long term plans for new products.

8.4 SUMMARY OF NEW PRODUCT REQUIREMENTS

The following portfolio of new products is a summary of the results given in the previous sections. The machines are listed in order of priority.

1. No. 1 size manual toolchange vertical spindle CNC machine with target selling price £10,000 (implemented 1981).

2. No. 2 size manual toolchange vertical spindle CNC machine with more sophisticated control (implemented 1982).

3. No. 1 size vertical knee and column machining centre with a selling price below £35,000 (1980 prices). (This new product to be implemented immediately there is any evidence of the existing product failing to establish market dominance).

4. No. 2 size (16" - 20" cube capacity) horizontal spindle machining centre with auto pallet change, swarf conveyor, 30 tool ATC, maximum tool diameter 8". The machine to be designed for maximum productivity, technological value-for-money and in compliance with the requirements determined by Technological Forecasting and Competitor Research.

5. No. 1 size (10" - 14" cube capacity), horizontal spindle machining centre with an auto pallet change option and selling at below £60,000 (1980 prices). The machine to be designed for maximum flexibility with options such as rotary table fourth axis.

6. No. 2 size vertical machining centre with a similar specification to that of (4) above.

Introduction of the above machining centres will need to be accomplished by the end of 1982 at the latest.

8.5 EARLY RESULTS OF THE MDI INTRODUCTIONS

The no. 1 size manual toolchange MDI machine was launched in the U.K. in July 1981 and on international markets in September 1981 at Hannover.

The success of the machine in the U.K. is illustrated by the Product Life Cycle curves for manual toolchange CNC machines. The decline of this sector is illustrated in Figure 4.2 (pre-MDI). Figure 7.9 (post-MDI) shows how this decline has been completely reversed and how continued growth through to 1985 is being forecast.

A further illustration was discussed in Section 7.5.2 in which Figure 7.12 showed how the machine had revived the flagging substitution process (and thereby restored U.K. market share).

Sales forecasts were made based on decomposition using Figure 7.12 and the PLC method (Section 7.5.1 and 7.5.2). The limitation of this technique resulted in these sales forecasts being restricted to the U.K. market and export sales had to be estimated on historic CNC export ratios.

By March 1982 around 200 orders had been received for the machine. This figure was over 30% above the anticipated levels which were forecast in June 1981.

This forecasting error is not unusual in the industry (See Section 7.4), but it nevertheless can be explained in the following way:

1. The home forecasts (shown in Figure 7.12) were, on average, reasonably accurate and within 10% of actual.

2. The export forecasts turned out to be a little over half of the actual order intake, but this was largely due to machines being sold to the U.S.A. where the sister company was not manufacturing this particular model and so machines were being shipped from the U.K.

3. In March 1982 the No. 2 size machine was introduced at the METCUT 82 exhibition. This machine introduced complex intra-substitutional factors which had to be estimated for forecasting purposes.

The situation was exacerbated when, less than a week after this launch, H.M. Government announced the Small Engineering Firms Investment Scheme (SEFIS) which offered small firms a 33 1/3% grant towards the purchase of CNC machine tools costing over £15,000.

This scheme presented an unpredictable element into sales forecasting and domestic orders for the low priced No. 1 machine are currently running considerably below forecast while the new No. 2 MDI machine is enjoying a highly successful introductory period in the U.K.

CHAPTER 9

IMPLEMENTATION

9.1 INTRODUCTION

The portfolio of new products listed in Section 8.4 was developed in collaboration with the technical, marketing and financial departments of the company. This provided the necessary preparedness for the next stage which was implementation.

The introduction of the two MDI machines has already been described in Chapter 5, and the initial successes and results were given in Chapter 8. This chapter will discuss the implementation of the plans for the other machines, up to the time of writing (May 1982).

In each case, before any plan was implemented, a thorough financial evaluation of the proposal was performed to assess viability. This was particularly important in cases where new products would involve large amounts of capital and technical expenditure.

9.2 KNEE AND COLUMN MACHINING CENTRE

Although this machine has already been launched, there is some suggestion that it may not be competitive and therefore not achieve the strategic goal of sectoral market dominance.

Plans have been made so that if this should happen, then a new knee and column machining centre will be developed to offer increased technological value-for-money.

This additional investment is consistent with the sectoral strategies which have been developed for this product range.

9.3 HORIZONTAL MACHINING CENTRES

Since these machines represented a new venture for the company, the implementation was approached with a high degree of formality and rigour.

The early stages of implementation therefore involved a considerable number of reports based on the findings of strategic planning, forecasting and marketing research.

These reports were used by senior management as important sources of information when making decisions about future new products, and in this way, in September 1981, the decision was made in principle to proceed with the introduction of horizontal machining centres.

It was immediately apparent that the biggest problem would be in meeting the requirement to launch the machines before the end of 1982. This was because the development of a radically new machine tool usually takes between two and three years at least, and often longer in practice.

Several alternative solutions to this problem were identified and investigated during October 1981. The alternative included concentrating the entire engineering effort of the company into this project, at the expense of every other project, or else sub-contracting or recruiting additional engineering staff, but it was doubtful if even this would achieve the timescale improvements which were required.

All the existing products were examined for the possibility of using them as a basis for a horizontal machining centre, but there was no satisfactory alternative to a purpose designed machine.

Factoring and building under licence were also considered. These were very attractive alternatives as they provided minimum risk solutions, offering proven and fully developed machines in the shortest possible time.

Building under licence had particular attraction since this method would utilise existing manufacturing facilities and therefore provide an injection of expertise into every department of the company. In addition there is one major disadvantage in factoring which a licencing agreement would overcome, and that is that factoring would normally be restricted to the U.K. market only since the international markets would be served by other distributors appointed by the original manufacturer. This is an important consideration in view of the strategic importance of export markets (See Section 7.4).

Following this investigation in October 1981, a report was presented which made recommendations that suitable partners be sought for a licence agreement. The decision was made to proceed and the subsequent investigation soon narrowed the search to Japanese manufacturers. The reasons for this were as follows:

1. Between them, Japanese manufacturers had over 50% of the world market and thus the greatest accumulated experience.

2. The strength of the Japanese infrastructure in component parts (controls, leadscrews, motors etc) means that many manufacturers worldwide already use this equipment. A Japanese partner would provide direct access to this infrastructure.

3. Collaboration of this nature would be most attractive to Japanese manufacturers who are under increasing pressure to limit their exports to the E.E.C. and U.S.A.

4. The deal would effectively eliminate a Japanese competitor.

5. A licencing agreement would necessarily exclude potential sales in the country of origin of the machines. Since high sales volumes could never realistically be expected into Japan, a Japanese sourced machine would offer maximum export potential.

6. Japanese manufacturers seem to be attracted to agreements involving the U.K. This is illustrated by the large number of direct and co-operative ventures already in operation. This is probably because of the combination of wide geographic separation, accessibility to the E.E.C., and the English language.

9.3.1 INVESTIGATION OF JAPANESE MANUFACTURERS

A comprehensive investigation was conducted into Japanese manufacturers of horizontal machining centres. This investigation resulted in a comprehensive 100 page report entitled "JAPANESE HORIZONTAL MACHINING CENTRES UNDER 10 H.P. – The Machines, Manufacturers and European Distributors" which was issued at the end of October 1981.

In this report 41 manufacturers of machining centres were identified, 23 of which sold horizontals under 10 h.p.

Each of these 23 manufacturers was examined in depth and a considerable amount of information was obtained about each one. This information came from Trade Directories in the Japan Trade Centre in London, from magazines (especially "Metalworking, Engineering and Production") and from the JMTBA Year Books (ref. Anon (JMTBA) 1981, JMBTA 1981).

The accumulated information on each manufacturer was summarised in a standardised format (Figure 9.1) and where necessary, some estimates were made so that a comprehensive comparison could be made.

The 23 manufacturers were found to be building 50 different models and the full technical specification of each of these fifty machines was included in an appendix.

Once this information had been collected, the companies were compared using various parameters and a selection process was developed using the following criteria:

1. <u>MARKET LEADERSHIP</u>

It was felt that market leadership was an important criterion as leaders have high production and sales volumes and the benefits accruing from high market share and experience.

2. <u>SPECIFIC EXPERTISE</u>

Companies were rated on the length and breadth of their experience with horizontal machining centres in particular.

3. <u>SMALL MACHINING CENTRE EXPERTISE</u>

Several manufacturers had entered the market through larger type machines such as horizontal borers. These companies were given a lower rating than those who had accumulated experience in the design and manufacture of the smaller purpose-designed machines.

4. <u>MACHINE SPECIFICATION</u>

Two companies (Roku Roku and Fanuc) were eliminated completely for offering only a single machine of below No. 1 size capacity. (It was, in fact, the same model offered by both companies). Another manufacturer (Wado) was eliminated for offering only a single model of unconventional design and with no APC facility and limited auto toolchanger.

5. <u>MACHINE CONTROL</u>

Companies who could not offer the world leading Fanuc control were considered to be less attractive partners.

6. <u>WIDTH OF PRODUCT RANGE</u>

It is conceivable that additional licencing or factoring requirements could arise in the future. Companies which manufactured vertical machining centres and/or N.C. lathes were consequently given a higher ranking under this criterion.

7. JMTBA MEMBER

It was felt that more confidence could be held in a company which was a member of the builders association. All companies except Wado were members in 1981.

8. COMPANY SIZE

Companies were rated by capitalisation, number of employees and turnover of the machine tool division. Manufacturers with large company back-up were also recorded.

9. STRONG EUROPEAN CONNECTIONS

Some manufacturers (for example Makino, Toyoda) had already established European manufacturing agreements, and others were planning to start direct European operations (for example Yamazaki) and so these could be eliminated from the search.

10. EUROPEAN REPRESENTATION

Existing arrangements included the use of distributors, direct sales operations and/or arrangements with the large Japanese trading houses. For some companies coverage was wide and thin and for others it was patchy. Information was sought on the quality, standing, capability and performance of each of these distribution channels. To this end, all the company's European distributors were interrogated and interviews were held with U.K. merchants. Further information was obtained from experience within the company. Trade Directories such as Kompass and Dun and Bradstreet provided some additional data on the U.K. distributors.

From this information, some degree of performance ranking of each firm, by country, was achieved.

9.3.2 THE SHORTLIST

On the basis of the above selection criteria, four manufacturers were found to meet every requirement and these were placed on a shortlist. A second choice list was also compiled which comprised the companies which failed to satisfy on only one of the minor factors. Five companies were placed onto this second choice list.

After extensive discussions within the company a final selection was made of four companies, two of which were taken from the original shortlist, the other two coming from among the second choices.

In December 1981, the four companies were each presented with a proposal by the chief executive in person and subsequent discussions and further visits by company directors are expected to result in an announcement being made later in 1982 or during 1983.

9.4 VERTICAL MACHINING CENTRES

Throughout this work, little reference has been made to the requirements of the American markets. This is because of the sister company which is located in the U.S.A. and serves these markets. It is a large machine tool company which is approximately three times the size of the U.K. facility.

It is consequently incumbent upon this company to identify and satisfy the needs of American markets (U.S.A. and Canada in particular). Work in this area in the U.S.A. has produced proposals for a comprehensive range of vertical machines. Within this range is a vertical machining centre which is closely suited to the U.K. requirements which have been identified here.

This machine is expected to be launched in the U.S.A. this year, and if satisfactory, will be subsequently introduced into the U.K. and world markets.

CHAPTER 10

CONCLUSIONS

10.1 INTRODUCTION

This work has described the development and implementation of a new product methodology within a major machine tool company. The conclusions which have been drawn from this work will be presented in this chapter.

In the first part, conclusions arising from the overall methodology will be discussed and these will be followed by a summary of the conclusions which have been drawn from the individual elements of the methodology. The final section of this chapter will present the conclusions to date regarding the practical implementation and success of the project as a whole.

10.2 GENERAL METHODOLOGY CONCLUSIONS

10.2.1 THE MODIFIED METHODOLOGY

It has been shown how a conventional approach to new product development was initially tried, but for a number of reasons, this approach was found to be unsatisfactory and so a modified methodology was developed (see Figure 2.9).

The experience gained in implementing this modified methodology has revealed some important benefits and so it is a conclusion of this work that conventional new product development procedures can be improved by adopting this modification.

The major benefits resulting from this improved methodology include:

1. Strategic market planning requires an understanding of corporate planning parameters such as business definition, the company's strengths and weaknesses and objectives and goals. Since strategic market planning is the first stage in the modified methodology these important considerations are consequently fully considered and form the foundation of the new product planning process.

2. Communication of ideas with senior management is improved since the modified methodology is an extension to and compatible with senior management's corporate thinking.

As a result it has been found during this project that most proposals have been generally considered reasonable and very little selling of ideas has been required.

3. The process of developing plans for each sector of the product portfolio clearly identifies the role of new product development and in this way provides a valuable insight which is of assistance at each subsequent stage in the methodology.

4. Strategic market planning reduces the need for idea generation. The generalised ideas which are suggested from the planning process effectively narrow the search area for new products.

5. Product ideas which are developed directly or indirectly from strategic market planning require considerably less screening than ideas generated from other sources since they are basically compatible with the company's technical, financial and marketing criteria and consequently profile matched.

10.2.2 IMPLEMENTATION

There are a number of factors which cause the practical implementation of the methodology to be rather different from the idealised model which was given in Figure 2.9.

It has been shown how the step-by-step approach of Figure 2.9 developed into a complex network of iterations which is shown diagrammatically in Figure 8.1.

It is therefore concluded that the idealised representation of the methodology is a useful tool for communication but in practice the new product development process is considerably more complex and continuously changing.

Some of the factors which have contributed to these changes and others which will result in future change are given below.

1. Environmental Factors. With the passage of time, environmental factors change and present fresh opportunities or threatening developments. In addition, ideas change, technological developments occur and fresh information is accumulated. These factors all combine to make new product development a continuous process and not a simple sequential activity.

2. Major Events. The random timing of major contributory events such as exhibitions and forecasting seminars also tends to disrupt the strictly sequential approach of developing new product strategies.

3. Position on the Business Cycle. The state of the economy affects short and medium term corporate priorities and strategies. The availability of cash and the preparedness to take risks will also change relative to the fluctuations in the business cycle.

4. Technological Substitution. The replacement of conventional machines with N.C. encourages use of substitution forecasting. This technique will become less relevant in the future as an increasing number of machines become numerically controlled.

5. Field Research. If more use was made of direct customer contact techniques, then valuable information could be generated in the areas of idea generation, market analysis and forecasting. Less emphasis would then be placed on alternative desk research methods.

6. Information Systems. As experience is gained and effective information monitoring systems are set up, then the time to develop new product strategies will consequently decline.

10.3 CONCLUSIONS FROM USING THE BOSTON MATRIX

There are four principal conclusions which have been drawn following the experience gained in using the Boston matrix.

1. It is simple to use and to understand and is consequently a powerful tool for communication. The matrix concept was quickly understood by all levels of management within the company and the jargon soon entered everyday vocabulary ("STARS" etc). This is a very significant advance in a company which historically has been production orientated.

This conclusion is parallel to Hussey's experience with the Directional Policy Matrix. He says "I would set the value of the use of the technique in this way (communications) as about equal to its value as a tool for strategic analysis". (Ref. Hussey 1978).

2. It is a valuable diagnostic tool. In this work the matrix was used only as a simple graphic aid to help understand product strengths and weaknesses and to suggest the sort of balanced portfolio at which to aim.

Most criticisms of the matrix arise as a result of developing the techniques beyond this relatively superficial level and so have not proved to be a problem in this application.

3. The Boston Matrix is a valuable tool for examining and analysing the current state of the portfolio, but to be an effective planning tool, it needs to be complemented with time based techniques which can examine the historical progress and future development of the product range.

The need for complementary forecasting was identified by Abell (op cit) and was satisfied in this work partially by Substitution Forecasting, but mainly with Product Life Cycle analysis.

4. Unless there is a wide commitment by a number of senior and experienced personnel within the company, then the Boston Matrix is a more suitable tool than the more sophisticated "Market Attractiveness" types.

10.4 CONCLUSIONS FROM USING THE PRODUCT LIFE CYCLE CONCEPT

From the experience gained in using the PLC in this work, the following conclusions have been made.

1. The PLC is a valuable complementary technique to the Boston Matrix. The PLC concept is not only conceptually compatible with the Boston Matrix but it also reveals the unfolding development with time of each product in the portfolio. In this way, the PLC provides the third (time) dimension to the Boston Matrix.

2. The conventional PLC cannot be used directly in cases where the business cycle has a large amplitude. A modified PLC has been developed which is based on market share and this overcomes these difficulties.

3. The PLC is simple to use and understand and consequently provides a valuable tool for communication.

4. The modified PLC provides a very powerful tool for sales forecasting and also forms the basis for Gap Analysis.

It has been found that the forecasts developed using the PLC concept exhibit a high degree of realism.

5. Problems associated with international statistics limit the applicability of the PLC in its modified form. It was found in this work that the PLC could only be accurately used in the UK market and was thereby limited.

6. Some evidence has been found in support of the theory that PLC's are shortening with time.

10.5 CONCLUSIONS FROM IDEA GENERATION AND SCREENING

1. It has already been shown how the need for idea generation and screening is reduced when strategic market planning is performed. During the course of this work a second factor emerged which also reduced this need. This was that the company was found to adopt a basically conservative strategy. In this way, low risk new products are preferred and "follower" type strategies are more acceptable than "leader" types.

It can therefore be concluded that in such a strategically conservative environment, then the need for formal idea generation and screening methods is reduced.

2. It is concluded that the processes of idea generation, screening and specification refinement could have been improved if direct customer observation and interrogation techniques had been performed.

3. It is concluded that, where customer interrogation techniques are not possible or applicable, then a substitute method can be used which comprises the following stages:

a. Identify current and historic requirements of existing customers using internal sources (customer lists, guarantee cards, salesforce etc).

b. Determine total market requirements from examination of workpiece statistics and machining surveys.

c. Identify market opportunities by thorough analysis of competition.

d. Project trends using technological and substitution forecasting techniques.

e. Maintain surveillance of published reports and surveys.

10.6 CONCLUSIONS FROM PERFORMING MARKET ANALYSIS

1. Market analysis has been found to be the key element in the new product development process (see Figure 8.1). It provides an input to every stage and technique in the process and also supplies information upon which decisions can be taken.

2. Market analysis should comprise all three of the following elements:

a. Statistical Market Research.

b. Competitor Research.

c. Customer Research.

In this work, customer research was inadequately performed because of the lack of field research and so potentially valuable information was not available (.e.g. who is buying what type of machine for what purpose and are they satisfied with it?)

3. Statistics for the Machine Tool Industry are reasonably well documented worldwide, but these statistics do require a certain amount of care in interpretation because of difficulties experienced in classification and compatibility.

4. A thorough investigation of international machine tool exhibitions provides an extremely valuable contribution to competitor analysis.

Additional benefits can be gained when these exhibitions are held overseas as this provides an additional international perspective to the analysis.

10.7 CONCLUSIONS FROM FORECASTING

1. New products, by their nature, will be introduced and sold in the future. Forecasting is consequently vital to all aspects of new product development, and for machine tool applications both technological and economic/sales forecasting needs to be performed.

2. In industries subject to a high amplitude business cycle, it is extremely valuable to separate the cyclic component from the underlying trend prior to forecasting.

3. The prediction of turning points in the business cycle can be performed considerably more accurately than amplitude forecasts.

This has been found to be true, not only in forecasts performed in this work, but also from the published work of professional forecasters.

4. It has been found to be beneficial to use a number of different forecasting techniques when preparing a sales forecast.

5. There are two types of new product for purposes of sales forecasting:

a. The replacement new product where some historical data is available and
b. A product which is completely new to the company.

It has been found that these two product types require different forecasting methods.

6. The mechanism by which numerical control is replacing conventional machines has been shown to be technological substitution.

The Fisher-Pry forecasting technique is consequently an appropriate tool during this transition period, and the results to date suggest that it can be a reasonably accurate forecasting method.

7. The Fisher-Pry technique can, under certain conditions, be successfully used for forecasting sales of particular types of CNC machines.

In this work, manual toolchange CNC machines have been successfully forecast using this technique (see Section 7.5.2), but attempts at forecasting machining centres have proved to be less satisfactory.

8. The wide range of published forecasts relating to manufacturing technology and machine tools can provide a substantial contribution to new product development in the machine tool industry.

9. It is unlikely, in the medium or long term, that the UK machine tool market will substantially recover from the decline experienced in 1980/1981.

10. It is anticipated that the world market for machine tools will make a normal cyclic recovery.

11. From the above conclusions it is evident that export markets will become increasingly more important to UK based machine tool manufacturers.

10.8 OVERALL PROJECT CONCLUSIONS

In Chapter 8, the initial results of the No. 1 size MDI machine were shown to be very good. It could be concluded from this that the methodology has been proven. There are, however, some other considerations which should be noted.

Firstly, the machine was, to some extent, a replacement new product, the risk factor was therefore fairly low, and the likelihood of success consequently greater.

Secondly, this machine was conceived when the methodology was partially developed. Technological and Substitution forecasting was virtually complete and strategic market planning had identified the need for the machine in broad outline. However, the competitor analysis had not been fully completed and the important PLC analysis was not developed until after the machine was specified.

It can be concluded, therefore, that the methodology made a contribution to the development of the successful MDI machine.

The case for the machining centres is much more certain since the full rigour of the methodology has been used to develop these product strategies. Unfortunately, the success of these particular new products will not be known for another 12 - 18 months until after the machines are launched.

The machining centres which have been proposed using this methodology are, however, now part of the company's current five year plan and implementation is well under way (see Chapter 9).

Since this implementation involves considerable capital expenditure, it can be seen that the company has confidence in the proposed portfolio.

It is therefore reasonable to claim success for the methodology, firstly for its contribution to the development of the two MDI machines and secondly, from its acceptability in providing a new product portfolio which has been accepted and adopted by the company.

Further evidence in support of this claim can be found in the fact that the methodology is currently being used for subsequent generations of machine tools, and that the author of this thesis was at one stage invited to continue this work at Corporate Headquarters in the U.S.A.

It can therefore be concluded that with careful selection of suitable techniques the modified methodology can be successfully used in a machine tool company to develop new product strategies.

APPENDIX A

IDEA GENERATION QUESTIONNAIRE

A.1 DESCRIPTION

This appendix contains a copy of the questionnaire and covering letter which were intended for distribution within the company to draw upon the internal resources for purposes of idea generation and specification refinement.

In this way, it was to have been used as step 3 in the original programme shown in Figure 2.1 and described in Section 2.2.2.

The questionnaire had an intended circulation of 69 people including Directors, home and international Salesmen, technical and quality personnel, selected Service Engineers and Production Managers.

Dear

As has become increasingly apparent in the last few years, new products are the lifeblood of industry, and well-researched successful new products are essential to prevent the decline which would otherwise be caused by the fall off in sales.

In line with other successful companies we are looking at new products by determining the needs of our customers and providing new machines to satisfy those needs.

The initial stage of this process is to develop one or two design concepts for full market analysis. One of the best methods of developing these concepts in our type of business is to select a sample of expert opinion from within the company and perform a survey.

Your opinion is therefore being sought of the market requirements of Leicester type machines, based upon your past and current experience. To make the results of this survey more uniform and simpler to analyse a questionnaire has been designed (your copy is attached). Please feel free to amplify your answers with comments wherever applicable.

For the purposes of answering the questionnaire consider a machine to be launched in three years time and still selling 1990.

Do not feel obliged to answer any questions about which you entertain any doubts.

The marketing department will respect your confidentiality and no information that you may give will be passed from the department.

Thank you in anticipation of your co-operation.

Yours sincerely,

Stephen LeBeau
Product Researcher

SAL/ls

CONFIDENTIAL

RESPONDENT: POSITION: COMMENTS REF

SECTION A - GENERAL

A1 Taking the 2S Machine as an average what capacity compared with the current 2S machine do you consider would be the most profitable for us to make?

- Rather Less than 2S ☐
- Slightly Less than 2S ☐
- 2S Capacity ☐
- Slightly Greater than 2S ☐
- Rather Greater than 2S ☐
- Other (Please State) ....

A2 Which method of machine control do you consider would be the most profitable over the next decade?

- Manual ☐
- Manual With Power Feeds ☐
- Manual With Tracing Option ☐

A2 continued ...			COMMENTS	REF
	Plugboard	☐		
	Manual Data Input (M.D.I.)	☐		
	C.N.C.	☐		
	C.N.C. With Handwheels	☐		
	Other (Please State)			
A3 For which machine configuration do you consider there is the greatest market potential over the next decade?	Knee and Column	☐		
	Bed Type	☐		
	Machining Centre	☐		
	Configuration unimportant	☐		
	Other Please state			

									COMMENTS	REF
A4	Which spindle orientation would be the most marketable?	Horizontal ☐								
		Vertical ☐								
		Universal Head ☐								
		Other (Please State)								
A5	What Selling Price (at todays prices) do you consider would be competitive for the type of machine you have indicated?	£ ☐								
A6	How strong is competition for the machine type indicated above ?	Intense	Considerable	Moderate	Slight	Nil	Unsure			
	By United Kingdom Manufactures	☐	☐	☐	☐	☐	☐			
	By Imported Machines	☐	☐	☐	☐	☐	☐			

MILLING MACHINES FITTED WITH THE FOLLOWING FEATURES SELL BETTER		Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree	COMMENTS	REF
A7	Infinitely variable speeds	☐	☐	☐	☐	☐		
A8	Infinitely variable feeds	☐	☐	☐	☐	☐		
A9	Larger than average Table Size	☐	☐	☐	☐	☐		
A10	Greater than average range of speeds	☐	☐	☐	☐	☐		
A11	Greater than average spindle power	☐	☐	☐	☐	☐		
A12	More rapid than average rapid traverse	☐	☐	☐	☐	☐		
A13	Hardened Slideways	☐	☐	☐	☐	☐		
A14	Ball Lead Screws	☐	☐	☐	☐	☐		
A15	Power Feeds to Axes	☐	☐	☐	☐	☐		
A16	Pendant Controls	☐	☐	☐	☐	☐		

							COMMENTS	REF
A17	Multiple Operating Positions	☐	☐	☐	☐	☐		
A18	'Joystick' type control for power feeds	☐	☐	☐	☐	☐		
A19	Coolant tanks removeable for cleaning	☐	☐	☐	☐	☐		

SECTION B - OPTIONS

IT IS IMPORTANT TO OFFER THE FOLLOWING OPTIONS WITH MILLING MACHINES IN ORDER TO INCREASE THE SIZE OF THE MARKET AND MAKE THE MACHINES SELL BETTER

		Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
B1	Universal Head	☐	☐	☐	☐	☐
B2	Digital Readout	☐	☐	☐	☐	☐
B3	Automatic Cycling	☐	☐	☐	☐	☐
B4	Universal Table	☐	☐	☐	☐	☐
B5	Adaptive Control	☐	☐	☐	☐	☐

							COMMENTS	REF
B6	In process gauging (on the machine)	☐	☐	☐	☐	☐		
B7	Shuttle Pallet Loading	☐	☐	☐	☐	☐		
B8	Robots	☐	☐	☐	☐	☐		
B9	Special Fixturisation design service provided by Bridgeport	☐	☐	☐	☐	☐		
B10	Automatic Tool Changing	☐	☐	☐	☐	☐		
B11	Dividing Head	☐	☐	☐	☐	☐		
B12	Rotary Table	☐	☐	☐	☐	☐		
B13	Swarf Removal Systems	☐	☐	☐	☐	☐		
B14	Independently powered overarm spindle	☐	☐	☐	☐	☐		
B15	Other(Please State)							

Continued Overleaf ....

DO YOU CONSIDER ?		Very Little Important	Somewhat Important	Important	Very Important	Absolutely Important	COMMENTS	REF
C1	Complying with the Health And Safety Act	☐	☐	☐	☐	☐		
C2	Reducing Operator Skill	☐	☐	☐	☐	☐		
C3	The Amount of Floor Space Taken Up	☐	☐	☐	☐	☐		
C4	Reliability	☐	☐	☐	☐	☐		
C5	Noise Level	☐	☐	☐	☐	☐		
C6	Operating Cost	☐	☐	☐	☐	☐		
C7	Payback Period	☐	☐	☐	☐	☐		
C8	Competitiveness Of Price	☐	☐	☐	☐	☐		
C9	Positioning Of Machine Controls	☐	☐	☐	☐	☐		
C10	Convenient table working height	☐	☐	☐	☐	☐		

SECTION D				COMMENTS	REF
D1	PLEASE INDICATE ALL FEATURES OF MILLING MACHINES DESIGN, PRODUCTION, MARKETING SERVICING ETC WHICH ARE <u>NOT LIKED</u>?				
D2	These processes are making increasing inroads into the milling machine market and are taking an increasing share of the business				
		Agree	Disagree	Uncertain	
	Grinding Processes	☐	☐	☐	
	Electrical Machining	☐	☐	☐	
	Forming/Forging	☐	☐	☐	
	Precision Casting	☐	☐	☐	
	Plastics	☐	☐	☐	
	Others (Please State)				

When completed, please return to Stephen LeBeau, Research Design and Development,

Thank you for your co-operation,

APPENDIX B

MDI USER SURVEY QUESTIONNAIRE

B.1 DESCRIPTION

This appendix contains a copy of the questionnaire which was completed by the company's Salesmen in conjunction with each of the first 38 purchasers of the No. 1 size MDI machine.

The survey was limited to these early adopters in order to determine the rates of substitution of the new machine for existing products, be they manual or CNC.

The survey was performed in October/November 1981 and the results are described in Chapter 5 under Section 5.4.

M.D.I. USERS SURVEY

To help us achieve even greater sales of this machine, it would be helpful to have the following information on each order you have already won.

Please complete one form for each machine ordered.

1. Customer's Name......................................

2. Location...

---

3. Was this customer previously a user of our products?

YES	☐
NO	☐

---

4. If YES, please state the number of machines he uses. (Insert quantity in box.)

Turret Mills	☐
CNC	☐
No. 1 size	☐
No. 2 size	☐
Others (please state)	☐

---

5. Do you feel that this order is new business with this customer or would he have placed an order with us for another type of machine?

New business	☐
Would have ordered alternative	☐

Continued/....

6. If you had not sold an M.D.I. do you feel that your customer would have definitely bought any of the following machines?

	Immediately	In 1 month	In 6 months
No. 1 Turret	☐	☐	☐
No. 2 Turret	☐	☐	☐
No. 1 CNC	☐	☐	☐
No. 2 CNC	☐	☐	☐
Retrofit CNC system	☐	☐	☐
Nothing	☐	☐	☐
Competitors machine	☐	☐	☐
2nd. hand machine	☐	☐	☐

---

7. Which were the most attractive features to this customer at the time of purchase?

Ease of programming	☐
Price	☐
Performance	☐
Handwheel capability	☐
Company reputation	☐

---

8. Your Name.................... Area No. ......

APPENDIX C

MACH 80 EXHIBITION COMPETITOR SURVEY

C O N F I D E N T I A L

SURVEY OF N.C. MILLING MACHINES

AND MACHINING CENTRES

CONDUCTED AT

1980 INTERNATIONAL MACHINE TOOL EXHIBITION-MACH 80

For the Attention of

Copies to:

S. LeBeau

May 1980

SUMMARY

The report describes the collection of data from MACH 80 on Numerically Controlled Milling Machines and Machining Centres. 82 Variations of 65 machines are tabulated in alphabetic order and are also classified by size into five groups. Information on exhibitors is also given.

The data has been analysed to give graphs of average selling prices and of national tendencies.

'Holes' in the market have been identified for further market research.

One of these holes identified the need for a mid range Horizontal machine. The choice of a 2S size machine for the next new product has also been confirmed by discovering a market hole.

The size of the U.K. market for a 2S capacity machine has been estimated at currently 250 machines p.a. worth about nine million pounds and growing rapidly.

CONTENTS

1. INTRODUCTION

An important part of any Market Research project is a survey and analysis of the competition. The current / /University Of Aston project is no exception to this rule and MACH 80 provided an ideal opportunity to perform this survey.

Previous work on the project has already isolated the growth area as in numerically controlled machines and so the survey was limited to looking at these machines. Every numerically controlled milling machine at the show was examined.

2. DISCUSSION OF VALIDITY

Although it was possible to obtain data on all the N.C. machines at MACH 80, it was not possible to obtain data on all N.C. machines on the Market.

These would fall into four catagories:-

1. Additional Machines In The Range Of The Type Exhibited.
   - For this case the machines on show would be representative and probably the most marketable configuration manufactured.

2. Machines At Other Exhibitions.
   - At least one machine (the Wanderer) was at another show in Germany, but this action signifies that the home German Market is more important than the export market and thus the machine is of no interest in this survey.

3. Companies Not Exhibiting at MACH 80
   - There were no significant absentees from the exhibition

4. Show Machine which have previously been sold
   - This unlikely event was investigated and the result showed the opposite to be more true, that tendentious machines previously sold were on show

On the other hand, there may have been, at the Exhibition, non-representative machines which should not be included in the survey. These could fall into three types:

1. Prestige machines shown to demonstrate Exhibitor's technical excellence.

-A medium sized stand could cost £1000 per hour to operate and so this is an expensive piece of publicity. Machines of this type would easily show up in the sales quantity figures and be eliminated if necessary. Any machines found in this catagory were not eliminated because since machines of this type are in a growth market they are useful indicators even if not significant in terms of sales.

2. Prototype Machines not yet available.
-Examples of this are the Bridgeport ATC and the Beaver NC10. These machines have been included for the same reasons as for one above.

3. Machines on show which have been sold to UK customers, and would otherwise not have been on show.
-An example of this is the Whali Machining Centre. These machines have been sold in the UK and are therefore considered to provide extremely valuable information. They are considered to be a bonus to the survey.

Conclusion

It is concluded that the machines on show at the Exhibition are representative of the most marketable and numerically controlled products that the exhibitors have to sell not only for this year but for a couple of years to come.

It is also concluded that the large quantity of machines covered provides more of a consensus survey than a sample, and so any conclusions drawn have a high degree of validity.

3. METHODOLOGY

A survey of this type to determine technical and marketing facts can be performed by using either a questionnaire, framed interview or an open ended interview.

In the former, the respondent is led through a series of questions while the interviewer completes a questionnaire, while in the latter apparently random open-ended type questions are used to which the respondent answers freely in his own words.

It was decided to use an open-ended type interview for the following reasons :-

1. Open ended questions tend to produce 'richer' information. This was, in fact, found to be true and confidential information regarding the quantity and rate of sales of machines was obtained in 25% of the cases interviewed. It would have been impossible without causing suspicion to ask for this information on a fixed format questionnaire.

2. The technique is more informal and puts the respondant at ease, creating a situation with which he is used.

3. Presenting a questionnaire defines a timescale for answering, a factor which could easily discourage a respondant, particularly if the stand was busy.

4. Even the remote possibility that the questions were being asked with a machine purchase intention would provide the respondant with the incentive to answer fully and freely. Answering a questionnaire would obviously not result in a sale.

5. The breadth of questions could be maintained in an informal interview by obtaining factual technical data from the sales literature, and concentrating the questioning on Marketing facets which would be noted after leaving the Stand.

Identity

The identity of the interviewer was described as 'Researcher' University Of Aston. When questioned further it was admitted that the research was sponsored by

4. RESULTS

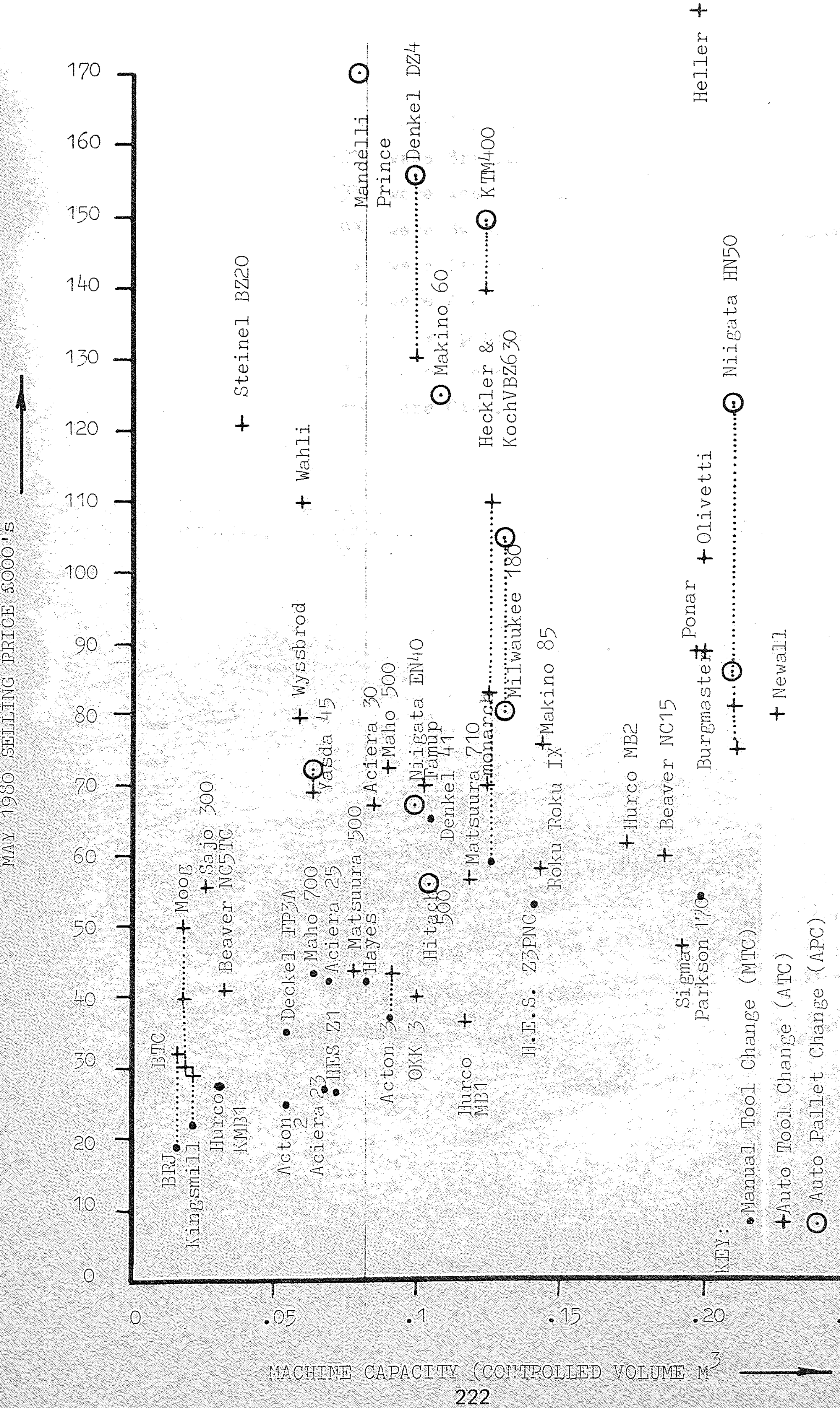
4.1 General

All numerically controlled milling machines including retro-fitted manual machines and machining centres exhibited at MACH 80 were studied.

Data has been obtained on 65 different machines (82 machines including variations). This figure is still increasing as further quotations are being received.

The price vs machine capacity has been plotted for each machine and is shown in Fig. 1. Machine capacity for purposes of this analysis is defined as the total controlled volume = X x Y x Z.

FIGURE C.1



PRICE OF N.C. MILLING MACHINES Vs. CAPACITY (May 1980)

Of the machines at the show,

23%	were Japanese
20%	were British
15%	were West German
9%	were Swiss
8%	were Italian
8%	were American
6%	were Spanish
3%	were French
8%	were Others

4.2 Technical Sophistication

Automatic Tool Change (ATC)

100% Japanese machines had ATC fitted
64% U.K. Machines had ATC fitted
63% West German machines had ATC fitted

Automatic Pallet Change (APC)

Of the eleven APCs at the Exhibition,
6 were Japanese
1 was U.K.
1 was West German

NUMERICALLY CONTROLLED MILLING MACHINES IN ALPHABETICAL ORDER

MAKE/MODEL	CONTROLLED AXES X	Y	Z	CONTROLLED VOLUMN(M^3)	H/V	HP	SALES	DATE OF UK LAUNCH	BASIC PRICE £
ACIERA									
23TNC	500	300	450	.067	V	2			26700
25NC	500	300	470	.070	V	3			42000
NC30	600	300	470	.085	V	5	1-France 1-Switzerland 0-UK	1980	67000
ACTON									
Power Centre III	914	500	200	.091	V	5)		1978	43750
Powermil 2	914	400	152	.056	V	3)	TOTAL 150	1978	24950
Powermil 3	914	500	200	.091	V	5)		1978	36750
BEAVER									
NC5 ATC	600	360	152	.033	V	5	200/6 per month		41000
NC15	750	500	500	.187	V	10	2 Sold Batch = 12	1980	60000
NC10	750	500	500	.187	H	13.4	0	1981	60000

MAKE/MODEL	CONTROLLED AXES X	Y	Z	CONTROLLED VOLUMN (M^3)	H/V	HP	SALES	DATE OF UK LAUNCH	BASIC PRICE £
BROWN & SHARP									
1000VC	1016	635	550	.355	V	7.5	World 350)	1978	93135
1500VC	1500	760	635	.724	V	10	UK 23+)	1976	117970
BURGMASTER									
HTC 325	915	610	355	.198	H	7.5	0 U.K.	1980	89000
T220					V				45000
CINCINNATI									
10HC	1000	1000	660	.660	H	10		1980	112000
10HC + APC Etc									140000
DECKEL									
DZ4	500	400	500	.1	H	10			130000
DZ4 + APC etc									156000
FP41NC	770	370	370	.105	V	5	?		65000
FP3A	490	290	390	.055	V	5	?		35000
ELLIOTT									
Sturdimatic 300									56000

MAKE/MODEL	CONTROLLED AXES X	Y	Z	CONTROLLED VOLUME(M^3)	H/V	HP	SALES	DATE OF UK LAUNCH	BASIC PRICE £
H. ERANULT SOMUA									
Z3 PNC	1000	320	440	.141	H	10			52780
Z1	720	250	400	.072	H	4			26250
FAMUP									
Uniforall CN1	550	400	470	.103	V	6	15 France	1974 Italy 1980 UK	70000
GASTON DUFOUR									
T7000					H		12 France		155000
HAMAI									
MC 50V	1100	700	500	.385	V	15	0	1980	75450
HAYES									
No 2	711	305	381	.038	V	7.5			42000
HECKLER & KOCH									
VBZ630(Point-Point)	630	400	500	.126	V	20			59000
VBZ630(Point-Point)	3 Axes Contouring Plus 20 Tool ATC								83000
VBZ630(Point-Point)	4 Axes Contouring Plus 40 Tool ATC								110000

MAKE/MODEL	CONTROLLED AXES X	Y	Z	CONTROLLED VOLUME(M^3)	H/V	HP	SALES	DATE OF UK LAUNCH	BASIC PRICE £
HELLER									
BEA1-H	630	500	630	.198	H		At Least 1 to Motor Industry	1977	180000
HITACHI-SEIKI									
MN500	600	500	350	.105	H	5	0	1980	56000
630					H				8/90000
HURCO									
KMB1	610	355	150	.032	V	2.5		MID 1978	27000
MB1	760	380	405	.117	V	3	80		37000
MB2	810	420	510	.173	V	6			62000
KEARNEY & TRECKER									
Milwaukee Matic 180	508	508	508	.131	H	10			78000
Milwaukee Matic 180 Tooled Plus Full CNC									105000
KINGSMILL									
K600	735	355			V	3)		1978	18991
K600DC	735	355			V	3)	20	1978	21500
K700	600	300	120	.022	V	2)		1978	22616
24 Tool Changer									6990

MAKE/MODEL	CONTROLLED AXED X	Y	Z	CONTROLLED VOLUME(M^3)	H/V	HP	SALES	DATE OF UK LAUNCH	BASIC PRICE £
KTM									
400	500	500	500	.125	H	10			140000
400 With 4APC									150000
2500	2500	1000	600	1.500	H	20			200000
MAHO									
MC500	500	400	450	.09	H	5.3			72600
MH-C700NC	500	400	400	.064	H	5.3			41500
MAKINO									
MC100	1000	800	630	.504	H	15			150000
MC60	600	400	450	.108	H	10			125000
FNC85-A20	860	410	410	.144	V	7.3			76000
FNC125-A24	1250	700	600	.525	V	14.7			90000
MANDELLI									
Regent	2800	1200	1200	4.032	H	14.7			300000
Prince 500u	500	400	400	.08	H	10	6 - UK	1979	170000
MATRIX									
V50	1000	500	870	.435	V	15	7 Sold 7 On shop		92000

MAKE/MODEL	CONTROLLED AXES X	Y	Z	CONTROLLED VOLUME(M^3)	H/V	HP	BALES	DATE OF UK LAUNCH	BASIC PRICE £
MATSUURA									
MC500V	510	330	460	.077	V	4.7	15 Sold Now 2/month Soon 4/month		44200
MC710V	710	350	475	.118	V	6			57000
MC1000V	1016	508	530	.273	V	13			80000
MC1500V	1524	635	600	.580	V	13.3		1980	106000
MONARCH									
VMC 75	1000	500	250	.125	V	7.5			70000
MOOG									
Super 10	500	250	150	.019	V	5			30000
Model 1000					V				40000
Model 3000	500	250	150	.019	V	5			50000
NEWALL									
Vertex 200	900	500	500	.225	V	10	9 Sold-Aero 3 to China	1976	80000
NIIGATA									
EN40	500	400	500	.1	H	6			67200

MAKE/MODEL	CONTROLLED AXES X	Y	Z	CONTROLLED VOLUME(M3)	H/V	HP	SALES	DATE OF UK LAUNCH	BASIC PRICE £
NIIGATA CONT.									
HN50	650	650	500	.211	H	10			75320
40 Tool ATC Instead of 30ATC									2890
60 Tool ATC Instead of 30ATC									5800
2 Pallet APC									11050
6 Pallet APC									33500
12 Pallet APC									43750
NC Rotary Table									6450 EA
HN70	900	800	600	.432	H	10			96400
40 Tool ATC Instead of 30									3300
60 Tool ATC Instead of 40									6000
2 Pallet APC									17100
6 Pallet APC									41500
12 Pallet APC									60000
NC Rotary Table									8700 EA
OKK									
MCV300	720	310	450	.100	V	7.5			40000
MCH700	1500	800	800	.960	H	15			96000

MAKE/MODEL	CONTROLLED AXES X	Y	Z	CONTROLLED VOLUME(M^3)	H/V	HP	SALES	DATE OF UK LAUNCH	BASIC PRICE £
OLIVETTI									
Horizon 23-24	1100	1010	750	.833	H	15			250000
Multiauctor 22	800	500	500	.200	V	10			102000
PARKSON									
M1700V	1065	407	457	.198	V	20	0	1980	54000
1250V					V	2	2-3 Sold	1979	29000
PEDERSEN									
Vepematic 10VJC	1000	650	550	.357	V	10			89000
PONAR									
HP4	610	500	650	.198	H	10	0	1980	89000
PRATT & WHITNEY									
Triax VII	1371	660	508	.436	V	7			70000
ROKU ROKU									
Vertimac-IX	750	400	475	.143	V				58000

MAKE/MODEL	CONTROLLED AXES X	Y	Z	CONTROLLED VOLUME(M3)	H/V	HP	SALES	DATE OF UK LAUNCH	BASIC PRICE £
SAJO									
300 CNC	710	365	100	.026	H	7.3	UK Several		56380
HMCP600	1250	650	750	.690	H	24.5			225000
SIG									
CF3	400	200	700	.056	H	20			110000
SIGMA									
MC6/800	800	400	600	.192	V	10	6/month	Nov 1979	47000
STEINEL									
BZ20	400	300	320	.038	H	6.7			121000
TOS									
FCV63NCA	1500	630	630	.595	V	33			81000
WADKIN									
V5.10					V				70000

MAKE/MODEL	CONTROLLED AXES X	Y	Z	CONTROLLED VOLUME	H/V	HP	SALES	DATE OF UK LAUNCH	BASIC PRICE £
WAHLI									
W51 Minormatic	500	400	300		H	14.6	At Least 2 Sold		110000
W51 Minormatic Fully Tooled									130000
W51 Minormatic with APC									160000
WHITE SUNDSTRAND									
OM-2A	1015	815	660	.546	H	15	0		140000
WYSSBROD									
MC510	500	300	400	.060	V	10.5	0-UK Few-Europe		80000
YASDA									
YPC 45	500	400	400	.064	H	10			69000
YPC 45 with APC									72000

4.4 CLASSIFICATION OF NUMERICALLY CONTROLLED MILLING MACHINES/MACHINING CENTRES BY SIZE

KEY TO GROUPS

GROUP I	Controlled Volume	0-.049m^3
GROUP II	Controlled Volume	.050 - .099m^3
GROUP III	Controlled Volume	.100 - .149m^3
GROUP IV	Controlled Volume	.150 - .299m^3
GROUP V	Controlled Volume	.300 - 1.000m^3

TERMINOLOGY AND ABBREVIATIONS

Controlled Volumn	=	X x Y x Z
MDI	=	Manual Data Input Only (i.e. No Tape Reader)
ATC	=	Automatic Tool Changer
M	=	Manual Tool Changer
APC	=	Automatic Pallet Change
P-P	=	Point to Point Control
CONT	=	Contouring on at least 2 axes Simultaneously
HP	=	Horsepower of main Spindle
H	=	Horizontal Spindle
V	=	Vertical Spindle
£	=	Basic Machine Price IN UK May 1980
O	=	Data Unavailable.

GROUP I

CONTROLLED VOLUME $0-.049M^3$

VOL		MDI	ATC	APC	PT-PT	CONT	HP	H/V	£
.017	Bridgeport		M			x	2	V	19000
.017	Bridgeport M/C Centre		X			x	2	V	32000
.019	Moog Super 10		10		O	O	$1\frac{1}{2}$	V	30000
	Model 1000		24		O	O	0	V	40000
	Model 3000		24			x	5	V	50000
.22	Kingsmill 700		24			x	2	V	29000
			M			x	2	V	22000
.26	Sajo 300		18			x	7.3	H	56380
.32	Hurco KMBI	X	M			x	2.5	V	27000
.33	Beaver NC5 ATC		30			x	5	V	41000
.38	Steinel BZ20		24			x	6.7	H	121000

GROUP II

CONTROLLED VOLUME = .050-.099M^3

VOL		MDI ONLY	ATC	APC	P-P	CONT	HP	H/V	£
.055	Deckel FP3A		M			x	2.6	V	35000
.056	Acton 2 (Powermil)		M			x	3	V	24950
.056	SIG CF3		O	O		x	20	H	110000
.060	Wahli		16			x	14.5	H	110000
.060	Wyssbrod		24			x	10.5	V	80000
.064	Maho 700	x	M		x		5.3	H	41500
.064	Yasda 45		32	2		x	10	H	72000
			32			x	10	H	69000
.067	Aciera 23		M		x		2	V	26700
.070	Aciera 25		M			x	3	V	42000
.072	H.E.S. Z1	x	M		x		4	H	26250
.077	Matsuura 500		16			x	4.7	V	44000
.080	Mandelli Prince		35	2		x	10	H	170000
.083	Hayes	x	M			x	7.5	V	42000
.085	Aciera 30		24			x	5	V	67000
.090	Maho 500		24			x	5.3	H	72600
.091	Acton 3 Powermil		M			x	5	V	36750
.091	Acton III Power Centre		24			x	5	V	43750

Workpiece volume of 2S = .083

GROUP III

CONTROLLED VOLUME .100-.149M^3

VOL		MDI	ATC	APC	P-P	CONT	HP	H/V	£
.100	Niigata EN40		30	2		x	6	H	67200
.100	Deckel DZ4		30			x	10	H	130000
			30	2		x	10	H	156000
.100	OKK 300	0	15			x	7.5	V	40000
.103	Famup CN1		24			x	6	V	70000
.105	Deckel FP41NC		M			x	5	V	65000
.105	Hitachi 500		18	2		x	5	H	56000
.108	Makino 60		30	2		x	10	H	125000
.117	Hurco MB1	x	12			x	3	V	36395
.118	Matsuura 710		25			x	6	V	57000
			25			x	10	H	140000
.125	KTM 400		25	4		x	10	H	150000
.125	Monarch VMC75		20			x	7.5	V	70000
			M		x		20	V	59000
			20			x	20	V	83000
.126	Heckler & Koch VBZ630		40			x	20	V	110000
			30	2		x	10	H	78000
.131	Milwaukee 180		30	2		x	10	H	105000
.141	H.E.S. 23PNC		M			x	10	H	52780
.143	Roku Roku 1X		20			x	7.5	H	58000
.144	Makino 85		20			x	7.3	V	76000

GROUP IV

CONTROLLED VOLUME .150-.299M^3

VOL		MDI	ATC	APC	P-P	CONT	HP	H/V	£
.173	Hurco MB2	x	24			x	6	V	62000
.187	Beaver MC15		18			x	10	V	60000
.192	Sigma MC6/800		6T			x	10	V	47000
.198	Burgmaster HTC325		20			x	7.5	H	89000
.198	Heller BEA1-H		24	0		x	0	H	180000
.198	Parkson 1700	x	M			x	20	V	54000
.198	Ponar High PRO4		24			x	10	H	89000
.200	Olivetti 22		20			x	10	V	102000
.211	Nigata HN50		30			x	10	H	75320
			60			x	10	H	81120
			30	2		x	10	H	86370
			60	12		x	10	H	124870
.225	Newall Vertex 200		24			x	10	V	80000
.273	Matsuura 1000		30			x	13	V	80000

GROUP V

CONTROLLED VOLUME .300-1.000M^3

VOL.		MDI	ATC	APC	P-P	CONT	HP	H/V	£
.355	Brown & Sharp 1000		24			x	7.5	V	93000
.357	Pedersen Vepematic 10VTC		30			x	10	V	89000
.432	Nigata HN70		30			x	10	H	96400
			60			x	10	H	102400
			30	2		x	10	H	113500
			60	12		x	10	H	162400
.435	Matrix V50		30			x	15	V	92000
.436	Pratt & Whitney		M			x	7	V	70000
.504	Makino MC100		30	2		x	15	H	150000
.525	Makino FNC125		20			x	14.7	V	90000
.546	White Sundstand OM2A		60			x	15	H	140000
.595	TOS FCV 63NCA		M				33	V	81000
.609	Sajo 600		45			x	24.5	H	225000
			30			x	10	H	112000
.660	Cincinnati 10		30			x	10	H	140000
.724	Brown & Sharp 1500		24			x	10	V	118000
.833	Olivetti 23-24		40			x	15	H	250000
.960	OKK 700		30			x	15	H	96000

4.5 AVERAGES FOR CLASSIFICATION GROUPS

	GROUP I	GROUP II	GROUP III	GROUP IV	GROUP V
Proportion with ATC	73%	53%	86%	93%	89%
Proportion with APC	0%	12%	33%	16%	16%
Average No Tools in ATC	22	25	25	28	36
Proportion Vertical Spindle	82%	55%	47%	50%	50%
Average Prices £000's	42,5	62	85	86,5	123
Average Prices with ATC	50	81	89	89	129
Average Prices with MTC	22.5	34.5	59	54	75.5
Average Prices with APC	-	121	105	86	132
Average Horsepower	3.6	7.1	9.5	11.2	13.4

4.6 IMPORTERS (BY COUNTRY)

CZECHOSLAVAKIA	
TOS Strojimport	Selson
DENMARK	
Pedersen	Northampton Industrial Supplies
FRANCE	
Gaston Dufour H. Ernault-Somua	Capital Machinery H.E.S.
ITALY	
F.A.M.U.P. Mandelli Olivetti Sigma	K.T.M. Stanhope British Olivetti Stuart Davis
JAPAN	
Hamai Hitachi Seiki Matsuura Makino Niigata O.K.K. Osaka Kiko Roku Roku Yasda	Acton Tarex PMT N.C. Machine Tools W. Watts Vaughn Associates Norton Machine Tools PMT
POLAND	
Ponar Pruszkow	T.I. Polmarch
SPAIN	
Acton Kingsmill	Acton Kingsmill
SWEDEN	
Sajo	Sajo
SWITZERLAND	
Aciera Sig-Societe Genovoise Wahli Freres Wyssbrod	Dixi Societe Genevoise Matchless John Brown

U.S.A.

Brown & Sharp	Mollart
Burgmaster	Herbert
Kearney & Trecker	Staveley
Monarch	Dean, Smith & Grace
Pratt & Whitney	Hepworth
White Sundstrand	Kingsbury

WEST GERMANY

Deckel	Deckel
Heckler & Koch	A.M.C.S.
Heller	Heller
Maho	Hahn & Kolb
Steinel	Catmur

4.7 U.K. EXHIBITORS OF NUMERICALLY CONTROLLED MILLING MACHINES/MACHINING CENTRES

Beaver
Bridgeport
Cincinnati
Eliott
Hayes
Hurco (U.S. Design)
KTM
Matrix
Moog
Newall
Parkson
Wadkin

4.8 Catalogues

Nearly 100 catalogues and leaflets were collected during the survey and this library is increasing as additional information is arriving through the post.

The catalogues are filed in alphabetic order in a lever arch file and are available in the marketing department through Stephen LeBeau

5.1 AVERAGE SELLING PRICES

Figure three shows Average Selling Prices plotted against the machine capacity indicator., Controlled Volume.

It was expected that, as the size of the machine increased, the proportional cost of the control unit would decrease and hence the Average Selling Price plot would be a curve of dy/dx positive and decreasing (i.e. concave down).

The wide scatter of points prevents this effect from being prominant at the smaller size of machine considered in Figure three, but the effect does start becoming evident at Controlled Volumes of .3 and over.

'Closest Fit' straight lines were drawn through the three sets of points :-

1. Machines with Manual Tool Change
2. Machines with Automatic Tool Change
3. Machines with Automatic Pallet Change

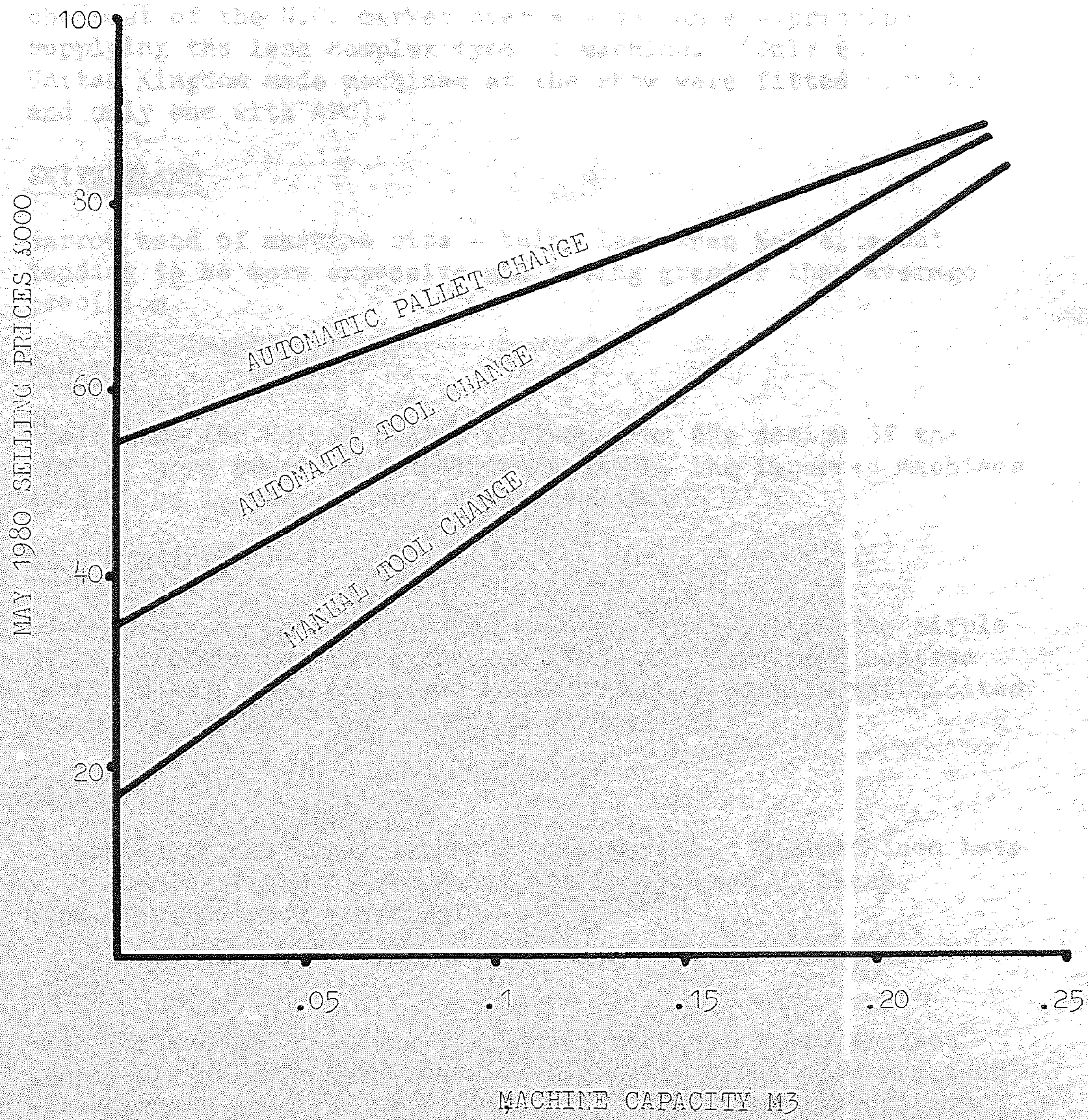
The use of straight lines was further endorsed when checks of deviation of points from the line at each end and in the middle showed no significant curvature.

Machines were only considered upto £100,000 for this analysis because those priced over £100,000 are mainly special in either mechanical complexity or possessing very high accuracy capabilities. Figure One also shows the dearth of machines between £80,000 - £120,000, indicating that £100,000 provides a natural separation line.

These curves, with a suitable inflation adjustment can be used as a guide when setting the selling price of the new N.C. Machines.

FIGURE C.3

AVERAGE SELLING PRICE (MAY 1980) FOR
NUMERICALLY CONTROLLED MILLING MACHIES
UNDER £100,000



5.2 NATIONAL TENDENCIES

From the plot of machine prices against capacity, (Figure 1), certain national tendencies can be seen. These are shown in a generalised form on the attached plot. (Figure 2).

UNITED KINGDOM

Particularly strong in the small and inexpensive "Bridgeport" style machines where the only foreign competion comes from Spain.

With the exception of KTM, the United Kingdom Supplies the cheapest of the N.C. market over a wide range - principally by supplying the less complex type of machine. (Only $\frac{2}{3}$s of the United Kingdom made machines at the show were fitted with ATC and only one with APC).

SWITZERLAND

Narrow band of machine size - being less than No2 size but tending to be more expensive and having greater than average precision.

U.S.A.

Apart from the United States influence on the design of the smaller more successful British machines, the imported machines tend to be larger and more sophisticated.

WEST GERMANY

Good spread of machines in the mid size range, from the simple MTC at one extreme up to complex ATC + APC machining centres at the other. The equipment has a tendency to be sophisticated, expensive and of a high standard of quality.

ITALY

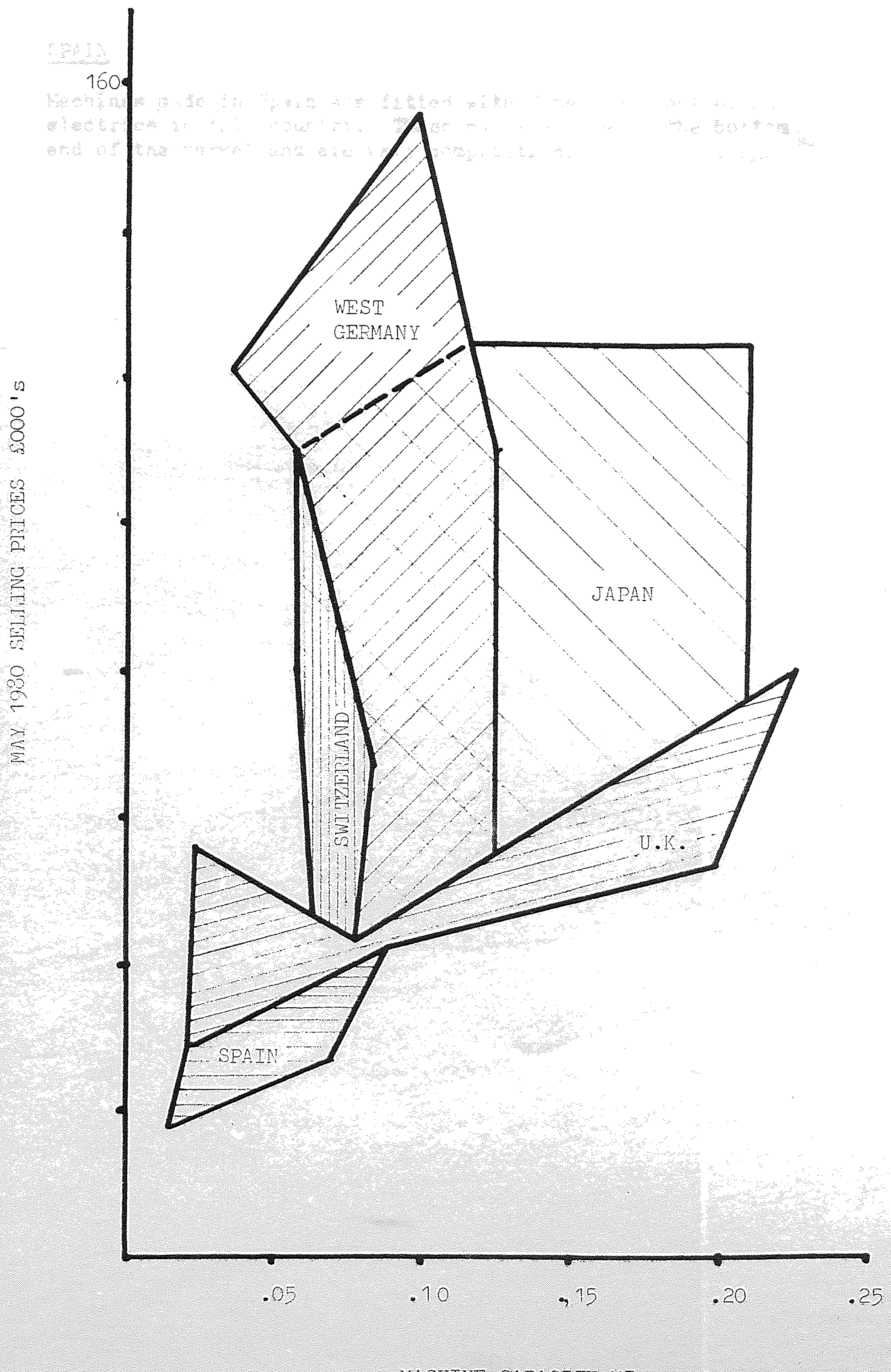
No particular national tendency is apparent. The machines have a random selection of the qualities large, small, cheap, expensive, complex and simple.

JAPAN

With the exception of the very small machines which are not supplied, the Japanese range is excellent, being wide and deep All Japanese machines were fitted with ATC, many were fitted with APC or offer it as an optional extra. For the level of sophistication many of the prices are very competitive.

FIGURE C.2

GENERALISED FORM OF NATIONAL TENDENCIES



SPAIN

Machines made in Spain are fitted with Numerical Control and electrics in this country. These machines are at the bottom end of the market and are very competitive.

5.3 HOLE IN THE MARKET ANALYSIS

From Figure 1, the plot of machine size against price, the vertical line shown at .083 is the controlled volume of the current 2S machine. Since previous work has indicated that this is the area of major interest, a consideration of machines on or close to this line is valuable and gaps in supply may well show up as areas into which we may aim our new product.

Moving up the line we find

£ 0 - £25000 - 'Hole'

£25000 Three MTC Machines

1. Acton 2
2. Aciera 23
3. H.E. Somua Z1

£30 - £35000 'Hole'

£35000 - £45000 5 MTC and 4 ATC Machines

MTC:
1. Deckel FP3A
2. Maho 700
3. Aciera 25
4. Hayes
5. Acton Powermil 3

ATC:
1. Matsuura 500V
2. Acton Powercentre III
3. OKK 300
4. Hurco MB1

£45,000 - £65,000 'Hole' except Hitachi 500 and Matsuura 710

£65,000 - £80,000 5 ATC machines and 2 APC Machines

ATC:
1. Yasda 45
2. Aciera 30
3. Maho 500
4. Famup
5. Deckel 41

APC:
1. Yasda 45
2. Niigata EN40

£80,000 - £120,000 'Hole'

£120,00 + Specialised plus sophisticated low volume machines.

The market is, therefore, split into three sections with two holes.

There is, however, only general correlation between price and technical sophistication and so use can be made of the holes between these sections.

The options which present themselves from this analysis are:-

a. M.T.C. machine priced below £25000 - Medium Quality

b. M.T.C. machine priced £30-35000 - High Quality

c. A.T.C. machine priced £30-35000 - Medium Quality

d. A.T.C. machine priced £45-65000 - High Quality

e. A.P.C. machine priced £45-65000 - Medium Quality

The Hitachi 500 is the only machine in catagory e
The Matsuura 710 is the only machine in catagory d

Configuration

In addition to the above analysis the spindle configuration can be analysed in the same way. From the results shown in 4.5 it can be seen that the average proportion of horizontal to vertical spindle orientations for machines in Groups II and III is roughly 50 : 50.

Considering each of the sections of machines above the following facts emerge:-

£25,000 Section - 2 out of 3 are vertical

£35,000 - £45,000 - 8 out of 9 are vertical

£65,000 - £80,000 - 3 out of 7 are vertical

Therefore, at the size being considered there are only two horizontal machines available under £65000. This, therefore, indicates a quite significant hole in the market. When market requirements are considered e.g. workpiece statistics, this could provide a very suitable hole to aim for.

Considering machines of this size at £100,000and under there is no significant difference in price between horizontal and vertical machines at the varying levels of sophistication viz. MTC and ATC, The fact that horizontal machines generally appear more expensive is explained by the fact that there is no APC machine available in vertical form. This, therefore, has identified another market hole.

Country Of Origin

Examination of the national tendency figure (fig 2) shows the U.K. weakness at the machine size being considered. Over the spread of prices the Japanese, Spanish, Swiss and West Germans have a significant presence but there is almost nothing from the U.K. This hole endorses the choice of machine size so that advantage can be taken of Governmental and Patrotic buyers in the U.K.

Conclusions

The analyses have discovered the following market 'holes' into which our new machines could be aimed.

a. MTC machine below £25000 - Medium Quality

b. MTC machine £30-35,000 - High Quality

c. ATC machine £30-35,000 - Medium Quality

d. ATC machine £45-65,000 - High Quality

e. APC machine £45-65,000 - Medium Quality

f. Horizontal Axis Machine below £65,000

g. Vertical Axis Machine with APC

h. U.K. Manufactured Machine with 2S Capacity

The Market Research exercise currently being performed will test the above variables of price, quality, axis, APC and ATC/MTC to determine which is the most potentially lucrative hole.

5.4 U.K. Market Size

For the size of machine envisaged a certain number of sizes either side will be direct competitors and should be considered in the market size calculations. If it is possible to estimate the total current U.K. Sales of these machines then the total market size for that particular size of machine could be determined.

Considering the Annual Sales of each of these machines :-

MACHINE	ANNUAL SALES 1979/80	VALUE (£)
Acton 2)	80	2,400,000
Acton 3)		
Aciera 25	0(E)	
Aciera 23	5(E)	125,000(E)
Aciera 30	0(E)	
Deckel 41	5(E)	320,000 (E)
Deckel FP3A	20(E)	700,000 (E)
H.Ernault Somu Z1	15(E)	400,000 (E)
Famup	3(E)	210,000 (E)
Hayes	2(E)	80,000 (E)
Hitachi 500	0	
Hurco MB1	80	2,960,000
Matsuura 500	15	660,000
Matsuura 710	3(E)	170,000 (E)
Maho 700	10(E)	415,000 (E)
Maho 500	2(E)	150,000 (E)
Niigata EN40	4(E)	270,000 (E)

OKK 300	1(E)	40,000 (E)
Wyssbrod	0	
Yasda 45	0	
TOTALS	245	8,900,000
Rounded off	250	9,000,000

(of which only 1/3rd is an estimate)

Conclusions

The total U.K. market size for No 2 size machines last year was approximately 250 machines valued at £9million. From forecasts already performed at the growth of N.C. milling machines, this figure should be about 380 machines by 1984 when the new machine could be in full Production. This market would then be worth nearly £14 million at 1980 prices.

6. CONCLUSIONS

1. The survey has provided technical and marketing data (fig 1) on a very large proportion of the total N.C. milling machine market. Obtaining this data and the method adopted proved efficatious.

2. The three principal countries exhibiting were Japan (23%), U.K. (23%) and West Germany (15%)

3. The technical sophistication of the Japanese machines was greater than that from any other nation.

4. The market could be segmented into National tendencies and a plot was drawn (fig 2). The Japanese had the widest range of sizes and specifications, the British machines had a wide range of sizes at the cheap end of of the market while Switzerland and West Germany concentrated on No 2 size machines with a wide range of specifications. Britain competes with Spain at the very small inexpensive corner of the market.

5. Graphs of average price could be plotted against machine capacity for various levels of mechanical sophistication i.e. APC, ATC, MTC (fig 3). These can be used to assess the selling prices of N.C. machines in the range and also to assist in determining selling price of the future machines.

6. The choice of No 2 capacity machine was endorsed in a 'market hole' analysis.

7. The following market holes were identified:

a. MTC machine below £25000

b. MTC machine £30-35000

c. ATC machine £30-35000

d. ATC machine £45-65000

e. APC machine £45-65000

f. Horizontal Axis machine below £65000

g. Vertical Axis machine with APC

Further market research will ascertain which one or which combination of these holes to aim the new products.

8. The current UK market size for No 2 size numerically controlled milling machines is about 250 per year worth about £9 million. This is expected to grow to about 380 machines worth £14 million by 1984.

This limited market size means that there is time to consider the market needs carefully before manufacturing.

APPENDIX D

SOURCES OF MARKETING INFORMATION

D.1 INTRODUCTION

This appendix provides a summary of the major sources of information which were used for marketing research during this project. The list of sources is not comprehensive as many items of information are transmitted orally through Sales Engineers, Trades Associations, Meetings etc. In addition there is a wide range of lesser-used sources such as trade directories and specialist press, and all these provide contributions to the total picture.

D.2 INTERNAL

D 2.1 MARKETING INFORMATION SYSTEM

This is the collection, storage, reporting and dissemination of company statistics. There are currently some 32 reports circulating which cover the following:

Gross orders

Cancellations

Nett orders

Sales

Despatches

Orders-on-hand

Quotations

Stock levels

Each of these subjects is, to a greater or lesser extent, reported by:

Home

Export

Location

Order number

Machine type and specification

Volume

Value

A copy of each of these reports is stored for a period of indefinite time. The major problem of changing product lines and requirements means that the data is not usually consistent or comprehensive over a long period of time. This problem was identified during the course of this research and budget allocation has been granted to computerise the M.I.S. This will be done as soon as this project is completed.

D.2.2 CUSTOMER LIST

This is a computerised list of all existing customers and potential customers. It can be interrogated by type, geographic location, nature of business, number of employees and machines purchased. At approaching 30,000 entries, it is one of the best lists in the industry and has been of considerable use during this project.

D.2.3 MACHINE & SERVICE REGISTRATION CARD (Figure D.1)

This card ostensibly provides the customer with an official registration of his new machine, but it is in fact a marketing information input to the company. Much use was made of the results of this card and these are reported in Chapter 6. The card shown in Figure D.1 was designed as part of this project to obtain customer information after it was discovered that field research was not going to be possible.

D.2.4 COMPETITOR INFORMATION REPORT (Figure D.2)

The form shown in Figure D.2 was produced as part of this project to extend the use of the existing "lost order form" which already provided much useful information regarding the reasons for losing business to competitors.

The new format has proved to be more appealing by being less negative and returns have increased considerably.

FIGURE D.1

MACHINE & SERVICE REGISTRATION CARD

Machine Type ....

Serial No ....

Date Purchased ....

Purchased From ....

Sold to Company ....

Full Postal Address ....

....

....

....

Telephone No ....

Total number of persons employed at this site ....

How many other milling machines at this site ....

> Please complete and return this card to
> within 10 days

Please mark answers with an 'X'

Where will this machine be used?

- ☐ Maintenance
- ☐ Sub-Contract
- ☐ Mould & Die
- ☐ Toolroom
- ☐ Research & Development
- ☐ Education & Training
- ☐ Production
- ☐ Other ....

Which of the following factors influenced your choice of this machine?

- ☐ Technical Specification
- ☐ Manufacturer's Reputation
- ☐ Price
- ☐ Previous Use
- ☐ Previous Ownership
- ☐ After Sales Service
- ☐ Recommendation
- ☐ Other ....

Card Completed By ....

Name Position

FIGURE D.2

COMPETITOR INFORMATION

REPORT

To be completed by Sales Engineer when he learns of any useful information relating to our competitors. Examples of useful information would be:

News of New or Changed Machines
Price Lists
Catalogues
Quotations
Number of Employees/Representatives
Special Offers and Discounts
Production Quantities
Turnover
Contracts Won
Change of Address etc.
Recent Installations

NATURE OF INFORMATION

RECENT INSTALLATIONS

In the event of discovering a competitors machine installed, the following information would also be useful.

1. Company

2. Machine Bought

3. Bridgeport Product Offered

4. Date of Purchase

5. Reason for Purchase.

....

SALES ENGINEER ....

DATE ....

SAL/cmd 4/3/1982

D.2.5 MARKETING MANUAL

As a means of increasing credibility in this project a company "Marketing Manual" was started which formally recorded the results of all marketing research performed under specific chapter headings.

The contents page of this manual is reproduced in Figure D.3.

At the time of writing there are still one or two difficulties in compilation, but when these are sorted out then the manual will be issued to senior management and regularly updated as a working tool.

D.3 EXTERNAL

Source	Nature of Information
Banks (ad hoc)	
– Abecor County Reports - Barclays	Worldwide market reports.
– Economic County Reports - Nat West	Economic reports on individual countries.
– Overseas Trade Reports - Midland	
British Business (weekly)	Magazine of department of industry giving government statistics such as indices of industrial production, G.D.P. etc., also business news, trade information and market reports. Volume index numbers for metalworking machine tool industry MLH 332. Wholesale price indices. Survey of investment intentions etc.
BOTB	
– Export intelligence service	World economic commentary by country, specific leads.

FIGURE D.3

Chapter:	Section:	Issue:	Date:	Page:

Marketing Manual

C O N T E N T S

CHAPTER 1. INTERNAL DATA

1. Despatches
2. Sales
3. Orders
4. Nett Orders Weekly
5. Quotations

CHAPTER 2. U.K. MARKET DATA

1. Market Share
2. Market Share
3. Imports
4. Exports
5. Trade
6. Market Study Group
7. D.O.I. Statistics
8. M.T.T.A. Survey

CHAPTER 3. COMPETITION

1. Lost Order Analysis
2. Names
3. Distribution
4. Prices
5. Production and Sales

CHAPTER 4. INTERNATIONAL

1. Distributors List
2. International Market Share
3. Market Share
4. Country Profiles

CHAPTER 5. FORECASTS

1. 2 Week
2. This Year
3. 5 Year
4. CBI Survey
5. Henley
6. NMTBA
7. F.T. Survey

CHAPTER 6. FINANCIAL

1. Competitor Results
2. Pricing Analysis
3. Price/Quantity Curves
4. Exchange Rates
5. F.T. Index

Source	Nature of Information
BOTB (cont'd)	
– Library (London)	Full representation of international trade figures. Imports and exports worldwide plus other trade.
Business Monitor PQ 332 (Quarterly)	Enquiry into metalworking machine tool industry. Tables 1 - 5: 1. Sales by UK manufacturers. 2. Export sales by UK manufacturers. 3. New orders received by UK manufacturers. 4. New export orders received by UK manufacturers. 5. Exports. 6. Imports. 7. Wholesale price indices.
CBI Industrial Trends Survey (Quarterly)	Survey by industry sector (including machine tools) of: optimism, home and export prospects, output, order book, stock holdings, numbers employed, prices. Expected orders, output, and deliveries home and export.
CECIMO	Int. trade statistics from member countries.
Competitors Catalogues (ad hoc) from:	
– Exhibitions, reps, customers etc.	Details of competitors products.

Source	Nature of Information
Customs and Excise (monthly)	
– Imports and exports from bill of entry section	Imports and exports by country by volume weight and value under headings:
	Milling ACI 8445 4800
	Milling O/T ACI 8445 5210
	Milling Used 8445 5250
	Machining Centres 8445 9410
EEF Short Term Trends (Quarterly)	Forecasts and commentary on Mechanical Engineering Industry.
Exhibitions	
– In particular MACH and EMO Exhibitions (2 yearly)	Competitors catalogues, chance to see the products, sales and marketing information on competitors.
Inter Company Comparisons	
– Business Ratio Reports ICC London (annual)	For Machine Tool Manufacturers a summary of financial data including assets, turnover, profits, number of employees etc. A comprehensive set of comparison ratios.
Journals	
– Metalworking Production – Machinery and Production Engineering – The Engineer – Machinery Market – Engineering Today – Production Engineer – CME – Industrial Equipment News – Numerical Engineering	Editorial provides information on competitors, also found in advertisements. Technical developments and relevant reports and forecasts are also covered.

Source	Nature of Information
Journals (cont'd)	
— The UK Commline	
— Engineering, Production & Design	
— Engineers Digest	
— Industrial Products	
— International Equipment News	
— What's New	
— etc.	
Journals (Overseas)	
— American Machinist	
— Taiwan Machinery	
— Metalworking Engineering and Marketing (Japan)	
— Business Brief (Europe, Asia etc.)	
— Maschinenmarkt (Germany)	
— etc.	
MTTA Forecasting Seminar	Forecasts for the Industry for 5 years.
MTTA Statistics Bulletin	Provides information under the following headings for the UK machine tool industry: Commentary Orders and sales indices Production indices Imports and exports Number of employees Labour turnover Redundancies BEAMA labour costs CBI Industrial survey

Source	Nature of Information
MTTA Statistics Bulletin (cont'd)	Earnings and hours
	Wholesale price indices
	Specific reports or events
MTTA Guide to International Markets for Machine Tools	Market reports and international data by country.
MTTA Trends Survey (Quarterly)	Results of a survey into the following industry aspects:
	Home order intake
	Export order intake
	Number of weeks backlog
	Number of firms operating below capacity
	Nature of shortages which are restricting the level of activity
	Turnover
	Export ratio
MTTA Imports Summary (Quarterly)	Cumulative reports of imports by heading, by country (from C & E)
MTTA Exports Summary (Quarterly)	Ditto for exports.
MTTA Machine Tool Statistics (Annual)	Summary of all statistics relevant to machine tool industry.
Metalworking Production Surveys	Survey of all machine tool installations by type and date of installation in the UK.
NMTBA Economic Handbook of the Machine Tool Industry	Highly comprehensive source of international statistics covering production, sales, orders, despatches, trade etc. Particularly comprehensive review of USA machine tool industry.

Source	Nature of Information
NMTBA Survey of Major Export Markets for Machine Tools	Statistics and commentary and market reports on all major countries worldwide.
National Machine Tool Industry Catalogues e.g. – Alatne Masine Jugoslavije (Masino Savez Belgrade undated) – British Machine Tools & Equipment (MTTA London 1982) – Chinese Machine Tools (China National Machinery Import and Export Corporation, Shanghai 1975) – Guide to Indian Machine Tools (IMTMA Bombay 1975) – Japanese Machine Tool Guide 1981/82 (News Digest Nagoya 1981) – Macchine Utensili Italiane (UCIMU Milano undated) – Machines Outils Francaise (SCFMO Neuilly Sur Seine 1977) – Machine Tools and Related Products (NMTBA McLean Virginia 1977) – Maquinas Ferramentas Portuguesas and accessories (CIMAF Lisbon 1979) – Schweizer Werkzeugmaschinen (Zurich 1977) – Technical Information 81 (JMTBA Tokyo 1981)	These are produced by individual countries to publicise their machines tool industries. They are usually available at exhibitions and contain statistics and details of individual products and manufacturers.

Source	Nature of Information
<u>National Machine Tool Industry Catalogues e.g.</u> (cont'd) – Werkzeugmaschinen Austria (Fachverband der Maschinen und Stahlbauindustrie Osterrichs – Wien 1981) – Who Makes Machinery (Hoppenstedt Wirtschaftsverlag – Dormstadt 1981)	
<u>NEDO Economic Development Committe for Machine Tools</u>	Ad hoc reports on the industry.
<u>Newspapers e.g.</u> – Financial Times – Times – Telegraph – Export Times – etc.	Financial Times survey of business opinion. Business news, reports on published forecasts, economic reviews and international market reports. Competitors results (financial).
<u>OECD Economic Outlook (twice yearly)</u>	Comprehensive forecasts and commentary on situation in all OECD countries. Also contains comprehensive historic statistics.
<u>Published Reports (ad hoc)</u> – Business International – Larson Sweeney – Frost & Sullivan – Planning Research & Systems	Multi-client reports on Machine Tool Industry in specific countries or by particular product types. Usually include simple forecasts.
<u>Transterra Business Brief (weekly)</u>	Commentary on business opinion, opportunities and outlook. Monthly statistics of production labour, inflation etc.

Source	Nature of Information
Treasury Economic Progress Report (monthly)	Details of UK economy, budgets, targets, prospects etc. Statistics and economic indicators also included.
Workpiece Statistics Pera Opitz etc. (op cit)	Details of workpiece configurations and machining requirements.

APPENDIX E

PRODUCT MOMENT CORRELATION COEFFICIENT (PMCC)

AND ITS USE IN ESTIMATING SUBSTITUTION REPLACEMENT FACTORS

E.1 PMCC

The product moment correlation coefficient is a measure of the degree of closeness of a series of data to a straight line. It is defined as:

$$r = \frac{1}{N}\sum \frac{(x - \bar{x})}{(s_x)} \frac{(y - \bar{y})}{(s_y)} \qquad \text{......A}$$

where r = product moment correlation coefficient

N = sample size

x, y = variables

$\bar{x}, \bar{y}$ = variable means

s_x, s_y = standard deviations of variables given by

$$s^2 = \sum \frac{(x - x)^2}{N} \qquad \text{......B}$$

A convenient transformation of equation A is:

$$r = \frac{\frac{1}{N}\sum uv - \bar{u}\,\bar{v}}{s_u s_v} \qquad \text{......C}$$

where u = (x - arbitrary origin) x 10 ......D

and v = (y - arbitrary origin) x 10 ......E

The figures are multiplied by 10 to eliminate decimals.

This appendix gives one example of PMCC. The variables are, % increase in CNC (x) and % decrease in turret mills (y).

The data table is given in Figure E.1.

From this table it can be seen that N = 31

and the arbitrary datum for CNC = 5%

and the arbitrary datum for turret mills = 72%

FIG. E.1. DATA TABLE FOR CALCULATING PRODUCT MOMENT CORRELATION COEFFICIENT

10 × %CNC	10 × % Turret	U	V	UV	U^2	V^2
26	762	-24	42	-1008	576	1764
30	755	-20	35	- 700	400	1225
30	756	-20	36	- 720	400	1296
34	758	-16	38	- 608	256	1444
39	751	-11	31	- 341	121	961
44	736	- 6	16	- 96	36	256
48	739	- 2	19	- 38	4	361
50	736	0	16	+ 0	0	256
55	730	5	10	+ 50	25	100
60	724	10	4	+ 40	100	16
70	715	20	- 5	- 100	400	25
76	714	26	- 6	- 156	676	36
86	717	36	- 3	- 108	1296	9
96	707	46	-13	- 598	2116	269
100	690	50	-30	-1500	2500	900
100	688	50	-32	-1600	2500	1024
103	691	53	-29	-1537	2809	841
98	701	48	-19	- 912	2304	361
101	707	51	-13	- 663	2601	161
102	704	52	-16	- 832	2704	256
107	700	57	-20	-1140	3249	400
102	716	52	- 4	- 208	2704	16
107	696	57	-24	-1368	3249	576
102	700	52	-20	-1040	2704	400
95	707	45	-13	- 585	2025	169
93	711	43	- 9	- 387	1849	81
100	707	50	-13	- 650	2500	169
97	707	47	-13	- 611	2209	169
101	695	51	-25	-1275	2601	625
104	687	54	-33	-1782	2916	1083
109	672	59	-48	-2832	3481	2304
Totals		915	- 141	- 23205	51311	17553

also $\bar{u} = \frac{915}{31} = 29.52$

$$\bar{v} = \frac{-141}{31} = -4.55$$

and $\bar{u}\,\bar{v} = -134.27$

Standard deviation s_u is given by

$$s_u{}^2 = \frac{1}{N} \sum u^2 - (\bar{u})^2$$

$$= \frac{1}{31} \times 51311 - 871.43$$

$$= 783.76$$

$$s_u = 27.995$$

Similarly

$$s_v{}^2 = \frac{1}{N} \sum v^2 - (\bar{v})^2$$

$$= \frac{1}{31} \times 17553 - 20.702$$

$$= 545.5$$

$$s_v = 23.35$$

Substituting into equation C

$$r = \frac{-751.77 - (-134.32)}{635.68}$$

$$= \underline{\underline{-0.944}}$$

Hence showing very strong negative correlation. This correlation identifies the substitution process.

E.2 MECHANISM OF SUBSTITUTION

It is possible that the apparent substitution could be due to other factors and these should be examined.

E.2.1 INCREASES IN COMPETITIVE ACTIVITY

It is possible that short term increases in specific turret mill competition could cause the substitution. This statement is explained by the following model:

Increasing specific turret mill competition has been observed in the form of the Taiwanese imports which started at about the same time as the launch of the CNC.

The effect of these Taiwanese machines would be to reduce the % of turret mills and increase the % of all other lines. At the same time, the increase in CNC would have the effect of reducing the % of all other lines.

Given the necessary balance, it is possible to obtain the observed results of 2S, and horizontals remaining relatively level and CNC apparently increasing at the expense of turret mills.

The reason that this particular difficulty has arisen is because of the limitations of published statistics. This same limitation now affects any attempt to make accurate apportionment between technological and competitor substitution.

Her Majesty's Customs and Excise (heading 8445 5210) publishes import statistics. These statistics give the total number of Taiwanese milling machines entering the U.K. The figures are 'lumpy' because of container packing and also do not reflect the actual sales of machines because when imports are high, distributors could be buying machines for stock, and when imports are low (as in 1980), distributors are de-stocking.

The best alternative is to estimate how many turret mill orders have been lost to the Taiwanese over the entire life of the CNC and see how this affects the average substitution.

1. THE ACTUAL SITUATION

Total number of CNC ordered in U.K. = a

Total number of turret mills ordered in U.K. = b

Total number of machines ordered in U.K. = c

CNC as proportion of total $= \frac{a}{c} = p$

Turret mills as proportion of total $= \frac{b}{c} = q$

2. TAIWANESE CORRECTION

Total number of milling machines entering U.K. from Taiwan = 694

Estimated number of Taiwanese turret mills sold in U.K. = d

Estimated number of turret mill orders lost to Tai machines

= (turret mill market share) x d

= e

With Taiwanese correction, i.e. if the company lost no orders to Tai machines, the new totals are:

Turret mills + Taiwanese turret mills = b + e

Total + Taiwanese turret mills = c + e

therefore,

CNC as proportion of total $= \frac{a}{c+e} = r$

and

Turret mills as proportion of total $= \dfrac{b + e}{c + e} = s$

Therefore the effect of the increasing Taiwanese competition during the life of the CNC is:

Effect on CNC proportion $= (r - p) \times 100 = -.17\%$

Effect on turret mill proportion $= (s - q) \times 100 = +.82\%$

Both of these differences are fractional and so this method has shown that Taiwanese turret mills have had little effect on the substitution of turret mills by CNC and the model has been proved invalid.

There is also a parallel model to the Taiwanese case described above. This other model considers the reduction in turret mills caused by competitors' CNC products. When this analysis is performed it is shown that the effect is even smaller than that of the Taiwan influence.

This second model is only of secondary importance to this research because it is a contributory part of the technological substitution. Hence, even if the effects were large it would not be necessary to adjust the analysis.

E.2.2 THE 1980 RECESSION AND TOTAL ORDER VOLUME

During the period under consideration total order volumes have changed considerably from the highs of 1979 to the low levels of 1980. The closeness of fit of the regression line along its entire length indicates that the substitution is independent of the business cycle (Figure E.2).

E.2.3 THE 1980 RECESSION AND CHANGING DEMAND PATTERNS

It is possible that the recession has CAUSED the increase in proportion of CNC by altering demand patterns. If this were true then the regression line for CNC against 'others' (i.e. 2S models and horizontals) would also show a partial correlation during the recession year 1980. This has been performed and no such correlation has been found.

E.2.4 CHANGE IN PRODUCT MIX

During the period under consideration there has been no change in the product mix which would lead to a distortion of the figures.

E.2.5 CONCLUSION

Several alternative mechanisms of substitution or data distortion have been discussed but none provide collaborating evidence to support any large scale deviation from the hypothesis of technological substitution.

E.3 REGRESSION ANALYSIS OF CNC ON TURRET MILL

In order to set up the equation of the regression line we must first identify the variables.

These are:

% CNC – to be called C and

Turret mill – to be called B.

Then from equations D and E in Section C.1

$$u = 10\,(C - 5) \qquad \text{and} \qquad v = 10\,(B - 72)$$

$$\text{therefore} \quad C = \frac{u + 50}{10} \qquad \text{and} \qquad B = \frac{v + 720}{10}$$

and the averages will be given by:

$$\bar{C} = \frac{\bar{u} + 50}{10} = \frac{29.52 + 50}{10} = 7.952$$

and $\bar{B} = \dfrac{\bar{v} + 720}{10} = \dfrac{-4.55 + 720}{10} = 71.545$

We also have that

$$s_C = \frac{s_u}{10} = \frac{27.995}{10} = 2.8$$

and $s_B = \dfrac{s_v}{10} = \dfrac{23.35}{10} = 2.33$

The equation for the regression line is given by

$$C - \bar{C} = r\frac{(s_C)}{(s_B)} \quad (B - \bar{B})$$

that is $C - 7.952 = -0.944 \dfrac{(2.8\ )}{(2.33)} (B - 71.545)$

which reduces to

$$\underline{\underline{C \;=\; -1.134B + 89.08}} \qquad \text{......F}$$

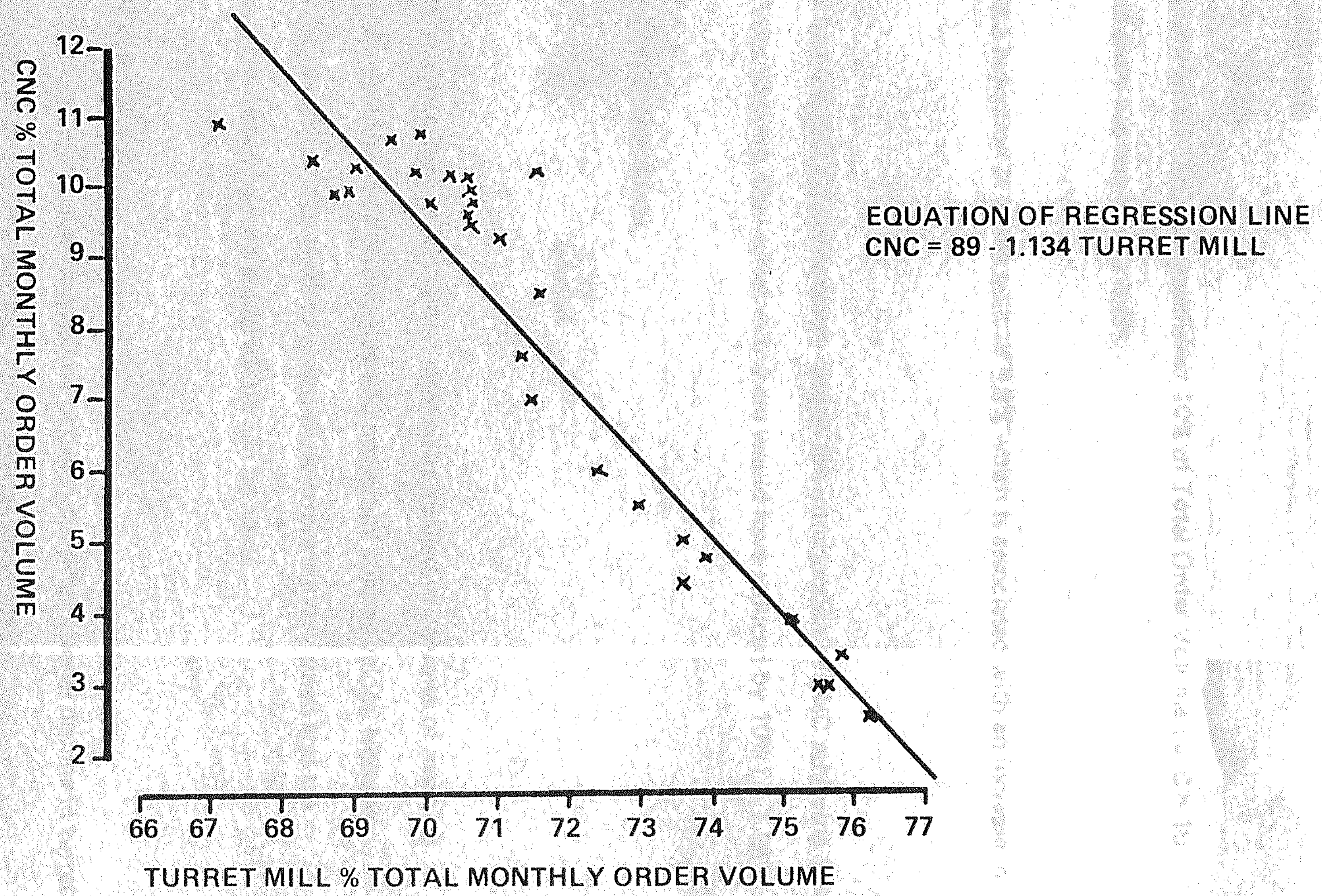
This equation is shown graphically in Figure E.2.

E.4 CALCULATION OF REPLACEMENT FACTOR

It has been estimated that the CNC machine is three times more productive than its manual counterpart thus suggesting that one CNC will replace three turret mills (replacement factor = 3.0). Individual buying behaviour is not that simple and so it is generally expected that the figure would be lower. In addition, since markets are growing, and since there is a large disparity in sales volumes of the two products, it is probable that the figure could be very much lower. It is even conceivable that the replacement factor may be fractional. With such large variations in intuitive estimates it is important to perform the following analysis:

FIGURE E.2

REGRESSION LINE OF CNC GROWTH ON TURRET MILL DECLINE



The regression equation relating % CNC (C) and % turret mill (B) has been shown to be

$$C = -1.134B + 89.08 \qquad \ldots\ldots F$$

Before the introduction of CNC i.e. at C = 0

then % turret mills was:

$$B = 78.5\%$$

Consider the point where CNC has established 10% of Total Order Volume i.e. C = 10

then turret mill share has reduced by 8.8%.

This represents a reduction in turret mills of 8.8% which is associated with an increase in CNC of 10%.

If all products had reduced proportionately due to the introduction of CNC achieving 10% of the Total Order Volume, then turret mill share would have reduced by 10% i.e. 7.85%.

Therefore the replacement factor:

$$r = \frac{8.8}{7.85} = \underline{\underline{1.12}}$$

This value of the replacement factor cannot strictly be applied to volumes of machine orders because the data base was percentages and not actual volume values. However, since the replacement factor is so close to unity, these errors are very small and the transformation from percentages to actual values can be made.

E.5 CONCLUSIONS

1. Close correlation has been observed between the proportional decline in turret mills and the proportional increase in CNC. This indicates substitution.

2. This substitution is not on a 1:1 basis, there is oversubstitution of turret mills by CNC of 1 CNC replacing 1.12 turret mills (replacement factor = 1.12).

3. The effect of a parallel substitution of Taiwanese machines for turret mills has also been examined. An analysis was performed which showed that any competition substitution had very little effect on the technological substitution; it can therefore be concluded that the observed substitution is technological.

4. Other potentially distorting influences were discussed but there was no evidence to suggest that these were applicable in this case.

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