# STRATEGIC PLANNING FOR COST REDUCTION IN AN ENGINEERING COMPANY

in Two Volumes

VOLUME I

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# SUMMARY

This thesis reports on a project which used an analytical approach to tackle the problem of planning in a particular company.

The project developed in a series of steps, beginning with questions raised by the company's planners, concerning the validity of their planning model. Their main strategic objective of market share maximisation was based on the hypothetical relationship between cumulative output and declining unit costs of production expressed in the 'experience curve' model. Analysis showed that both unit cost and average price of their products could be modelled in this way, but that cumulative output was not the only explanatory variable. In the second stage, this result was confirmed in tests on a wider range of data, with implications for the validity of basing such a strategy on the experience curve model.

However, the analyses of price and cost data had also provided evidence of a disturbing trend for the company; total unit cost of manufacture was declining at a slower rate than the average price of the product in the UK (in constant value terms). Additional analysis indicated the specific areas for concern.

Since survival of the business would depend on the future control of unit costs, research in the third stage contributed to plans both for cost reduction and for increasing volumes of sales.

Evidence from this research did not support the hypothesis that the experience curve model could be used to predict unit costs over a period in which sales volumes change radically. In the company concerned, plans for growth of market share resulted in an increase, rather than a decline, in unit costs. The principal conclusion is that strategic plans should not be based on projections derived from manipulation of variables in a model such as the experience curve.



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Experience curve, strategic planning, models for unit costs.

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# CHAPTER ONE

## INTRODUCTION: PLANNING METHODS AND THEIR APPLICATION IN A PARTICULAR COMPANY

This thesis is concerned with the problems of planning in a particular company, BOC Arc Equipment.

For 4-5 years BOC Arc Equipment, an operating company of BOC Ltd., had been using an approach to planning suggested by a firm of business consultants in 1972. The resulting plan included ambitious market share objectives, based on the assumption of a certain type of model for the business.

However, by 1977, the company's management team were unable to establish whether the plan was a success. They did not know if the specific objectives were being met, or whether the model was still valid. Consequently they had little basis for deciding whether or not to continue with this plan.

At this stage they approached IHD to investigate the possibility of setting up a project to examine their approach to planning, in particular, to investigate the validity of the model and the way in which it was being used.

Beginning with their initial problems, the project developed to apply an analytical approach to many aspects of planning at BOC Arc Equipment. The thesis gives a historical account of the interaction between the project and the company, and the ways in which some of their problems were solved.

Results from most of the research pertain specifically to BOC Arc Equipment: many of the recommendations are concerned solely with the planning and management of their business. (Chapter Eleven). However, these problems are also set into the wider context of different approaches to planning. Conclusions arising from the work of the project are then used to make observations on the planning of companies in general. (Chapter Thirteen).

The introductory chapter consists of three parts. In 1.1, a review of the development of current methods of planning raises various issues for companies who are appraising their own approach. This was not an integral part of the project, but indicates the wider field of application for results.

However, the project itself was concerned with the problems of the company, and thus only with those issues relevant to these problems. The particular aspects of planning which formed the basis for the initial stage of the project are described in 1.2.

The third part of this introductory chapter (1.3) is used to explain the structure of the remainder of the thesis, which is based on the way in which the project developed.

## 1.1 DIFFERENT APPROACHES TO THE PLANNING OF A BUSINESS

Several new approaches to planning have been developed over the past twenty years. Discussion of the growth of these methods highlights the suitability of differing approaches for varying situations. (1.1.1).

In the following section this discussion is used to identify the factors which should be considered by any company reviewing its own planning methods, with a summary of the issues involved. (1.1.2).

### 1.1.1 The development of current approaches to planning

As a result of reviewing the literature on the subject, it became apparent that any business enterprise requires some degree of planning, regardless of its size. This applies across the whole range of businesses, from a self-employed plumber to the largest and most diversified company such as ICI Ltd., Batchelors Foods Ltd., or BOC Ltd. itself.

In the case of the plumber, his objectives are probably those of ensuring a stable income, satisfactory profits and a viable cash flow. In order to ensure that these objectives are achieved, he must plan the allocation of his time, purchase of materials, and the invoicing of completed work. On the other hand, a company such as Batchelors Foods has to find some means of co-ordinating its multi-product, multi-technological business in order to achieve its objectives, expressed in terms of market share and return on capital employed. (Goodall, 1977).

All of these activities are covered by the term 'planning'. Ackoff (1970) defines planning as 'the design of a desired future and of effective ways of bringing it about'.

In this context, planning refers to the making of plans for achieving the objectives set for the business. Discussion of different approaches by various authors (see references in each section) shows that these can be formal or informal, long or short-term, explicit or implicit.

It would appear that, since the 1960's, planning has developed into a more rigorously defined tool for management of a business. Strategic planning as defined by Taylor (1977) is a systematic process for guiding the future development of an enterprise. According to Irving (1970) and many others (see (d) below), the term 'corporate planning' now refers to a continual management process of planning for the business as a whole. This includes the translation of strategy into detailed operational plans, and making sure that they are carried out.

The approaches in current use fall into four main groups; reviewed under (a) to (d) below. Discussion of these methods forms the basis for identification of the main factors determining the suitability of different types of planning for different companies. (1.1.2).

a) <u>Informal planning</u>

In the early stages of a business or industry, planning is generally informal.

The objectives and policy are embedded in the concept of the business held by the original entrepreneur. Strategy is equally implicit, usually concerned with building the business up into a stable and profitable position. Although the objectives can be long term, plans and decisions generally cover short term goals. There may be some evaluation and analysis of plans at a tactical level, such as in the appraisal of contracts or the development of new products.

Implementation is carried out through the operating decisions of the owner/ manager, and monitored using simple measures such as monthly accounts.

Ansoff (1976) terms this entrepreneurial behaviour, giving the user advantages of flexibility and a capacity for instant reaction to the environment. For this reason informal planning suits small businesses concerned with small or specialised markets, or in the early growth stages of a new type of industry.

However, informal planning methods will not provide sufficient direction and control once the scale of activity becomes too large, and the organisation of the business more complex. In this case, the need to co-ordinate the different parts of the business requires some type of formal plan, probably with a longer time scale for the long term planning of resources.

If plans can be based on a continuation of the current or related product/ market mix, then the need for formal planning can be met using budgetary methods.

b) Budgetary Methods

Willsmore (1960) defines budgeting to be systematic planning in large scale industry to ensure co-ordination of production, purchases and finance, with probable sales.

According to Hofstede (1966), budgets are management tools to facilitate the task of leading a company to its goals. This will be achieved by higher profitability resulting from co-ordinating efforts, avoiding waste, and improving management decisions, and from optimal liquidity due to the advanced knowledge of cash needs.

Generalising from the many descriptions of budgetary methods (see references at the end of this section), in this type of planning the objectives of growth or optimal profit maximisation are usually implicit. The long term plan concerns continual development and efficient production and marketing of existing or related products.

The emphasis is placed on operational management and tactics for improving the efficiency of the business. A detailed operating plan, usually for a one year period, is expressed in financial terms in the budget. This gives management both involvement in, and control of the business at all levels.

Budgets frequently encompass all the elements of planning, including the setting of goals, the co-ordination of resources, and the management and control of plans. The way in which this is done gives rise to the different forms of budget;

Bottom-up; in which operational plans and forecasts of sales and costs from departments are co-ordinated and revised by management in the light of their objectives.

Top-down; where goals set by the management in the budget form targets for operational plans devised by departments. Management then co-ordinate these plans in line with available resources.

Cyclical (the 'corporate planning cycle'); bottom-up and top-down proposals alternate until agreement is met on a budget which will achieve company objectives with available resources.

Extended budgets may be prepared for longer time periods if required for decisions on major issues such as expansion of capacity.

For further details of budgetary methods see Batty, 1970; Willsmore, 1960; Bacon, 1970; Robson, 1966; Hofstede, 1966.

The main conclusion to be drawn from discussion of these methods is that budgeting anticipates continuation of the current product/market mix. If demand for a product is still growing, and the market not yet saturated, market behaviour will be predictable. Planning can then be based on the extrapolation of past trends, and budgets will fulfill the requirement for formal planning.

However, circumstances may demand a change in the mix, or the need to add unrelated product lines. The exhaustion of current markets, imports of cheap foreign goods, or changing technology are typical situations cited by Ansoff (1976) requiring a change of strategy. This could also be due to the enlargement of a company's scope of activity by acquisition or diversification. (Taylor, 1977).

The need to generate and evaluate different strategies for achieving company objectives was met by the development of a more systematic approach to strategic planning.

c) <u>Strategic Planning</u>

Strategic planning involves a regular review of corporate strategy in the light of corporate objectives. The element of change is expressed by

Ackoff (1970) in his definition, 'a process directed towards producing one or more future desired states not expected to occur unless something is done'. However, this rather general statement could be used to express the purpose of any type of planning. More specific is the definition by Anthony (1965), 'the process of deciding on the objectives of an organisation, on the resources used to attain these objectives, and on the policies that are to govern the acquisition, use, and disposition of these resources'.

Most discussions about strategic planning concern the use of a systematic approach to this process, which consists of several distinct steps (Ackoff, 1970; Taylor, 1977; Bridge & Dodds, 1978; Argenti, 1980):

i) Specification of objectives and goals, which may be financial ones such as profit and return on investment, ambitious, for example growth or market dominance, or stylistic as in technological leadership.

ii) Appraisal of the environment, including market trends, competitive action, technological development, and possibly social and political factors.

iii) Appraisal of company resources, strengths and weaknesses.

iv) Generation and evaluation of strategies for achieving the objectives, based on the findings of (ii) and (iii).

Several techniques have been developed to facilitate this approach. These include portfolio analysis, in which products or businesses are divided into a portfolio of different investments, and gap analysis, in which plans are made to 'close the gap' between the current path of the business and the desired position.

Models can be used for the generation and evaluation of strategic plans, by providing a basis for quantifying the important factors in a business, and hence the effect of changes in these factors.

v) Conversion of selected strategy into detailed operational plans, programs, budgets etc. Tactical plans may be prepared for production, resource development, product development, marketing, and the organisation in general.

vi) Setting up a system to monitor and control the progress of the plan against a set of clear criteria.

This typical description of the strategic planning process uses many terms which are usually undefined and rather vague in meaning. This leads to some confusion in terminology between the various types and levels of planning.

In the context of the thesis, the terms in general use are defined as follows.

Strategic planning refers to the process of devising and choosing strategies, which are the means by which the objectives for the business will be achieved. These will be long term plans, probably spanning five years or more, and involve major decisions on product/markets, resource requirements such as capacity and level of manpower, methods of generating these resources, methods of production, and so on.

Once these decisions have been made, the factors involved become fixed constraints for the next level, that of operational planning. This concerns the ways in which resources will be utilised, how the chosen product/market will be exploited, the running of the manufacturing operation and day to day organisation of the business. Plans are shorter term, usually for one year, with objectives developed from the first steps of the strategic plan. Monitoring and control of the operational plan is frequently done by use of budgets. ((b) above).

Tactical planning generates the ways in which the goals of the operational or strategic plans may be achieved. For example, operational plans may include marketing plans for increasing volumes of sales. Within this plan, tactics may be based on aggressive pricing policies, use of publicity, different routes to the market, and different types of packaging. In this way, strategic, operational and tactical planning form a hierarchy of planning levels, in which implementation of a plan at one level uses that of the next level down.

Corporate planning, literally the planning of a corporate body, should strictly be at the head of this hierarchy, including strategic planning as a part of its process. However, again in the literature terminology is confused, with corporate and strategic planning sometimes used indiscriminately to refer to the same thing.

In this thesis, corporate planning is taken to refer to the management process which includes the making and methods of implementation of plans for all aspects of the business. This is explained further in (d) below.

d) Corporate Planning

Taylor (1977) proposes that, for top management, corporate planning means the determination of objectives, strategies and policies, so that divisional management and corporate staff can develop their plans within broad guide lines. It means that they are thinking ahead about the organisation, so as to start new products in good time, and consider new projects in the context of alternative strategies for the division and the company as a whole. Taylor goes on to say that corporate planning is a philosophy of change - not so much a battery of techniques and systems as a style of management involving a continuous dialogue about the future of the organisation.

Descriptions of this process vary. Hussey (1974) sees corporate planning divided into operational management dealing with existing products, and strategic management for developing new products. The strategic plan is at the centre of the process, with operating plans for marketing, administration and production, and progress plans for diversification, acquisition, research and development. He then develops this idea into a total planning system which copes with the planning and control of all aspects of the business.

In contrast, another system, devised by the Stanford Research Institute (Stewart, Allen and Cavender, 1963), divides the strategic plan into the corporate development plan dealing with investment, diversification etc., and the operating plan for production, marketing etc.

## Other Approaches

There are several other types of planning which have been developed more recently, such as Gaming Policy and Policy Analysis. Gaming Policy, as described by Howard (1971) and Radford (1975 & 1977), considers all external agents who are capable of influencing the future performance of the business and tries to predict their behaviour and the resulting outcome. In describing Policy Analysis, Taylor (1975) suggests that research into long range planning in both the public and private sectors could be used to diagnose general policy problems and so recommend ways of improving the decision-making process. Although not yet part of the mainstream of current approaches to planning, these methods could prove useful under certain conditions. (1.1.2(e)).

Summary

The main approaches in current use are the informal type of planning in a small business, formal planning using budgets or extended budgets, strategic planning, and corporate planning.

These approaches are not all distinct; budgets may well be an outcome of strategic planning, which can itself be a large part of the systematic approach to corporate planning. Thus, although each type of planning can stand alone, it can also form part of a hierarchy of levels of planning in a corporate planning system.

Within each group specific methods may vary, particularly in the strategic planning process where several different techniques have been developed to help with the generation and evaluation of strategies.

Some of the points raised in this review of planning methods can be used to identify factors which determine the most appropriate choice of approach for a particular company or business.

## 1.1.2 Important issues in choosing the approach to planning for a particular company

The types of planning reviewed in 1.1.1 range from the informal and generally short term plans used in entrepreneurial behaviour to full corporate planning systems involving formal plans for each aspect of the business. The suitability of any one approach for a particular company depends on several factors, some of which are evident from the above discussion. (1.1.1).

Firstly, the most obvious factor is the size of the organisation, which will generally determine the need for a formal or informal approach. (1.1.1(a)). When the scale of the business is such that some type of formal planning is needed, if only to control all of the activities within the business, a further choice must be made.

At this stage the state of the business becomes the second important factor to be considered. A simple budgeting system may be perfectly adequate, provided that market behaviour is predictable and business objectives can be achieved with the existing range of products. (1.1.1(b)). If, however, existing markets are exhausted, technology is changing rapidly, or if the company wishes to diversify into other areas, then strategic planning methods provide a rational basis for evaluating alternative options. (1.1.1(c)).

The third factor arising directly from discussion of general methods is typified by the situation in which a large company has to manage a variety of businesses with some control over the overall direction. The complexity of this problem may require a full corporate planning process. (1.1.1(d)).

Research has shown that use of formal planning methods is not always successful, and that there may be other factors which influence the effectiveness of such a process.

Studies in both the U.S.A. and the U.K. have produced evidence showing that introduction of a full corporate planning system coincides with improved performance in terms of various financial criteria. (Thune and House, 1970; Ansoff et al, 1970; Karzer, 1975; Anderson, Clarke, and Tudor, 1976). But this does not justify the assumption of a cause and effect relationship between the two, since the apparent correlation may be due to the correlation of each with a third factor, such as the size of the company. (See results of PIMS study reported by Schoeffler, Buzzell, and Heany in 1974, and by Buzzell, Gale and Sultan, 1975).

In their study of organised planning in major UK companies, Taylor and Irving (1971) conclude that the introduction of planning generally coincides with other changes and so cannot be treated in isolation.

These authors suggest that, in cases where this approach has not been successful, the faults lie partly in the use of the methods, but mainly in the success of the implementation.

In drawing conclusions from his survey of planning in major UK companies, Ringbakk (1969) maintains that 'most planning is characterised by undue financial and quantitative concern'. Projections of sales, volume growth, etc. are meaningless if consideration has not been given to the underlying factors affecting sales, and how their behaviour would affect these quantities.

Failure to implement the plans may be due to a lack of commitment by all concerned. Taylor (1977) claims that the corporate planners' first requirement is a solid power base.

In addition, too little thought is given to the changes required in the organisation to implement changes of strategy.

As Ansoff (1976) says, with the invention of strategic planning, it was assumed that a firm would muster and allocate its energies to effect realignment from the old to the new posture. But, time and time again the following mustering of energy proved inadequate for moving the firm to the new position. This requires a cultural transformation in changing objectives, the structure of responsibility relationships, managerial skills and systems. To effect changes, a firm needs trained and motivated managers, strategic information, fluid and responsive systems and structure. Lacking these, strategic plans will fail to overcome the resistance to change due to organisational inertia.

These observations suggest that the style and strength of management, and its ability to implement changes, should be a further factor governing the choice of approach to planning.

In addition, both Ansoff (1976) and Taylor (1975) have expressed doubts about the capability of any formal planning system for coping with a future of rapidly changing technology, in which the rate of change is too high for the time scale of a formal planning process. Ansoff maintains that companies will have to return to the entrepreneurial type of behaviour (1.1.1(a)), in order to ensure adequate flexibility and reaction time. Taylor recommends an alternative type of planning in his Policy Analysis (described at the end of Section 1.1.1).

The main conclusion arising from this study is that in considering its planning process, a company has the choice between several broad types of planning, each with a range of specific techniques. The most important issues to be considered when making this choice, or appraising the current system, are the following:

a) Choice of broad approach to planning

The business will require some type of planning to enable it to cope with its internal organisation and external environment. Whilst informal methods give flexibility and the capacity to make a speedy response to any change in the environment, the size and complexity of the organisation may determine the need for a formal system. If so, budgetary methods may be adequate, or strategic planning methods may be necessary to evaluate plans for changing the product/market mix. In a large organisation, management and control of the business could be improved by the introduction of a corporate planning system.

b) Choice of specific techniques

In the case of budgetary methods, there are several different ways of arriving at the final budget. (1.1.1(b)). Each method has advantages and disadvantages. The bottom-up approach provides involvement and motivation at departmental level, but overall targets may not satisfy managers' objectives for the business. With the top-down approach the situation is reversed; management targets may be unrealistic and impractical, with a resulting lack of commitment at lower levels. The results from a planning cycle could satisfy all concerned, or be an unhappy compromise.

If strategic planning methods are used, some techniques may be more suitable than others (1.1.1(c)). Analysis of the environment could be sketchy or more detailed, and could include ecological and social factors if relevant for the business. Some method will be required for evaluating alternative options, which may involve use of a model, whether relatively simple or more complex.

c) Implementation

Since planning will be ineffective without successful implementation, some thought should be given to the means by which this is done.

If a change of strategy is likely, the management system must have the capability to put changes into effect. Plans to strengthen current management may be a pre-requisite for strategic planning.

d) The requirements of changing conditions

Strategic planning as part of a formal process was developed to cope with changing conditions in markets and technology. (1.1.1(c)). In the event of any acceleration in technological progress, it may be necessary to review the suitability of a formal system for coping with the rate of change in external factors.

## 1.2 THE PARTICULAR PROBLEMS OF BOC ARC EQUIPMENT

Only certain of the points covered were of immediate relevance to the managers of BOC Arc Equipment.

In the first phase, planners at BOC Arc Equipment were not concerned about their general approach to planning, but about the methods they used to derive strategy.

They claimed that their strategic plan was based on the assumption that an 'experience curve model' was valid for their business.

The 'experience curve model' is the supposed decline in the total unit cost of the product as experience in all parts of the business is accumulated. Since actual costs are affected by inflation, unit costs must be divided by some index representing this factor, in order to indicate any reduction in constant value terms.

In most cases, experience is represented by the cumulative output of production, the total number of units of the product ever made. The standard model takes the log of cumulative output as the independent variable, and log of unit cost as the dependent variable (2.4.2(c)). One feature of this model is that with every doubling of cumulative output, unit cost declines by a fixed percentage, popularly termed the 'slope' of the model.

The Boston Consulting Group (BCG) claimed that there were many businesses where this relationship fitted the decline in unit cost, giving many examples in their literature. (See BCG, 1970). They used the model to derive a strategy of market share maximisation. (Hedley, 1976). This consists of investing in market share in a growth market in order to grow to a position of dominance. Then, when growth slows, the company with dominant share should have the highest cumulative output and hence, lowest unit costs and highest profits.

Managers at BOC Arc Equipment had been advised by BCG in 1972 that their business was on an '83% curve', and was suitable for a strategy of market share maximisation in order to achieve higher profitability. Having followed this plan for some years, the management team were now concerned about its success. They wanted to know whether the 83% curve was still applicable to their business, and whether their unit costs were declining faster than those of their major competitors.

An additional matter for concern was the behaviour of the average price per unit. In literature published by BCG (1970), they gave examples of differing patterns of price behaviour. In some cases the average price of the product followed the same curve as unit cost, whereas in others the price remained fairly constant whilst unit costs declined, forming a price 'umbrella'. (Hedley, 1976). In the latter situation, it is possible for one company suddenly to drop their price and obtain a significant advantage over competitors, referred to as a 'price break' by planners at BOC Arc Equipment and in some of the BCG literature. (Conley, 1970).

In summarising their initial problems, the company recorded them in the form of four questions:

a) Was the BOC Arc Equipment business still on the 83% curve estimated by BCG in 1972?

b) Was the rest of the UK industry on the same slope curve?

c) Did the price curve follow the cost curve, or was there a 'price umbrella'?

d) In the case of an industry price umbrella, could a price break be forecast?

Although not explicitly stated, the first question embodied their concern for the validity of the model and its use as a basis for the strategic planning of the business. They wanted the investigation of this assumption to be the primary task for the project.

If results from the research showed that the model was valid, then planners in the company wished to extend its use for more detailed levels of planning. This would include looking at 'shared experience' between different products; the extent to which experience gained in the manufacture of one product could be passed on, in order to increase efficiency and lower the costs of manufacture of a related product.

On the other hand, if the results of analyses showed that the model was not valid or was inapplicable for some reason, then there would be an immediate need to appraise the implications of this finding for the planning of BOC Arc Equipment.

This summarises what was known about the proposed problems of the company before beginning the project. The initial approach taken in examining these problems is discussed in Chapter Two.

The final section of this introductory chapter is used to explain the subsequent development of the project and the structure of the thesis.

## 1.3 STRUCTURE OF THE THESIS

The project consisted of an analytical approach to the planning of BOC Arc Equipment. Beginning with the initial problems posed by the company (1.2), the work developed in a series of logical steps. Results from each stage produced a range of options for the next one. At the same time, the company provided a dynamic background of changing priorities. The choice of option pursued at each stage was made in response to the needs of the company.

In Stage I the project tackled the initial questions concerning the company's planning model. After establishing the importance of these issues, the investigation proceeded to test the fit of this particular model to data for BOC Arc Equipment and the U.K. arc welding equipment industry.

Results from this work suggested two areas of concern for planning in the company, the first relating to the model, and the second to the success of the current strategy. In Stage II the project actually followed both of these avenues in turn, resulting in recommendations for both short and long term planning in the company.

In Stage III, responding to changing priorities in the company, the project assisted with plans for achieving two of the short term goals recommended at the end of Stage II. This formed the last part of work contributing to the planning of BOC Arc Equipment.

The structure of the thesis follows the successive stages in the project:

Section I: Investigation of the initial problems presented by the company. (Chapters 2-5).

Several essential pieces of research preceded the actual analysis of data. Firstly, a period of familiarisation in BOC Arc Equipment provided necessary background knowledge of the company, its business, and its planning methods (Chapter 2). This was followed by a more detailed evaluation of the importance of the questions posed by the company (Chapter 3). The next step consisted of a critical examination of the current state of knowledge on the experience curve model and its uses in planning (Chapter 4). Finally, the fit of this particular model was tested on data from BOC Arc Equipment and the U.K. arc welding equipment industry (Chapter 5).

Section II: Investigation of alternative planning models, and the success of the current strategy. (Chapters 6-8).

The project followed both of the avenues suggested by the results of Stage I, examining alternative models to the one in current use (Chapter 6), and investigating reasons for certain trends discovered during the initial analyses (Chapter 7).

Results from the research undertaken in stages I and II had serious implications for planning in BOC Arc Equipment. Recommendations arising from this work, together with the changing situation in the company, determined the problem areas to be tackled in the remaining time available. Since this was a crucial point in the life of the project, these issues are discussed in a separate chapter (Chapter 8).

Section III: Contribution to tactical plans (Chapters 9 and 10).

This section reports on ways in which the project contributed to tactical plans for implementing two of the recommendations made at the end of Stage II. Results from research into schemes for reducing costs (Chapter 9) is followed by a summary of various pieces of work which provided the basis for new marketing plans (Chapter 10).

Section IV: Conclusions, recommendations, and implementation (Chapters 11-13).

A discussion of the implications and recommendations for planning in BOC Arc Equipment (Chapter 11) is followed by a report on the ways in which some of these recommendations have been implemented (Chapter 12).

In the final chapter, results from the project are used to comment on planning in companies in general, to make recommendations where pertinent, and to suggest areas for further research. The opportunity is also taken to discuss the success of the project. (Chapter 13).

# CHAPTER TWO

## FAMILIARISATION WITH BOC ARC EQUIPMENT AND ITS BUSINESS.

The problem presented by BOC Arc Equipment concerned the validity of its planning model and the consequences of using the model to generate and evaluate strategies. The planners claimed that their current strategy (1977), involving major decisions on capacity and resources allocation, was based on this model.

If the model proved to be a valid one for their business, they wished to develop and extend its use for more detailed levels of planning. If results from the research showed that it was either invalid, or inapplicable for some reason, then there would be an immediate need to appraise the implications, and consider alternative bases for planning in BOC Arc Equipment (1.2).

In approaching this problem, the first concern was to establish whether the questions posed by the company justified the attention of this type of project. This involved determining whether investigation and solution of their problems would affect the company in some way, and whether these questions were the right ones to ask. In other words, did planning in BOC Arc Equipment really depend on the experience curve model, and was the validity of the model of crucial importance?

However, in order to be able to evaluate the importance of these questions, the author had to become familiar with the company, its business and its planning methods. This process took several weeks and consisted of various activities designed to acquaint the author with all parts of the business.

The information gained from this period of familiarisation was used throughout the project, and is included in the thesis at this stage in order to provide the basis of knowledge required for subsequent chapters.

A brief description of the activities undertaken during this period is given in 2.1, an introduction to the business in which the company was engaged, in 2.2, discussion of the main characteristics of the company itself, in 2.3, and their approach to planning, in 2.4.

## 2.1 ACTIVITIES DURING THE FAMILIARISATION PROCESS

Three main activities were undertaken during this period, which provided familiarisation with the products manufactured by BOC Arc Equipment, characteristics of the market in which they traded, and the financial aspects of the business.

At that time, BOC Arc Equipment manufactured and sold arc welding equipment. A short course in the company's welding school provided an introduction both to the welding process and to the main features of the products.

This was followed by an exercise in plotting trends for annual sales, direct costs, and contribution levels of the company. As well as the financial information, this also provided familiarisation with the accounting procedures, sources of financial data, the typical split between UK and export sales, and financial split between the four main product groups. Sales data from BOC Arc Equipment was also used to find lag/lead indicators for the business, by testing correlations with data from other industries whose sales could be related to those of arc welding equipment. As well as giving the author some idea of the market for this equipment, the exercise provided the company with useful information on existing and potential lag/lead indicators for future sales.

Finally, a rather ambitious project was designed to familiarise the author with all aspects of the business. The objective, an appraisal of the strengths and weaknesses of BOC Arc Equipment and major competitors, was to be achieved by the Delphi method of collating the opinions of anyone likely to have some insight in relevant areas.

A questionnaire was designed to find out about the following aspects of the business:

- Market position: market share and overall trend
- Management: strong/weak, traditional, enterprising, idealistic, etc.
- Marketing: price, distribution, advertising, sales strength, etc.
- Product: range, quality, design, reliability
- Production: capacity, vertical integration, type of premises, etc.

Participants, who ranged from BOC salesmen to management personnel from the parent company, were asked to rate the company and its major competitors for each of these attributes. Results were analysed and presented as a strengths and weaknesses matrix for the better known companies in the UK arc welding equipment market.

Although taking rather a long time, this piece of work provided the company with something of immediate use, and introduced the author to many aspects of the industry, characteristics of the UK market, and the position of BOC Arc Equipment and its competitors in this market.

The information gained from these activities is given in the remaining sections of this chapter, beginning with the type of business in which BOC Arc Equipment was engaged.

## 2.2 THE ARC WELDING EQUIPMENT BUSINESS

The industry consists of those companies who develop, manufacture, sell and service arc welding sets and accessories. At that time, they ranged from large established companies who performed all of these functions, to small distributors, importers, and the one or two man service business.

An understanding of the products and their markets is made easier by understanding the basic welding process.

### 2.2.1 The arc welding process and the products.

This is an electric arc fusion process. An arc is struck between the electrode, encased in a torch held in the hand, and the workpiece. Heat from this arc is used to fuse the joint metals together, often with the addition of another metal to reinforce the weld.

In the original process, known as Manual metal arc, referred to as MMA or MANUAL, the weld is perfected by a layer of flux around the electrode which melts with the electrode, forming both an inert surrounding atmosphere and a protective layer of slag for the weld.

Later developments produced processes which shield the weld from atmospheric contamination using a protective gas; either by a metal inert gas such as $CO_2$, which gives its name to the MIG process, or by an inert gas such as argon which, by being a tungsten inert gas, gives its name to the TIG process.

PLASMA welding is a process very similar to TIG, but giving higher quality welds at low current.

In both the MIG and the original MANUAL processes, the metal introduced forms the electrode used to strike the arc; MANUAL uses a stick electrode and MIG a continuous bare wire which flows through the centre of the torch. These electrodes are hence referred to as consumables.

TIG has a non-consumable electrode, and so when reinforcement of the weld is required, the filler wire must be introduced separately, as in gas welding.

Thus, the basic equipment required for the process of arc welding consists of a power source, a torch, interconnecting hoses and cables, and frequently a cylinder of gas.

In addition, MIG, most TIG and DC Manual types of welding require a D.C. output from the power source, and thus have a rectifier as an integral part of the set. The whole power source is then frequently referred to as a rectifier.

The rectifier can also be supplied as an add-on unit for converting existing AC Manual sets.

Additional equipment may be required for the different processes. MIG welding requires the use of a wire feeder unit, and the sophisticated TIG process may need gas flow meters, weld timers and D.C. suppressors, either built in or supplied as optional extras.

Plasma is a process extension from that of TIG welding, used for precision welding in thin metals. Plasma sets are technologically sophisticated, but still developing, with the market in a very early growth stage.

### 2.2.2 The Market for arc welding equipment

The following descriptions of the UK and other markets for arc welding equipment refer to the situation as it was at the time of the project, i.e. 1977-1980.

Information on the size and growth rates of these markets was obtained from the BOC Arc Equipment strategic plan for 1978-83 (prepared 1977/78). The actual source and accuracy of this data was difficult to establish.

At that time there were no published statistics for UK sales of arc welding equipment as a separate category. The only source of data was BEAMA, the British and Electrical Allied Manufacturers Association. The ten or so companies in the UK industry who were subscribing members of BEAMA submitted data on value and volumes of their sales of rectifiers, and received in return the aggregated totals for all members. At that time it was thought that this data covered approximately 80% of UK sales of arc welding equipment.

On the basis of this information, together with the knowledge of their own sales, the planners at BOC Arc estimated that the size of the UK market was approximately £22m, of which BOC AE had 39% share, GKN Lincoln (recently amalgamated with Rockweld) 18% share, and the Swedish firm ESAB approximately 15% share. The remainder of the UK market was supplied by hundreds of small companies, both British and foreign.

Volume growth in the market over the period 1965-76 was 9% p.a., although there had been a downturn in demand since 1974.

Most of the larger companies manufactured their own products, but some were distributors holding a franchise for foreign manufacturers, often with very high quality products. BOC Arc Equipment was unusual in that it offered a full range of MIG, TIG, Manual and Plasma sets; most companies specialised in one or two of these product groups.

The differing applications of MIG, TIG, and Manual welding meant that the markets for each process had differing characteristics. The market for the Plasma process was small and very specialised.

AC Manual, although still the most widely used process, was a mature market with very little growth. Its traditional users, such as the shipbuilding and structural steel industries, were changing process from MANUAL to MIG welding with its greater speed and ease of use. AC welding equipment was still purchased however, mainly for its reliability and relatively low price, with sets in the range £80 - £500 approximately.

The MIG process had the advantages of technical quality, flexibility, and ease of use requiring less skill and training for the operator. Market growth rate was approximately 10% p.a. The process had a wide range of applications from light metal fabrication and repair, for example in the motor body repair trade, to heavy fabricating industries such as manufacturers of electric generating plant, storage tanks, etc. However MIG sets had a shorter working life, and were in the higher price bracket of between £600 - £2,000.

TIG welding was used when weld strength and finish was of paramount importance, as in the aerospace, nuclear, food-processing equipment and petrochemical industries. Sales of TIG sets depended on the need for the process; the market had a steady volume growth rate of approximately

5% p.a. which was expected to continue. Due to their greater complexity, TIG sets tended to cost more, with prices in the range £800 - £2,500.

It may be seen from these descriptions that companies supplying the needs of this market were supplying goods to a broad sweep of industries. Sales tended to be cyclical, of 4-5 years in length, related to but not directly correlated with those of the engineering industries; they were correlated with GDP and output of manufactured goods.

The size of the European market was estimated to be approximately £110m, with particularly high volume growth taking place in Spain and Italy. This market was spread over many companies who each had a small market share. ESAB was probably the strongest company overall in the European market. The rest of the world comprised a market of approximately £150m, mainly in the USA but with some demand in Eastern Europe, the Middle East and Nigeria.

## 2.3 THE COMPANY: BOC ARC EQUIPMENT

BOC Arc Equipment, subsequently referred to as BOC AE, was in the business of manufacturing and marketing power sources and arc welding equipment. It considered that its main product was the welding rectifier.

BOC AE was an operating company of BOC Ltd., which was itself a subsidiary of BOC I (International). BOC AE was part of the engineering division of BOC Ltd., which also included companies making welding consumables and Plasma cutting equipment.

After describing the size of BOC Arc Equipment and its chief product and marketing characteristics, a review of the development of the company leads into discussion of its current organisation and management, since this was dependent on some of the historical factors.

### 2.3.1 Product range and market position

BOC AE had a turnover of £8m p.a., of which approximately 30% was from export sales. The company was the dominant producer in the UK, with estimated market share of 39%. It is interesting to note that although this figure had no factual basis it was given as 'BOC's market share' by almost everyone who was asked.

BOC's share of the western European market was small, but they hoped to increase this by concentrating on four major countries. With this aim in mind, BOC AE was in the process of acquiring a French company, Socomé Nouvelle Société (SNS), who manufactured AC Manual equipment.

Sales were also made in the Middle East and Eastern Europe, but mainly on an 'opportunist' basis. Welding equipment markets in the rest of the world were covered by other BOC or BOC-associated companies.

BOC AE offered a full range of arc welding equipment. It manufactured power sources and most of the equipment for MIG, TIG, DC Manual and Plasma welding, and factored AC Manual equipment in order to complete its range.

The company had always been technological innovators and had a strong R & D department. BOC AE was proud of the high technology, quality and design of its products. It tended to initiate price increases and was considered to be in the upper quartile of market price.

Parts and service support was strong, and this operation was also a cash generator for the business.

However, BOC AE had little control over the selling operation in the UK. Its products were transferred to gases division at 80% of list price, and subsequently sold by the gases sales force, mainly by direct selling to the customer. Although able to supply sales support in the form of product training, the company had little influence over the routes to the market and the type of customer approached. Inevitably, the salesmen tended to concentrate on the bigger companies, who made large and regular purchases of gas.

Export sales were direct and managed entirely by BOC AE.

### 2.3.2 Historical development of the Company

A short history of the development of BOC AE will help to illustrate the type of manufacturing operation and provide a background to the company's current problems.

#### Early History

BOC had been associated with the electric welding process since its early development, mainly through the acquisition of various companies, and with the interest in the accompanying sales of gas.

In the early 1950's BOC acquired the selling rights for the new MIG process, and MIG equipment was manufactured and marketed by the BOC-owned company Quasi-Arc Ltd.

The development of this equipment was done in close collaboration with a company manufacturing rectifiers, called Hirst Welding Rectifiers; at that time this company was part of Hirst Electronics.

1965-72

In 1965 Hirst Welding Rectifiers became a separate company; BOC brought together its arc welding interests under the new name of BOC Arc Equipment, and bought a controlling share of 66% of the new company (HWR).

HWR supplied all BOC's rectifiers, but also sold to other customers, particularly to other equipment manufacturers.

The close collaboration in development continued between the two companies, but the identities of each were quite distinct. HWR was still run as a family business with an autocratic manager, and little need for systems or paperwork; BOC AE as part of the larger company was accustomed to the more sophisticated methods used to manage a multi-business operation.

1972-77

In 1972 BOC took over HWR completely, amalgamating the two into BOC Arc Equipment.

The administrative, technical development, marketing and export functions moved into new premises in Milton Keynes. Production and design was still carried out in the old HWR factory in Ramsgate, with little change in management or systems.

1977 Onwards

In 1977 a new factory was opened in Broadstairs, referred to as Thanet. This had 2.5 times the capacity of the old one, with all the best plant and machinery. Production was of the batch type, as the product range was fairly wide.

The sets were examined and tested at Thanet, and then despatched to the warehouse at Milton Keynes, which was the distribution centre for sales. Goods were transferred at direct cost plus a percentage mark-up to cover fixed costs, enabling the factory to be a profit centre. This provided motivation and a means of monitoring costs, but required a separate accounts department.

### 2.3.3 Organisation and Management

The structural organisation of BOC Arc Equipment was departmental, with seven departments corresponding to each main function of the business. These were split between the geographical sites in the following way.

At the Thanet factory, the factory management department included production, the drawing office, and factory administration. Operations management covered purchasing, production planning and control etc., and special products incorporated development and design, as well as production of special products.

The main functions sited at Milton Keynes were those of finance and administration, business development, export sales, and the parts and service department. Finance and administration included accounts, data processing, corporate planning, and site services. Business development covered both development and marketing of the products.

Each site had approximately 200 people, with separate personnel departments, administration of site services, accounting procedures, and so on. Management of the company was carried out by a General Manager and a management board consisting of the managers of each main function, one or two representatives from SNS (the French company), and one or two external members from other BOC companies.

As an operating company of BOC Ltd., decision-making at BOC AE was supposed to be autonomous, except for decisions on major items of expense, major changes in product range and pricing, and changes in strategy. These were referred to the executive of BOC Ltd. Engineering Division, to whom the General Manager of BOC AE ultimately responded.

Funding from central sources was on a barter-trader basis; operating companies were supposed to be self-funding except for major investments, for example in financing the new factory.

From the above discussions, it can be seen that BOC Arc Equipment was trading in a full range of arc welding equipment, being dominant producers in the UK and having a small share of the Western European market. Its role as an operating company of BOC Ltd. provided both constraints and advantages. The company also had its specific problems resulting from the historical development of the business and the two geographical sites in which it was housed.

In the remaining section, the general approach of BOC AE to the planning of its activities is examined and discussed.

## 2.4 THE PLANNING PROCESS IN BOC ARC EQUIPMENT IN 1977

Comments on the company's general approach to planning are followed by an introduction to the specific methods in use, and the ways in which plans were implemented.

### 2.4.1 General Approach to Planning in BOC AE

By 1977 the planning function was well-established in BOC Arc Equipment. The function was performed jointly by the General Manager and the Corporate Planning Manager. Both were very enthusiastic about strategic planning methods (1.1.1), especially the particular ones in use. (2.4.2).

Planning was formal, with a rolling 5 year strategic plan reviewed and prepared annually at the beginning of each financial year. This was at the behest of the parent company, and part of the format was dictated by them, mainly concerning market share projections and financial forecasts which they could integrate into their corporate plans.

The plans were then submitted at a divisional level and had to be approved. In practice this took place both at the formal meeting and also at a series of informal meetings which agreed the main points before the plans were finalised. Within this constraint, choice of planning methods was left to the operating companies.

BOC AE used the formalised approach to strategic planning, following most of the steps outlined in Chapter One. (1.1.1(c)).

## 2.4.2 Specific Techniques in use

In 1972 the Boston Consultancy Group (BCG) was employed by BOC Ltd. to advise managers on corporate planning methods.

BOC AE were chosen for a pilot study to show the efficacy of the planning model which they advocated at that time; the use both of the model and the general guidelines for planning was continued by BOC AE.

The three essential parts of BCG methodology are as follows.

### a) General Framework

The first step in the process was a fairly detailed analysis of the background to the business, including definition of product/markets, market characteristics and growth rates. This led to the isolation of three or four factors felt to be crucial for the successful running of the particular operation.

Strategic alternatives were generated on the basis of this information, together with the position of the business in the corporate portfolio. The options were evaluated by considering financial forecasts, possible competitive reaction, and the development of the business as a whole.

The chosen option was then used to define goals for action plans, and some system was set up for monitoring and control.

b) Product portfolio

This form of analysis is used both to evaluate the strategic alternative for the business with respect to its corporate role, and to devise separate strategies for product groups with differing market characteristics. Factors considered are size, market growth, and relative competitive position of the business.

Classifications are as follows:

Star: Strong competitive position in high growth market. Strategy should be to maintain or improve the position. Cash will be consumed in the short term but business should eventually become a cash cow.

Cash Cow: Strong competitive position in low growth (mature) market. Strategy should be to maintain position with minimum investment, concentrate on operational efficiency.

Question Mark: Low competitive position in high growth market. Strategic alternatives; either invest cash and fund business until it is a star, or disinvest.

VLP (Very Low Profits): Low market share in low growth market, usually producing low profits, little potential for improving the position. Strategic alternatives: disinvestment or slow liquidation, retracting to potentially profitable subsegment, or strengthening by acquisition. (Risky in low growth market).

### c) The Experience Curve Model for Strategic Planning

BCG claims that many industries have observed a gradual reduction in the real costs of manufacturing their products, in terms of the average cost per item deflated using an appropriate index of inflation. This is often accompanied by a corresponding decline in deflated average price. (See 4.1.1 for examples and references).

The reduction in cost is due to many causal factors, such as economies of scale, increased efficiency, better production design, and improved technology both for the product and production methods, all difficult to quantify.

The experience curve attempts to model the cost and price reduction and use predictions based on these trends for future planning. 'Experience' in production is represented by cumulative output, the total number of units of the product ever made. The model relates cumulative output with unit cost in a logarithmic form:

$$c = aV^{-b} \qquad \text{or} \qquad \log c = \log a - b \log V$$

where

$c$ = total cost per unit

$V$ = Cumulative output

$a, b$ are parameters of the model.

The choice of logarithmic form means that, for every doubling of cumulative output there is a fixed percentage reduction in unit cost. Popularly termed the 'slope' of the curve, this provides a simple measure for comparison of models with different parameters. For example, a 20% reduction in unit cost for every doubling of cumulative output is termed an 80% slope experience curve model.

According to BCG, (Hedley, 1976), the implications of this model for strategic planning are as follows.

Since costs decline with 'experience', the producer with the greatest cumulative output should enjoy the lowest unit costs and hence the highest profit margins. Other things being equal, companies which are increasing their market shares should be gaining on their competitors in terms of cost reduction. This is most easily done in a fast-growing market. Thus, when growth slows, the dominant producer with largest market share will enjoy the highest profit margins.

The strategy resulting from this argument is one of increasing market share in order to reap long term benefits. BCG does however point out the importance of positively managing the strategy in terms of controlling costs and unit cost reduction. The group suggests that even if the total market is not fast-growing, the strategy may be applied to a segment of the market which does have a high growth rate. (Hedley, 1976).

One specific tactical plan recommended by the consultants in their literature was to invest in capacity ahead of demand in a downturn of a cyclical market. The consequence of this should be that, when the upturn comes, the company who has done this will gain an advantage in output, and hence in cumulative output and unit cost reduction. (BCG, 1968).

This summarises the planning methods recommended by BCG, and upon which BOC AE claimed that they had based their strategic plans. (1.2).
The validity of these concepts will be discussed throughout the thesis.

A more detailed examination of the ways in which BOC AE used these methods forms part of the evaluation of their initial problems, as described in Chapter Three.

Discussion of the company's planning process concludes with the ways in which plans were implemented and controlled.

### 2.4.3 Implementation, Monitoring, and Control

The strategic planning methods described in 2.4.2 were used to develop a range of strategic options by which the company could achieve its objectives. These were presented to planners at the divisional level of BOC Ltd., and eventually one option was agreed and adopted for use. (2.4.1).

This option was then translated into operating plans for each main function, consisting of finance, production, marketing, technical development, and so on. Implementation of these plans was the responsibility either of the manager of each department, or possibly of special working parties or committees set up to implement inter-departmental activities.

Detailed budgets were then made out for the first year of the plan. Estimates of sales revenue became targets for the monitoring of actual sales, and those for costs used to manage and control the day to day running of the business.

## 2.5 THE NEXT STEP IN THE PROJECT

At this stage, having amassed an amount of basic knowledge about the company, its business, structure and organisation, and its planning process, it would have been possible to start looking at the possibility of testing the experience curve model on some sort of data from the company.

However, this would have ignored the factors mentioned briefly at the beginning of this chapter. Although the managers at BOC AE considered that investigation of the experience curve model, and their use of it in planning, to be of the utmost importance, part of the service which such a project can offer is to provide an objective evaluation of their definition of the problem and if its solution would be critical for the business.

The planners' perception of the importance of this model may not have been realistic, in which case they could have channelled their efforts into some other aspect of planning. Alternatively, there may have been some other problem in their planning process of which they were not aware, but was more crucial to the success of the business.

In order to evaluate these and other aspects of their original questions (1.2), an examination was made of the strategic plans for BOC AE, 1972-77. This investigated the extent to which the plans relied on use of the experience curve model. The results of this investigation are reported in Chapter Three.

## CHAPTER THREE

### EVALUATION OF THE PROBLEM AS DEFINED BY THE COMPANY

The problem presented by planners at BOC Arc Equipment, for investigation in the project, concerned their use of the experience curve model for planning the business. Underlying the specific queries relating to parameters of models in use was an implicit requirement for the project to examine the validity of this model and the way in which they were using it. (1.2)

In carrying out such an investigation, the first essential task was to evaluate the importance of these issues for BOC Arc Equipment.

Firstly, it was necessary to establish the extent to which the company's strategic plans depended on the assumption that the experience curve model was valid, and whether plans would have to be changed if this assumption was found to be false. Otherwise, there would be no point in testing its validity.

The second point concerned the degree of accuracy necessary in estimating parameters of the model. If the exact slope of the curve was not critical for any part of the planning process, then the 83% estimated by BCG (1.2) would have been good enough for practical purposes.

Finally, the importance of these issues for the company had to be evaluated in the context of all critical factors in their planning process; the validity of the model may not have been the problem with most priority.

Investigation of these issues required further knowledge of the strategic planning process at BOC Arc Equipment, and actual plans made for the business.

The annual five year plans produced over the period 1972-77 were analysed in some detail, in order to establish dependence of plans on the experience curve model and the importance of any other crucial factors in the planning process. Results of this work are summarised in 3.1.

In the second part of the evaluation, data from strategic plans of 1972 was used to test the sensitivity of choice of strategic option to the parameter of the experience curve model used to project unit costs. This exercise is reported in 3.2.

Conclusions drawn from results of these investigations are discussed in 3.3.

## 3.1 ANALYSIS OF STRATEGIC PLANS FOR BOC ARC EQUIPMENT OVER THE PERIOD 1972-77

In the strategic planning process, the generation and evaluation of strategic options is usually based on certain factors. These may include market trends, the advance of technology, and environmental factors, as well as the capabilities and resources of the company itself. A model may be used to simulate the effects of different strategies, in order to aid evaluation and choice of option. (1.1.1 (c)).

This investigation was concerned with the extent to which strategic plans for BOC Arc Equipment depended on the assumption that the experience curve was a valid model for the business, and with the importance of the other factors which contributed to the success of the planning process.

Discussion of the objectives for the business is followed by examination of the generation and evaluation of strategic options for achieving these objectives, and how the final choice was made. Methods of implementation and control, a crucial part of the planning process, were also critically examined.

Results of the analysis are summarised in Table 3.1.

### 3.1.1 Objectives for the Business

Planning at BOC Arc Equipment was part of a hierarchy of planning levels within BOC Ltd. The overall objectives and constraints at each level were defined by the plans of the level above. Within these requirements, planners could incorporate their own objectives and devise their own plans.

As a result, the plans for BOC AE were subject to three sets of objectives. As seen by BOC Ltd., the main role of BOC Arc Equipment was to support the core business of the sale of gases, since some users of arc welding equipment were also consumers of gas. To this end, the operating company was encouraged to continue and improve its position as market and technological leaders. At the same time, BOC AE as a part of engineering division was also subject to divisional objectives. Since the division was required to be a cash generator for BOC Ltd., it passed demands for good rates of return on capital onto its operating companies. In later years, from 1975 onwards, policies changed as a result of the worsening economic climate, and operating companies were required both to generate cash and to finance their own expansion plans. In addition to these external constraints, the planners at BOC AE had their own objectives for the business.

TABLE 3.1 - Summary of objectives, strategic options and agreed plans for BOC AE, 1973-77.

| Year of Plan | Market Background | Corporate Objectives | Divisional Objectives | Company Objectives | Strategic Alternatives | BOC AE Preferred Option | Agreed Option |
|---|---|---|---|---|---|---|---|
| 1973 | MIG-fast growing<br>TIG-cash cow<br>PLASMA-embryonic star<br>AC Manual-very low profits | 1) Support core business<br>2) Maintain UK dominance<br>3) Technological leadership | 25% return on investment | Development of the business growth to equal dominance in Western Europe | 1) Retrench<br>2) Current path - some growth with some profit<br>3) Expand - Euromig growth & sacrifice of profit | Euromig | Growth plus some profit |
| 1974 | AS 1973 PLUS FURTHER STRATEGIC OPTION: | | | | 4) Further growth with slight adverse effect on profit | Further growth | Growth plus profits |
| 1975 | Same as 1973/74 | Improved utilisation of assets and control of working capital. Exploit current markets without damaging long-term strength of support businesses. | 20% ROCE competence in technology. Higher profits and cash targets. | Growth in Europe to make exports 50% of turnover. | NOT DEVELOPED | - | Operational plans to increase profitability. Some growth in export. |
| 1976 | AS FOR 1975, Plus requirement for growth to use planned increase in capacity | | | | | | |
| 1977 | Downwards revision of estimated market growth rates for MIG and TIG. | Control of funding, each business self financing. | SAME AS ABOVE | Some growth to use new capacity | 1) Growth to dominance in chosen markets.<br>2) Retrench/Harvest<br>3) Exit, even at a loss<br>4) Defensive strategy<br>5) Hold market position | Growth or Hold. | Hold with some growth |

Although not expressed explicitly, the general objectives of planners within the company appeared to be those of the long term growth and development of the business. Specific goals, upon which plans were based, concerned growth of market share. In the early years, 1972-74, the strategic aim was to increase market share in Western Europe to a position of equal dominance. This was later revised to a more general target of growth in Europe and, in 1976, to a policy of dominance in chosen markets.

These strategic aims were based on the assumption that the experience curve was valid for the business, and on the resulting implication that the producer with the highest market share would reap the highest level of profits. (1.2).

The resulting choice of strategic option was always a compromise between the differing objectives for the company, as may be seen in 3.1.2.

3.1.2 <u>Strategic Plans 1972-77</u> (See Table 3.1 for Summary)

The plans of BOC Arc Equipment dealt with the management of a portfolio of products within the business. Segmentation by process divides the products into four main groups, MIG, TIG (including DC MANUAL), PLASMA, and AC MANUAL. Strategies for each group were developed according to its position in the portfolio. (2.4.2(b)).

| | | Market Share | |
|---|---|---|---|
| | | High | Low |
| Market Growth Rate | High | MIG (Star) | PLASMA (embryonic star) |
| | Low | TIG (cash cow) | AC MANUAL (dog) |

Strategies for each group were the following:

MIG - alternative strategies were developed for this growth segment. (See below).

TIG - market position was maintained with minimal investment and marketing effort.

PLASMA - as a new technology and market, this segment was funded for development until it was realised that the high cost of the product would limit market growth.

AC MANUAL - as a very low profit segment, strategies were developed firstly for retrenching by rationalising the product range, then for refocusing on the subsegment formed by the air-cooled range, and then for strengthening by acquisition of the French company, SNS (2.3.1).

Strategies for the MIG Segment

As the main growth segment of the business, the MIG product group was the subject for the generation and evaluation of alternative strategies, which dominated the strategic plans of the company.

Since the options and agreed strategies changed over the period 1972-77, they are briefly reviewed for each year.

1972/73 (Plans for 1973-78)

At this time the MIG market growth rate was estimated to be 15% p.a. Alternative strategies proposed for this segment were as follows:

a) Retrench in order to generate immediate profit; minimise investment and grow only where to do so is not in conflict with profit.

b) Continue on the current path (i.e. as projected from past trends), to achieve some growth with some profits by improving existing sales methods, introducing some new products, and improving product supply.

c) Expand - Euromig. To attack the European market by means of merger/acquisition investment to secure at least co-dominance via growth by sacrificing some profits. Strategic aims consisted of dominance in at least two major European markets and production scale at least equal to the nearest European competitor. These were based on the assumption of an experience curve model for the business.

Alternatives were evaluated using forecasts of sales, estimated costs of capacity, manpower and marketing, and projections of production costs using an experience curve model with an 80% slope. Since there was no supporting paperwork either for these calculations or for the original BCG estimate of an 83% slope (1.2), it is not clear why the 80% model was used.

The planners of BOC Arc Equipment supported the Euromig policy, which was developed in far more detail, but had to compromise and follow the agreed option of continuing on the current path, to give growth with some profits.

<u>1973/74 (Plans for 1974/79)</u>

Estimated market growth rate for MIG was revised to 18% p.a.

In most respects the three alternative options suggested in the previous year remained valid. However, the managers at BOC Arc Equipment were still enthusiastic about pursuing a growth strategy in order to gain the benefits suggested by the experience curve model. They added an intermediate growth option to the list, hoping that this would be accepted at the divisional level of BOC Ltd.

The revised list of options were as follows:

a) Euromig; Acquisition or other routes to short term significant growth to achieve co-dominance in Europe, requiring heavy investment.

b) Retrench- maximise current and short term profits, accept declining market position and ultimate withdrawal.

c) Current path - growth with some profits, as adopted the previous year.

d) Further growth options - alternatives suggested for improving dominance in the UK and positions in European markets, with some slight adverse effect on short term profits.

Again the agreed option was that of growth with some profits, with support given to some of the tactics suggested in the further growth plans.

At this stage it was noted that the buildings at Ramsgate were close to full utilisation, and would reach capacity at 'current path' volumes in late 1974. Rearrangement of the layout to give more efficient use of the premises could extend this time span to June 1975.

1974/75 (Plans for 1975-1980) and 1975/76 (Plans for 1976-81)

Basically, strategic plans during these years were concerned with the development of strategies agreed in the previous years. However, since the objectives of BOC Ltd. included more profit and cash generation from operating companies, their planners were required to put more emphasis on improved efficiency and hence higher profits.

The key factors for BOC AE were seen to be control of the problems caused by sales fluctuations, better stock control, development of 'lower cost products which were still competitively superior', and good customer service. Emphasis was placed on the need to manage the strategy by the control of unit costs.

Since 1972/73, sales revenue had fallen and the arc welding equipment business was perceived to be in a slump, but with a 'boom' forecast for 1977/78. In the plan for 1976/81, there was a restatement of the strategic aims resulting from assuming an experience curve model, and support given to the tactic to invest in capacity ahead of demand. (2.4.2(c)). This was expected both to result in an eventual gain in market share, and to discourage competitors.

However, this must have been a retrospective justification for expansion in capacity, since plans were already going ahead for the planning and building of a new factory with 2.5 times the capacity of the old one.

1976/77 (Plans for 1977/82)

By this time, estimates of market growth for both the MIG and TIG product groups had been drastically revised downwards, demanding a complete reappraisal of strategic plans.

Five main strategic options were generated:

a) Growth to dominance in chosen markets, noting that growth which does not achieve dominance is unlikely to provide long term profits.

b) Retrench/harvest; manage business for cash generation by maximising profits, giving up market share, and sacrificing long term competitive position.

c) Hold market position; to maintain current profit levels.

d) Exit, even at a loss.

e) Defensive strategy depending on competitors being non-aggressive.

Two of these alternatives were eliminated by considering the constraints and requirements of the parent company. The exit and retrench options could not be reconciled with the need to continue support of the core business of BOC Ltd.

Growth would be difficult in a low growth market, particularly if it had to be self-funded. The defensive strategy appeared to be unattractive and was ignored.

This left option (c), to hold market position. However, the new factory at Thanet was due to be completed in 1977, presenting a need to utilise the greatly increased capacity.

Thus, the chosen option became to 'hold market position with some growth'. It must be noted however, that plans for growth included a targeted increase in UK market share from 39% to 45%, a significant amount in a low growth market.

### 3.1.3 Tactical Planning and Implementation

In each strategic plan, the first steps were developed for following the agreed option, and detailed objectives set out for each function of the business.

Operating plans and tactics in the years 1973/74 were concerned with marketing plans for increasing volumes of sales, and with developing the resources required to cope with the growth in volumes of output. Detailed estimates of requirements were prepared for factory capacity, manpower and marketing resources. Marketing plans for the UK included the development of products for the heavy MIG sector, expansion in the fabrication shop sector, and growth in TIG sales, by selling to arc welding equipment manufacturers who did not have TIG products in their range. Plans for development of the European market concentrated on improvement of the distributor outlets.

The more restrained plans of 1975 and 1976 meant that tactical planning concerned the four key factors mentioned in 3.1.2. It was hoped that improved forecasting methods and increased export sales would help the problems caused by fluctuations in UK sales. Tactics for increasing export sales included gaining market share in certain selected countries, gaining new sales in countries not previously covered, and concentration on obtaining large contracts. Stock control was to be tightened up, and buying efficiency improved by using the more accurate forecasting of demand. Plans to reduce product costs consisted of a design/production project to improve product quality, reduce work in progress, and reduce costs, together with new product plans to develop a smaller range and lower cost products, but with 'increased product integrity'.
These tactics were continued in the plans for 1977/82.

Detailed objectives for the first year of the strategic plan were converted into operating plans and budgets, used to monitor and control progress of projects and the implementation of departmental plans.

However, there was no evidence of overall monitoring of the progress of the strategic plan. Although some records were kept of volumes of sales, there were no means of accurately estimating market share (2.2.2), and unit cost was not measured at all. Consequently, it was impossible to monitor either movements in share or corresponding values of unit cost.

### 3.1.4 Summary and Conclusions

Analysis of strategic plans for BOC Arc Equipment over the period 1972-77 showed that the generation and choice of options were strongly influenced by the objectives of planners in the company. Their implicit objectives of long term growth and profitability for BOC AE had become confused with the strategic aims for dominance arising from use of the experience curve as a planning model. (3.1.1). Even when estimates of market growth were halved, the planners continued to suggest and support ambitious growth strategies for the business. (3.1.2).

In fact, it must be noted that plans and forecasts rarely appeared to incorporate a realistic assessment of the effect of downturns in market growth on the company's volume of sales.

Although encouraging some growth in the early years, the parent company also required a certain rate of return on capital invested, and later on, of actual cash generation.

As a result of these conflicting objectives, the agreed option was always a compromise, but always one which involved growth.

However, the strategic aims of planners in BOC AE were encouraged by the parent company in another way, which had a lasting effect both on the business and on subsequent plans. In 1974-75 support was given to a venture to increase the manufacturing capacity of BOC AE by a factor of 2.5. This was in direct response to the tactic advocated by BCG, to invest in capacity ahead of demand, based on the experience curve model. (2.4.2(c)). Plans for 1976 onwards then had to provide for the utilisation of this capacity even though market conditions had not improved.

Initially, operating plans were concerned with marketing tactics to increase volumes of sales, and with developing the capacity and resources to cope with the planned increase in output. By 1975 there was some mention of the need to control unit costs, with plans for improving efficiency in production and reducing direct costs of the products.

Evaluation of plans using the experience curve model was not carried out after the initial plans of 1972/73. There was little evidence of the monitoring and control of market share and unit cost, which were the two main criteria related to the success of the strategic plan.

An exercise demonstrating the sensitivity of such an evaluation to the parameters of the model is discussed in 3.2.

## 3.2 SENSITIVITY OF THE CHOICE OF STRATEGIC OPTION TO THE PARAMETERS OF THE EXPERIENCE CURVE MODEL USED IN THE EVALUATION

The alternative strategies proposed in the strategic review of 1973 were evaluated using forecasts of sales, estimates of fixed cost expenditure and capital investment, and predictions of production costs based on the assumption of an experience curve model with 80% slope for unit production costs.

In this way, forecasts were produced for each year, 1973/74 to 1977/78, for each strategic option being considered.

Criteria for selection appeared to be those of profit, cash flow and return on capital employed.

The following exercise investigated the sensitivity of this choice to the parameters of the model used in the evaluation, with respect to the above criteria; for this purpose, other factors entering the decision-making process were ignored.

Main points of the methodology are given below, followed by a summary of the results and discussion of the conclusions which may be drawn. Full details of methods and results are given in Appendix (A).

### 3.2.1 Methodology (See Appendix A, A.1 for details)

For each option, forecasts of sales, estimates of fixed costs and capital investment required are those used in the original evaluation. The only change required for this exercise is in the predicted production costs for each option, originally calculated using an experience curve model with 80% slope.

The model used has the equation

$$c = aV^{-b}$$

where

$c$ = cost per unit

$V$ = cumulative output of production

$a,b$ are parameters of the model. (2.4.2(c)).

Since the constant a is a scale multiplier representing the cost of the first unit to be made, altering its value would only produce a relative change in all subsequent values of c, which would be meaningless in this context.

The important parameter is the constant b, which represents the rate of unit cost reduction, and is related to the slope of the curve by the formula

$$\text{Slope} = \frac{1}{2^b}$$, expressed as a percentage.

The existing evaluation used a model with 80% slope (b = 0.322) to estimate unit and total costs of production for each option. This exercise produced forecasts of unit and total costs using models with slopes of 90% (b = 0.152) and 70% (b = 0.515), and examined the effect on the choice of strategy.

Prediction of unit costs from each model for each option presented some problems, since each required estimates of unit cost for the beginning of the period, and cumulative output for the beginning and end of the period (1972/73 to 1977/78), and the original calculations were not available. For details of the methods used, see Appendix A. The projections obtained were then in constant money terms, and were inflated to a more realistic value for each year, using predictions for the GDP index.

The original forecasts of sales, fixed costs and capital investment were then combined with the new estimates of production costs for each option using each model, and profit, cash flow and ROCE calculated in each case.

3.2.2 Results (See Appendix A, A.2 and A.3 for details)

The forecasts for each option obtained using experience curve models with slopes of 90%, 80% and 70% respectively are given in Table 3.2.

These results are then regrouped and presented as summaries of how the alternative strategies would appear as a result of using differing parameters for the model used in the evaluation. Criteria used in this evaluation are the total profit over 5 years, cash flow over the period, and ROCE. Further factors included were the total capital invested, and long term effects on the business, since these were considered to be important in choice of strategy at BOC AE. See Table 3.3.

Comments are made on the alternatives and choice of strategy for each parameter used in the evaluation.

a) Alternatives and choice under 90% slope experience curve model

If the choice is made on the basis of profit, cash flow and ROCE over the 5 year planning period, the choice must be to retrench since this gives good profits, positive cash flow and adequate ROCE.

However, longer term considerations must include the development of the business, which would have adverse effects resulting from a retrench option. The simulation indicates that a further option would probably be required in this situation, since the current path looks disastrous with negative cash flow and declining ROCE, and the expand option requires heavy funding with no or little return for the first four years.

b) Alternatives and choice under 80% slope curve

If funding allows, the expand option appears to give good returns and profits after two years. If funding is not available but the business is required to survive, then the current path provides some growth with some profits; ROCE is a bit low but increasing.

It must be pointed out that if the long term development of the business is not important, then the retrench option would provide good cash generation over the following 5-year period.

c) Alternatives and choice under a 70% curve model

If funding allows, then the expand alternative is the best one for profit, ROCE, and long term development.

If funding is not available, then the current path would provide adequate profit, ROCE and positive cash flow after the first year, and long term development is continued.

### 3.2.3 Conclusions

The choice of strategic options would be different if selected on the basis of the above criteria from forecasts made using models with differing parameters.

TABLE 3.2 - Forecasts resulting from simulation

£'000

| | 1972/73 (Current Year) | 1973/74 | 1974/75 | 1975/76 | 1976/77 | 1977/78 | TOTAL 1973/74-1977/78 |
|---|---|---|---|---|---|---|---|
| 1) RETRENCH OPTION | | | | | | | |
| SALES | 1929 | 2483 | 2500 | 2500 | 2600 | 2600 | |
| PROFIT-under 90% curve | 116 | 205 | 228 | 253 | 287 | 268 | 1238 |
| -under 80% curve | 116 | 246 | 305 | 361 | 429 | 439 | 1780 |
| -under 70% curve | 116 | 291 | 386 | 473 | 574 | 609 | 2333 |
| CASHFLOW | | | | | | | |
| -under 90% curve | 68 | 30 | 183 | 213 | 237 | 278 | |
| -under 80% curve | 68 | 71 | 260 | 321 | 379 | 449 | |
| -under 70% curve | 68 | 116 | 341 | 433 | 524 | 619 | |
| CAPITAL INVESTED | 10 | 10 | 10 | 10 | 10 | 10 | 60 |
| CAPITAL EMPLOYED | 1236 | 1360 | 1445 | 1445 | 1455 | 1465 | |
| ROCE | | | | | | | |
| -under 90% curve | 9.4% | 15% | 16% | 17% | 20% | 18% | |
| -under 80% curve | 9.4% | 18% | 21% | 25% | 29% | 30% | |
| -under 70% curve | 9.4% | 21% | 27% | 33% | 39% | 42% | |
| 2) CURRENT PATH OPTION | | | | | | | |
| SALES | 1929 | 2483 | 2916 | 3391 | 3891 | 4463 | |
| PROFIT | | | | | | | |
| -under 90% curve | 116 | 146 | 153 | 144 | 116 | 79 | 638 |
| -under 80% curve | 116 | 187 | 248 | 307 | 361 | 425 | 1528 |
| -under 70% curve | 116 | 232 | 349 | 474 | 604 | 758 | 2417 |
| CASHFLOW | | | | | | | |
| -under 90% curve | (42) | (164) | (77) | (127) | (144) | (211) | |
| -under 80% curve | (42) | (123) | 18 | 37 | 101 | 135 | |
| -under 70% curve | (42) | (78) | 119 | 204 | 344 | 468 | |
| CAPITAL INVESTED | 40 | 160 | 60 | 60 | 60 | 60 | 440 |
| CAPITAL EMPLOYED | 1251 | 1460 | 1725 | 1975 | 2240 | 2515 | |
| ROCE | | | | | | | |
| -under 90% curve | 9.3% | 10% | 9% | 7% | 5% | 3% | |
| -under 80% curve | 9.3% | 13% | 14% | 16% | 16% | 17% | |
| -under 70% curve | 9.3% | 16% | 20% | 24% | 27% | 30% | |
| 3) EXPAND OPTION | | | | | | | |
| SALES | 1929 | 2650 | 3550 | 5100 | 6950 | 9000 | |
| PROFIT | | | | | | | |
| -under 90% curve | 116 | (189) | (470) | 97 | 815 | 1539 | 1794 |
| -under 80% curve | 116 | (142) | (342) | 385 | 1349 | 2405 | 3655 |
| -under 70% curve | 116 | (91) | (181) | 674 | 1860 | 3197 | 5459 |

Cont'd.

Table 3.2 Cont'd.

£'000

| | 1972/73 (Current Year) | 1973/74 | 1974/75 | 1975/76 | 1976/77 | 1977/78 | TOTAL 1973/74-1977/78 |
|---|---|---|---|---|---|---|---|
| CASHFLOW | | | | | | | |
| -under 90% curve | - | (899) | (1300) | (933) | (395) | 249 | |
| -under 80% curve | - | (852) | (1172) | (645) | 139 | 1115 | |
| -under 70% curve | - | (801) | (1011) | (356) | 650 | 1907 | |
| CAPITAL INVESTED | | 540 | 400 | 300 | 290 | 230 | 1760 |
| CAPITAL EMPLOYED | | 2050 | 2815 | 3745 | 4865 | 6115 | |
| ROCE | | | | | | | |
| -under 90% curve | | - | - | 3% | 17% | 25% | |
| -under 80% curve | | - | - | 10% | 28% | 39% | |
| -under 70% curve | | - | - | 18% | 38% | 52% | |

TABLE 3.3 - Evaluation of alternatives using models with differing parameters

| Options | Total Profit over 5 years | Cash Flow | ROCE | Total Capital Invested | Long term effects on the business |
|---|---|---|---|---|---|
| a) Using 90% slope* curve | | | | | |
| Retrench | £1.2m | Positive, cash generation throughout | 15% inc. to 20% by 1977/78 | £50,000 | Adverse, lack of development etc. |
| Current path | £0.64m | Negative throughout | 10% declining to 3% by 1977/78 | £440,000 | Current level of development continued |
| Expand | £1.8m | Negative until 1977/78 | Non-existent for first 2 years, inc. to 25% by 1977/78 | £1.8m. | Growth to dominance in W.Europe |
| b) Using 80% slope* curve | | | | | |
| Retrench | £1.8m | Positive, cash generation throughout | 18% inc. to 30% by 1977/78 | £50,000 | Adverse - no development |
| Current path | £1.5m | Positive after first year | 13% inc. to 17% by 1977/78 | £440,000 | Current level of development continued |
| Expand | £3.6m | Negative for first three years, then good | Non-existent for first 2 years, then inc.rapidly to 39% by 1977/78 | £1.8m | Growth to dominance |
| c) Using 70% slope* curve | | | | | |
| Retrench | £2.3m | Positive, good cash generation throughout | 21% inc. to 42% by 1977/78 | £50,000 | Adverse - no development |
| Current path | £2.4m | Positive after first year | 16% inc. to 30% by 1977/78 | £440,000 | Current development continued |
| Expand | £5.5m | Negative until fourth year, then cash generated | Non-existent until 1975/76, but inc.to 52% by 1977/78 | £1.8m | Growth to dominance |

* '% Slope' refers to the parameter b of the experience curve model, where

$$\% \text{ slope} = \frac{1}{2^b} \times 100.$$

Even if the choice was constrained by lack of availability of funds, then recommended choices using models with differing parameters would be, to retrench or find another option using the 90% curve, to retrench or follow the current path using the 80% curve, and to follow the current path using the 70% curve.

It must be noted that the current path did not always produce safe profits and return on investment. Using a model with 90% slope, this option produced the lowest profits, negative cash flow and declining ROCE. This implies that an evaluation of this type is of the utmost importance, since apparently 'safe' strategies may not produce the expected results.

The findings and conclusions from this work, and from the analysis of strategic plans reported in 3.1, are now used to evaluate the importance of the problem posed by BOC Arc Equipment.

## 3.3 DISCUSSION AND CONCLUSIONS

As stated at the beginning of this chapter, the problem posed by the managers of BOC Arc Equipment concerned their use of the experience curve model as a basis for strategic planning of the business.

Analysis of strategic plans for BOC AE over the period 1972-77 showed that the objectives of planners within the company had a strong influence on the generation and choice of strategic options for the business. (3.1.4). Their main goal, the increase of market share to a position of dominance in chosen markets, was based directly on the assumed validity of the experience curve model and its implications for strategy.

There were other important factors affecting the planning process at BOC AE.

The conflicting objectives for the business arising from the hierarchy of planning levels in BOC Ltd. resulted in plans which were always a compromise, often trying to achieve diverse goals such as the expansion of facilities together with a high rate of return on capital invested. (3.1.1).

Another factor was to be found in the worsening economic climate and its effect on the market for arc welding equipment. The main problem appeared to lie in the general lack of recognition of this element in plans for growth.

Further potential problems were indicated by the lack of monitoring and control of strategic plans. (3.1.3). This meant that, for the most part, managers had no idea whether the current plan was successful or not.

However, the investigation showed that the ambitious market share objectives of planners within BOC AE had affected strategic plans and tactics at all levels. Whilst the agreed plan was a compromise, it always contained a strong element of growth, even in the face of the adverse market conditions (3.1.4). Moreover, on the basis of experience curve 'theory', managers at the company gained support for plans to double the manufacturing capacity of BOC AE, resulting in the building of a new factory.

Since these objectives were based on an assumed experience curve model for the business, the validity both of the model and of its implications was felt to be of the utmost importance.

In addition, the exercise reported in 3.2 showed that choice of strategic option was sensitive to the parameters of the model. Use of differing parameters had such an effect on projections of profit, cash flow, and ROCE, that the choice of strategy based on these criteria would almost certainly have been different for each parameter. (3.2.3).
It must also be noted that the simulation demonstrated the importance of making an evaluation, since the apparently safe 'current path' option did not always give safe results in terms of profit and cash flow. In fact, if BOC AE had included such an evaluation in subsequent plans (after 1972/73), decisions on choice of option may well have been different.

The work reported in this chapter showed that the validity of their planning model was one of the most important issues for BOC Arc Equipment, and that accurate estimates of its parameters would be needed if the model was going to be used for evaluation and monitoring of plans.

However, before investigating these problems, it was necessary to explore the work of other researchers in this field. The questions posed by planners in BOC Arc Equipment may well have been answered elsewhere, possibly by a study in a similar manufacturing company. In addition, a review of the current state of knowledge on the use of this particular planning model might shed some light on the best ways of tackling the problems of BOC AE.

The current state of knowledge on these issues, and relevance for the planning problems of the company, are reviewed and discussed in Chapter Four.

# CHAPTER FOUR

## THE CURRENT STATE OF KNOWLEDGE ON THE EXPERIENCE CURVE MODEL AND ITS IMPLICATIONS FOR STRATEGIC PLANNING

The Boston Consulting Group claim that the experience curve model, applied to costs incurred by all of the activities of a company in manufacturing and marketing the product, may be used for strategic planning by companies in a wide variety of industries. (2.4.2(c)).

These claims were investigated by examining the results of other research in this field, and discussion by other authors of the issues involved. This chapter contains a report of this work and its implications for the project.

In particular, the investigation aimed to answer the following questions:

a) Is there evidence that a regular and significant amount of reduction in unit cost occurs in all types of manufacture. Are there any common factors characterising its presence?

b) Can such unit cost reduction be modelled by a functional relationship between measurable variables, and hence used in some way for planning purposes?

c) If so, is there a uniformly best model for this purpose and is this model the experience curve?

d) In particular, is there any evidence that the experience curve, or some other model, is likely to be suitable for planning at BOC Arc Equipment?

Many articles have been written on the experience curve model, and on the learning curve from which it was derived. This asserts that the direct labour input to a product declines in relation to the cumulative output of products. Unfortunately, although many examples of this type of steady reduction in unit cost are cited, very few reports give results of testing the fit of models to relevant data. Those who do give hard figures are widely quoted by the remainder, in discussing the derivation, application, and uses of the model.

The first part of this chapter reviews the many examples of this type of behaviour in unit costs, the underlying causes of cost reduction, and ways in which this behaviour may be modelled. (4.1).

Results from cases in which various models have been tested in a rigorous way on actual data are summarised and discussed in 4.2.

However, the fit of a model is not the only criterion for its use in planning a business. The third part of this chapter considers criticisms of the way in which the experience curve model is used to derive the strategy of market share maximisation, and critical factors in the use of this strategy. (4.3).

Finally, the evidence and discussions from other studies are used to examine the questions (a) to (d) raised above, and to consider the implications of any findings for the way in which the specific problems of BOC AE should be tackled. (4.4).

## 4.1 THE BEHAVIOUR OF UNIT COSTS AND HOW IT MAY BE MODELLED

As expressed by Henderson (1968), the Boston Consulting Group claim that 'the experience curve effect may be observed and measured in any business, any industry, any cost element, anywhere'.

The first step in investigating these claims was to examine the behaviour of unit costs: is there evidence of a steady reduction in unit costs in a wide variety of industries, and, if so, why does this happen?

### 4.1.1 Examples of industries exhibiting a regular reduction in unit cost of production

The phenomenon of a regular and significant reduction in hours of direct labour required for the assembly of airframes was first noted in the USA in 1925 by Wright (1936), and well documented in the subsequent studies of airframe data by Alchian (1950), Christ (1951) and Asher (1956).

Since that time, examples of a regular reduction in direct labour input per unit, or corresponding increase in productivity, have been noted in a variety of manufacturing situations. Hirsch (1952) reports on cases in machine tool manufacture, Conway & Schultz (1959) give examples in a variety of products unspecified but ranging from simple to relatively complex, and Baloff (1966 & 1971) found evidence of this effect in products made by machine-intensive production, also in complex musical instruments, casual wear, and new automobile models.

In the wider category of total unit costs, Preston & Keachie (1964) give examples of gradual cost reduction in items of radar equipment, and Sultan (1975) discusses evidence of such trends in the manufacture of turbine generators, power capacitors and transformers.

The literature of the Boston Consulting Group is characterised by 'examples' of experience curves given in graphical form, totally unsupported by any evidence of statistical analysis. However, their claims are substantiated by the analyses of Woolley (1972), who was given access to their files when working on his Ph.D. These provide examples from chemical film and paper products, fabricated and knitted products, facial tissues, steel products, lawnmowers, and various electronic measuring instruments.

A paper by Noyce (1977), notes the dramatic declines in cost per unit of integrated circuits, cost per bit of computer memory, and in associated products such as hand-held calculators.

Thus, these examples show that a regular and significant reduction in unit cost or labour input has occurred in a wide variety of industries. Examples from machine-intensive and totally automated production imply that these reductions cannot be associated solely with human learning and improved efficiency of operations; there must be other underlying causes for this phenomenon.

### 4.1.2 Underlying causes of cost reduction

Andress (1954) was one of the first authors to attribute the observed reduction in labour input and associated costs to more than just the increased productivity resulting from learning how to do things more efficiently.

He and others suggested that overall efficiency can be increased by improvements in production methods, shop organisation, and production engineering as well as job familiarisation, the original 'learning effect'. Further benefits can be gained from better product design and effective systems, for example in parts supply. In addition, the effect of the management of the business can be felt in its capacity to innovate, improve, and organise. (Andress, 1954; Asher, 1956; Conway and Schultz, 1959; Kottler, 1964).

Hirschmann (1964) summarised these views by attributing reduction in unit costs to the 'inherent susceptibility of an operation to improvement, and the degree to which that susceptibility is exploited, depending on the resourcefulness of management'.

When applying the model to a wider cost base, BCG (Henderson, 1968) claims that unit cost reduction is the result of benefits from larger scale operations as well as the original 'learning effect'. These benefits include specialisation, and the possibility of investment in increased capacity and improvements in manufacturing methods.

It would appear that there are many underlying causes for the type of long term reduction in unit cost noted in the examples of 4.1.1. Any attempt to model this behaviour has to find one or more variables to represent the effect of the underlying factors.

### 4.1.3 Models for the behaviour of unit costs

Examination of the results of research in this field show that a variety of models have been tested on data for unit costs; in fact, variables other than unit cost itself have been used to measure the effects of increased productivity. Since these provide alternatives to the experience curve model, they are briefly reviewed below. Evidence for the fit of different models to actual sets of data is discussed in 4.2.

#### a) Dependent variable

Measurements of the effects of increased efficiency in production include the direct labour input per unit, either in hours or converted into costs. Some studies use indices of productivity such as output per hour or output as a percentage of capacity. (For examples see Table 4.1 in section 4.2).

Many examples use total unit cost, covering costs incurred by all of the activities in manufacture and marketing of the product.

BCG claim that the variable best representing increased productivity is that of added value per unit. (Henderson, 1968). However, such data is frequently difficult to obtain, and they recommend using the proxy variable of average price.

The use of average price, in the absence of cost data, to indicate trends in unit cost is of doubtful integrity. On the one hand, it offers a practical way of estimating such trends which could be good enough for planning purposes. On the other hand, price is affected by many more factors than is unit cost; behaviour of average price could be influenced by market conditions, aggressive pricing from a competitor or as a marketing policy of the company itself, or by imports of cheaper goods, changes in exchange rate, and so on. In their literature, BCG themselves cite examples of price 'umbrellas' and price 'breaks'. (BCG, 1968 and Hedley, 1976).

However, a model for average price may well be useful in itself for price-forecasting and marketing plans. (Jain, 1975).

b) <u>Independent variable</u>

Cumulative output, the number of units of the product ever made, is the variable used in most models, since it is an obvious measure of production experience. Sultan (1975) suggests that it combines the effects of the scale of production with changes which occur over time, such as technological progress.

Some authors such as Hirsch (1952), and Preston and Keachie (1964) have attempted to justify the use of cumulative output, or a combination of cumulative output and rate of output, by considering the theory of production functions and cost curves.

Production functions model the relationship between quantities of the input factors of production and the associated volumes of output. Short run cost curves represent the optimal combination of these factors for producing a given volume at lowest cost. Long run cost curves represent the effect of a change in one of the input factors, for example, by an increase in capacity or substitution of labour by plant. (For details, see Lipsey, 1963).

The above authors speculate that the long-term reduction in unit costs results from a change in the production function itself, brought about by changing technology and management innovation. But, however technical this argument appears to be, it still begs the question of why these improvements should be best represented by cumulative output, either alone or in conjunction with rate of output.

Alternative independent variables suggested and tested in various studies include rate of output, lot size (representing scale of operation), and elapsed time (Table 4.1 for examples).

Sultan (1975) uses a combination of cumulative output with a range of other factors including price changes, utilisation of capacity and technical transfer between firms. Stobaugh and Townsend (1975) include the number of producers, and a measure of product standardisation between producers, in their model.

c) <u>Form of the relationship</u>

The experience curve model postulates that the variables are linked by a logarithmic relationship. Some authors have tested alternative forms, generally either linear or log/linear (semi-log), and occasionally an inverse relationship. (Table 4.1)

Briefly, if $c$ = unit cost or other dependent variable

$V_1, V_2 \ldots$ are independent variables,

$a, b_1, b_2 \ldots$ are parameters of the model

then the main models tested in reports on this work are:

log/log; $\log c = \log a + b_1 \log V_1 + \ldots$ (experience curve model given by $V_1 = V$, $b_1 = -b$ )

log/linear; $c = \log a + b_1 \log V_1 + \ldots$

linear; $c = a + b_1 V_1 + b_2 V_2 + \ldots$

Inverse; $c = a + \dfrac{b_1}{V_1} + \dfrac{b_2}{V_2} + \ldots$

It may be seen that combinations of the variables described above, in different forms of relationships, give rise to hundreds of possible different models. In selecting or evaluating such a model, the first factor to be considered must be the way in which it fits relevant data.

Unfortunately, many examples are cited in the literature without giving supportive evidence of results of statistical tests. Results from those which have been tested in a rigorous way are reviewed in 4.2.

## 4.2 REVIEW OF CASES WHERE MODELS HAVE BEEN TESTED ON ACTUAL DATA, AND STATISTICAL RESULTS GIVEN

All of the models tested are either linear or transformed into linear form by logs. (4.1.3). Thus, the fit of models to the data can be tested using standard linear regression techniques.

For example, using the model

$$\log c = \log a - b \log V \quad \text{(standard experience curve model)}$$

the test of a linear relationship between log c and log V is expressed by testing the hypothesis b=0. Having chosen a significance level for the test, either of the two sample statistics t or F are calculated and compared with critical values $t_\alpha$ or $F_\alpha$. These determine whether the sample value of b is significantly different from zero, at the predetermined level of significance. (Appendix B.1 for details of method).

The results summarised below have been accepted only if the author is satisfied that the models have been statistically tested in this way. In most cases values of the sample statistic $R^2$ are also given. This is the proportion of total variation of the dependent variable explained by the regression, and provides a descriptive statistic of the goodness of fit of the model.

### 4.2.1 Summary of results

Table 4.1 summarises the results from all cases found in the literature where models were tested on actual data, and the statistical results were given. Examples in the table are numbered and referred to in the text.

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Table 4.1
Results from other research in which models have been tested on actual data.

| | Reference | Sample | Dependent Variable | Independent Variables | Form of model | Results |
|---|---|---|---|---|---|---|
| 1 | Alchian, A. | 22 airframe models | Direct labour input per pound of airframe. | Cumulative output<br>Time<br>Rate of output | log/log<br>"<br>" | Significant Parameters not given<br>" but sig. different for<br>" each airframe model<br>(Sig. levels not given) |
| 2 | Hirsch, W.Z 1952 | 7 different machine tools | Direct labout input | Cumulative output | log/log<br>linear | log/log sig. in all cases (at 5% level)<br>$R^2$= o.71 to 0.92<br>Slopes 79% - 84%<br>Linear gave better fit in one case only |
| 3 | Conway, R W & Schultz, A. 1959 | Unspecified products, simple to extremely complex | Labour hours req. per unit | Cumulative output | log/log<br>linear | Significant, in most cases log/log gives better fit (Sig. levels not given) |
| 4 | Baloff, N. 1966 | Production start-ups for 28 different products (machine intensive) | Input per unit of output | Cumulative output | log/log | All significant, at o.5%, values of $R^2$ vary between 0.88 & 0.99<br>Slopes vary between 61% and 89% |
| 5 | Baloff, N. 1971 | Production start-ups; 6 new models of musical instrument, 3 types of casual wear, 4 new automobile models | Index of cost or labour expen. per unit | Cumulative output | log/log | All significant at 1% level<br>Values of $R^2$ all exceed 0.73<br>Slopes vary between 55% and 90% |
| 6 | Preston, L.E. & Keachie, E.C. 1964 | 22 observations from 5 peices of radar equipment (pooled) | Unit labour cost<br>Unit total cost | )Both cumulative output<br>) and lot size<br>) included in each<br>) model | log/log | 6 models tested; both variables sig. at 5% level or better in all except one (unit labour cost in log/log model) $R^2$ range 0.88 - 0.90 |
| 7 | Woolley, K. 1972 | Chemical Film Products (8 observations) | Total Unit cost | Cumulative output | log/log | Significant at .01, $R^2$=0.92, slope=80% |
| | | Chemically treated paper (6 obs.) | " | " | " | " " .01, $R^2$=0.99, slope=86% |
| | | Two fabricated/ knitted products (5 obs.) | " | " | " | " " .01, $R^2$=0.97, slope=84%<br>$R^2$=0.96, slope=73% |
| | | Finishing & dye process (5 obs.) | " | " | " | " " .01, $R^2$=0.92. slope=73% |
| | | Facial tissues (13 obs.) | " | " | " | " " .01, $R^2$=0.95, slope=84% |
| | | Steel product (13 obs.) | " | " | " | " " .01, $R^2$=0.92, slope=52% |
| | | Lawnmower ## 1 (4 obs.) | " | " | " | " " .10, $R^2$=0.78, slope=81% |
| | | Lawnmower ## 2 (4 obs.) | " | " | " | " " .02, $R^2$=o.96, slope=73% |
| | | Complex elect. tube (11 obs.) | " | " | " | " " .01, $R^2$=0.92, slope=68% |
| | | Plastic film product | " | " | " | " " .01, $R^2$=0.96, slope=71% |
| | | 7 Electronic measuring instruments | " | " | " | )5 Significant at<br>) .01, $R^2$0.83 to 0.96 -<br>) slopes vary from 70% to 89%.<br>)1 Significant .02, $R^2$=0.55, slope=92%<br>)1 " .10, $R^2$=o.34, slope=92% |
| 8 | Sultan, R.G.M. 1975 | Production of Turbine Generators Power Transformers and Power capacitators | Average price and total unit cost | Cumulative output | log/log<br>Semi-log<br>Linear.<br>time trend | )All significant, log/log model gives<br>)best fit for power capacitors<br>)($R^2$=0.95) and transformers<br>)($R^2$=0.49 |
| | " | Turbine Generators | Direct cost per kilowatt | Cumulative output, Price inflation, Average size of unit Utilisation of capacity, Technological transfer, Price index for order backlog. | log/log | Significant variables,<br>Cumulative output<br>Average size of unit,<br>Price index for generator orders |
| 9 | Stobaugh, R.B. & Townsend, P.L. 1975 | 82 Petro-chemical products | Ratio of prices in successive products | Number of producers, Product standardisation Cumulative production Average production per year. | log/log | All independent variables significant over periods of 5-7 years, at 5% level. Only number of producers and cumulative output over 1 yr 3 years. Generally low values of $R^2$. Significance of constant term indicates missing time-related variable. |

In the rather limited sample of products and industries for which data was tested, variation in the dependent variable was significantly related to at least one of the independent variables tested.

In almost all cases, cumulative output was statistically significant as an explanatory variable. The exceptions are found in data from two products tested by Woolley (ex.7), where the small number of observations have raised the critical value of t, and the level of significance is fairly low.

However, in most of the cases where some measure of the scale of operation was tested, it was found to be significant. (Ex.1, 2, 6, 9). Although Hirsch (ex.2) did not find lot size significant, Preston & Keachie found that lot size was a significant variable in five out of six models tested. (Ex.6). Stobaugh & Townsend discovered that average production per year was not a significant variable in their model for price ratios, when data was taken over shorter periods of 1 to 3 years (Ex.9).

Although only specifically tested in two cases, elapsed time was found to be a significant variable both times (Ex.1 & 8). In addition, Stobaugh & Townsend considered that the statistical significance of the constant term in their model indicated a missing variable which was probably time-related (Details in Appendix B).

Other variables found to be significant related to conditions in the industry and in the market. These included the size of order book, which was inversely correlated with unit cost reduction (Ex.8), product standardisation between producers, and the number of producers in an industry (Ex.9). The latter was in a model for price ratio in successive time periods, used to indicate the rate of reduction in average price.

Different forms of relationship between the variables were only tested in four cases. (Ex. 2,3,6 & 8). In each case all forms tested gave a significant relationship between the variables. Although in some cases the log/log form gave a better fit to the data, this result was by no means universal.

### 4.2.2 Conclusions

The conclusions to be drawn from reviewing the evidence found in reports of other research are that some measure of the gradual increase in productivity, typically a decline in unit cost, can be modelled in a variety of ways.

In statistical tests, cumulative output was frequently found to be a significant independent variable, but so also was rate of output and elapsed time. A further range of independent variables, representing conditions in the industry and the market, were found to be significant in particular cases.

There is no evidence that any one of these models gives a uniformly best fit to the relevant data.

In addition, no particular form of relationship used as a model gave a uniformly better fit.

In this section, the models have been considered with respect to the statistical significance of relationships between the variables, and the goodness of fit to sets of real data.

It must be noted that models have only been tested for the extent to which they explain variation in the dependent variable. The only case in which the predictive accuracy of the model was tested was in the study by Alchian (Ex.1), who found an average 25% error between predicted and actual values of direct labour requirement per unit.

However, in BOC Arc Equipment, the experience curve was being used to derive a strategy of market share maximisation (3.3). The extent to which such a model fits the data may not be the only factor to be considered in evaluating the use of this model by planners in the company.

Some of the literature on the experience curve contains articles in which the authors discuss their stand point on the derivation and use of this strategy. Since some of the issues involved were relevant for planning in BOC AE, they are reviewed and discussed at this stage.

## 4.3 USE OF THE EXPERIENCE CURVE MODEL FOR DERIVATION OF STRATEGY

The basic strategy derived from assuming that this model is a valid one for the business is one of market share maximisation. If the model is valid, the company with highest cumulative output should have lowest unit costs and hence highest profits. Since ultimately, when market growth slows, the producer with the highest market share will have the most cumulative output, companies should aim to maximise their market share in a growth market. (Hedley, 1976).

This strategy and its basis for derivation is attacked on three main issues.

a) <u>The validity of the model in all circumstances</u>

Lofthouse (1976) criticises the inherent assumption in this model that unit costs will continue to decline for ever. However, his argument relies on some rather irrelevant examples drawn from learning curves and start ups of production. Far more important was the suggestion made by Jain, (1975), that the model is only applicable to products in the early stages of their life cycles, and in the absence of both a dominant producer and competition other than on the grounds of price.

Sultan (1975) argues that the experience curve model should only be applied to the direct costs of production. If a producer does gain an advantage in reducing direct cost per unit, then the advantage can be maintained by investing the surplus funds into research and development and marketing effort. Thus, overhead costs may well be a function of strategic planning, and not related to cumulative output.

b) <u>Cost reduction as an aim in itself</u>

The policy of management for unit cost reduction is criticised by Abernathy and Wayne (1974), who quote the case of the Model T Ford, where long term concentration on design for cost reduction was made at the expense of long term development of the product. This resulted in disaster for the company.

It must be pointed out, however, that the Boston Consulting Group do not advocate this policy. They claim that unit cost reduction should be the result of utilisation of new technology and improved methods of production. They stress that unit costs reduction must be controlled and managed, but not that it should be the ultimate aim.

c) Derivation of the strategy of market share maximisation

The second major criticism made by Lofthouse (1976) appears to be more significant. His contention that the fall in unit cost may not only be related to cumulative output, but equally significantly to elapsed time, is supported by results found in other reports. (4.2.1). Lofthouse points out that if benefits from increased productivity are significantly related to time, then it is not necessary to have a large market share in order to enjoy these benefits. This throws doubt on the main argument used by BCG in deriving this strategy.

d) Inherent dangers in a strategy of market share maximisation

There is a certain amount of evidence that companies with large market shares do have higher profits than others, for example in the results of the PIMS study of 57 major companies in the USA, reviewed by Schoeffler, Buzzell, and Heany (1974), and by Buzzell, Gale, and Sultan (1975), and in the work of Hall and Weiss (1976), analysing data from 340 large industrial corporations in the USA. Authors of the PIMS studies attribute the high correlation between market share and return on investment to the economies of scale, market power, and quality of management found in the larger companies. Hall & Weiss (1976) postulate that the need for significant capital requirements form a barrier to entry and are more important than high market share itself.

However, Bloom and Kotler (1975) point out that producers with high market share are more at risk from competitive attack, government regulations, and so on, and propose that the optimal market share should provide long run profitability with minimal risk.

The main problems appear to lie in the process of trying to gain market share, since any increase in profits may not justify the risks and costs involved in gaining share. Fruhan (1972) gives three examples of companies where the strategy has failed, and the business has not been left in a viable position.

Since this problem will be particularly acute in a low growth market, one solution suggested by BCG (1968) is to segment the market and apply the strategy only to high growth segments. Jain (1975) recommends that a company should plan a succession of such products in order to maintain competitive advantage.

Another approach is to evaluate the costs and benefits of gaining market share using a planning model, incorporating projections of unit cost and average price with other measurable factors such as market and company growth rates. Such models are suggested in the work of Woolley (1972) and Verschuur (1976).

Woolley's model estimates the effects of changing growth rates, and may be used for budgeting and control, and for investment or acquisition decisions.

Verschuur simulates the relationship between a dominant and second firm in the market, in order to evaluate decisions made by the second firm, on whether to enter the market, expand, or cease production altogether.

The main limitation of such models is that they cannot allow for sudden changes in market conditions such as technological change, price wars, or imports of cheaper products.

This concludes the review of relevant information or views of other authors on the experience curve as a model for cost reduction and its use as a basis for strategic planning. References for the welter of articles discussing uses of the model for production scheduling, costing, pricing, forecasts of capital and labour requirements etc. are given in Appendix B.

## 4.4 CONCLUSIONS AND IMPLICATIONS FOR THE PROJECT

The conclusions concerned the validity and use of the experience curve as a planning model, and the possibility that alternative models may fit the same set of data. (4.4.1). Issues raised in this discussion had implications for the way in which the problems of BOC Arc Equipment should be approached. (4.4.2).

### 4.4.1 Conclusions

The first question (see (a)) raised at the beginning of this chapter concerned the existence of a steady reduction in unit cost, and whether this can happen in all types of manufacture. Evidence from studies found in the literature supports the phenomenon of a gradual increase in productivity efficiency occurring in a variety of manufacturing industries, whether this is measured by reduction in unit costs or in some other way. (4.1.1 and examples in Table 4.1).

Basic underlying causes for this phenomenon are thought to be improvements in manufacturing methods, product design and technological progress, organisation and management of the business, as well as the original 'learning effect'. These generally require both investment resources and innovative management. (4.1.2).

The second question (see (b)) asked whether unit cost reduction can be modelled in some way which would be useful for planning purposes. Results from the better documented cases showed that the effect of underlying factors on productivity could be modelled in a variety of ways. (4.2).

In considering question (c), the conclusion is that the evidence does not support the hypothesis that the experience curve is the only, or the uniformly best-fitting model for the behaviour of unit costs. (4.2.2). Other models found to give equally significant results relate unit cost (or other dependent variable) to rate of output of production, elapsed time, or a range of variables representing market conditions. No one form of relationship used gave a universally better fit to the data. (4.2.1).

The last question raised at the beginning of the chapter (see (d)), concerned the suitability of the experience curve, or alternative model, as a basis for planning, particularly for BOC Arc Equipment. The main points raised by authors discussing the experience curve model relate to derivation and use of a strategy of market share maximisation.

One criticism of the universal application of this strategy is that the model may not be valid in all circumstances, particularly at certain stages of the product life cycle and in certain market conditions. (4.3(a)). A further point concerning the derivation of this strategy from the experience curve model is that if reduction in unit cost is equally related to elapsed time, a large market share may not be a necessary factor in achieving these benefits. (4.3(c)).

Finally, many authors point out the risks inherent in a strategy of market share maximisation, and stress the need to evaluate risks, costs and benefits to be gained before taking this on. Planners should also consider the viability of the business if the strategy fails to achieve the market share objectives. (4.3(d)).

### 4.4.2 Implications for the project

Previous work had shown that strategic plans for BOC Arc Equipment were based on the assumption that the experience curve was a valid model for the business. (3.3). The process of making this assumption could be segmented into three parts.

Firstly, the planners assumed that unit costs (in constant money terms) were gradually declining, and secondly, that this behaviour could be modelled using an experience curve with an approximate slope of 80%. (3.2). The last step was that of deriving a strategy of market share maximisation from the assumed validity of the model. The first two stages in this process were based on undocumented evidence produced by BCG in 1972: the strategy was derived using an apparently logical argument. (1.2).

Evidence gathered from reviewing the literature threw some light on each stage in this process, with resulting implications for the ways in which the project should tackle the initial problem of planning in the company.

Although none of the case studies involved data on arc welding equipment, a regular reduction in unit costs had been found in products as diverse as facial tissues, and turbine generators. (4.1.1). The critical factors thought to contribute to such cost reduction were improved production and organisational efficiency, product design, and various benefits arising from larger scale operations. (4.1.2). There was no reason to believe that the manufacturing operation at BOC AE should not be able to benefit in the same way.

Equally however, there was no reason to suppose that the experience curve model was the only one to fit this type of unit cost behaviour, since, when tested, other models fitted the data as well or better. (4.2.2). This issue did not only concern the accuracy of the model; if alternative models did fit the data, then the argument for a strategy of market share maximisation no longer followed automatically. (4.3(c)).

Moreover, several authors had pointed out the importance of evaluating this strategy on the basis of other factors such as market conditions, competitive action, and the risks and penalties of failure. (4.3(d)).

The main implication for the project concerned the evaluation of the company's use of their existing planning model. This should include the possibility of alternative models, and some consideration of the other factors which may affect the success of the strategy itself.

It was decided to approach the problem in three stages:

i) Test the experience curve model on data for BOC AE and the UK industry, incorporating their original questions into the investigation. (1.2).

ii) Test the fit of alternative models to this data.

iii) Evaluate the strategic aims of BOC AE in the light of the results from (i) and (ii), and of any other relevant factors.

The first stage of this investigation is reported in Chapter Five.

# CHAPTER FIVE

## INVESTIGATION OF THE FIT OF THE EXPERIENCE CURVE MODEL TO DATA FROM BOC ARC EQUIPMENT AND FROM THE UK ARC WELDING EQUIPMENT INDUSTRY.

Strategic planning and decision-making at BOC Arc Equipment was strongly influenced by the choice of the experience curve as a planning model. (3.3). In using this model, the planners were assuming that unit costs were declining, that this decline could be modelled by an experience curve, and that the resulting logical strategy was to maximise market share.

As a result of reviewing other research in this field, it became apparent that a full evaluation of the company's basis for strategic planning should include both the possibility that alternative models may fit the data, and other factors critical to the success of the strategy. (4.4.2).

However, the first stage in this process was to test the assumptions concerning the existing model, by examining the behaviour of unit costs of production in the company, and the fit of the experience curve to relevant data. At the same time, these analyses could be extended to include data for the UK arc welding equipment industry, and so answer at least some of the additional queries of planners in BOC AE.(1.2).

This chapter reports on the setting up of this investigation, and results of the various analyses. Some of the trends discovered during the course of this work reflected on the success of the current strategy. These were thought to be of such crucial importance for the future of the business, that further analyses to establish the extent of their significance were carried out immediately.

The data, problems, and methods used in the investigation are reviewed in 5.1, with details in Appendix C. Results from tests of the experience curve model are given in 5.2, observations on trends and details of further analyses in 5.3, and conclusions and implications in 5.4.

## 5.1 METHODOLOGY USED IN SETTING UP THE INVESTIGATION

So far the problem had only a very broad outline, that of testing the fit of the experience curve model to relevant data. This had to be defined more rigorously before considering the availability of data, and how to organise the analyses.

Definition of the problem (5.1.1) is followed by discussion of the data available (5.1.2), selection of data and general methods of analysis. (5.1.3).

### 5.1.1 Defining the problem

The basic assumption made by planners at BOC Arc Equipment was that the actual unit cost of production was declining in such a way that it could be modelled by an experience curve. This related the hypothetical variables 'unit cost' and 'cumulative output' in a particular way. (2.4.2).

In order to test the validity of this assumption, the model had to be defined for a specific product unit, and for independent and dependent variables which were relevant and measurable in this situation. The hypothesis that a specifically defined relationship existed between these variables could then be tested using the techniques described in 4.2 and Appendix B.1.

Assumptions concerning alternative models could also be stated and tested in this way. (6.1 and 6.2).

Product Unit

The unit chosen was a welding rectifier, which refers to an arc welding set in which a rectifier is an integral part, and includes MIG, TIG and PLASMA, and DC Manual welding sets. (2.2.1). This was chosen partly because it represents the class of products manufactured by BOC AE, and partly because the products are homogeneous with respect to methods and costs of manufacture. Remaining products were either factored (AC Manual sets), or peripheral equipment with different methods of manufacture and cost bases. (2.2.1).

Even within this category, models still varied with respect to type, size, and cost. For this reason, possibilities were explored for dividing products into the main groups, MIG, TIG, etc., and even into individual product lines.

Dependent and independent variables

The dependent variable varied according to the data which was available, but was generally some measure of unit cost or average price of a rectifier.

Cumulative output of rectifiers produced was used as the independent variable in all models. In most cases cumulative output for the beginning of the period for which data was available had to be estimated from trends in volumes of sales. (5.1.3).

### 5.1.2 Availability of data

The two main sources of data were the British Electrical and Manufacturers Association (BEAMA), and records from the two companies involved, BOC Arc Equipment and Hirst Welding Rectifiers. (2.3.2). Unfortunately, government data on annual sales for the welding industry, published in Business Monitor, covered all electric welding equipment, which was too broad a category to be of any use.

These sources provided the opportunity to test the model on three types of data:

a) Individual product lines (HWR data)

Data was available from HWR for the annual volumes of output, and selling price/transfer price of the product from HWR to BOC AE from 1966 onwards.

If the selling price/transfer price was taken to represent the direct cost, this data could be used to test the fit of a model relating direct cost to cumulative output of production, for a single product line, some of which had remained largely unchanged over the period in question.

b) Rectifiers (BEAMA data)

Available data covered quarterly volumes and value of sales of all rectifiers, from 1962 onwards, for both BOC Arc Equipment and aggregated data from all companies subscribing to BEAMA. Also, the same data split into MIG and TIG product groups was available for 1972 onwards. (TIG including DC MANUAL and PLASMA).

This data could be used to test relationships between cumulative output and the average price of a rectifier for BOC AE and the companies subscribing to BEAMA, and to examine behaviour of the average price of a rectifier in the UK as represented by these companies.

c) <u>MIG, TIG & PLASMA product groups</u> (BOC AE and HWR data)

BOC Arc Equipment did not keep records of the manufacturing costs of rectifiers as separate product groups, but data was available for sales revenue, direct and indirect costs incurred in the manufacture and marketing of MIG, TIG (including DC MANUAL) and PLASMA equipment, as separate groups, for 1965 onwards.

This could be used in conjunction with volumes of output of rectifiers from HWR to provide estimates of the average sales revenue, direct, fixed, and total costs of a rectifier plus associated equipment, per rectifier produced. Analysis of sales data which provided further splits of the main product groups into welding power sources (rectifiers) and welding equipment showed that the proportion by value formed by rectifiers of the total remained fairly constant over the period in question. (Appendix C. 3.1.3). Consequently, trends in sales and costs per unit of all equipment were taken to represent trends in sales and costs per unit of rectifiers.

Models relating each of the dependent variables to cumulative output of production could then be tested on this data.

Ultimately, each of these three main groups of data was used to test the respective form of the experience curve model. Analysis of the data for one product line (a) did not give satisfactory results and was eventually discarded. (5.2.1). The data from BEAMA (b) gave satisfactory results, but certain reservations were felt about the accuracy of the data. (5.2.2). Data from BOC AE (c) did not relate specifically to rectifiers and presented various problems in analysis; however it was the only source of data for costs, other than direct costs of production, and after adjustment was considered to give a fairly accurate impression of the various trends.

### 5.1.3 Methods of analysis

After dealing with specific problems mainly relating to inconsistencies found in data over a long time period, the remaining general problem was how to remove the element of inflation from sales revenue and costs. The experience curve model refers to a gradual reduction in unit cost or average price when the latter are expressed in constant value terms. (2.4.2(c)). Consequently, all data expressed in money terms had to be deflated, and some index had to be selected for this purpose. Finally, having adjusted data for inconsistencies, and deflated sales revenue and costs, the appropriate model was specified and tested.

#### a) Specific problems

Details of specific problems regarding treatment of data are covered in Appendix C. The worst ones were found in dealing with data from BOC AE trading accounts over the period 1965-77 which covered changes in products marketed by the company, in relationships between BOC AE and HWR (2.3.2) and between BOC AE and BOC Ltd., as well as in accounting methods. (Appendix C. 3.1).

In fact, although changes had occurred in the range of products marketed by the company, MIG, TIG and PLASMA remained as consistent product groups throughout this period, and so data for other products just had to be excluded. (Appendix C, 3.2.3).

The changing relationship between BOC AE and HWR was dealt with by treating the two companies as a joint business from 1965 onwards, amalgamating data to give total sales, direct and fixed costs. (Appendix C. 3.2.4 for details).

Adjustments also had to be made to sales revenue and marketing costs to compensate for the change in marketing methods in 1974. From this time onwards, goods were transferred to the gases division of BOC Ltd. at special transfer prices, and sold by the gases sales force. (Appendix C. 3.2.3(e) and (f)).

Problems incurred by changes in accounting methods were solved by analysing data into broadly consistent categories. (Appendix C. 3.2.3).

b) Index of inflation

In the first set of analyses, (5.2.1), two differing indices were used to deflate the data. Since the results from each did not differ greatly, one was used as the common index for all subsequent work. This was the index of wholesale prices for the output of all manufactured products, home sales (UK).

Thus, all models tested the behaviour of unit cost or average price compared with this particular index. An advantage of this was that parameters of models fitted to different sets of data could be compared on the basis that each set of data had been deflated using the same index.

c) <u>Methods used in testing the models</u>

After relevant adjustment had been made, values of annual sales revenue or costs were deflated using the index described in (b) above. The result was then divided by the volume of output for that year, to give deflated sales revenue or cost per unit of production.

Cumulative output was estimated for the beginning of the period for which data was available. The average compound growth rate of output in volume was calculated for the period covered by available data. This was then used as a basis for summing estimates of volumes projected 'backwards' for previous years. (Appendix C. 2.1.2). Values of cumulative output for subsequent years could then be calculated from actual volumes of output together with the estimate for the beginning of the period.

A check was made of the sensitivity of the slope of an experience curve fitted to this data to the estimated cumulative output at the beginning of the period. This showed that errors of ± 30%, ± 50% in estimated cumulative output would produce errors in estimated slope of the curve of approximately ± 3 or ± 5 percentage points respectively. For details see Appendix C 2.1.2(c) (iv)).

The fit of the experience curve model to relevant data was tested using the technique of linear regression analysis described in 4.2, and in further detail in Appendix B.1. Sample estimates of the parameter b for each experience curve model were used to derive sample estimates for the 'slope' of each curve, as described in 3.2.1.

## 5.2 RESULTS

Results obtained from the three sets of data described in 5.1.2 are given in 5.2.1, 5.2.2, and 5.2.3 respectively.

N.B. All descriptions of the behaviour of unit costs or average price refer to the deflated values.

### 5.2.1 Analysis of data from one product line

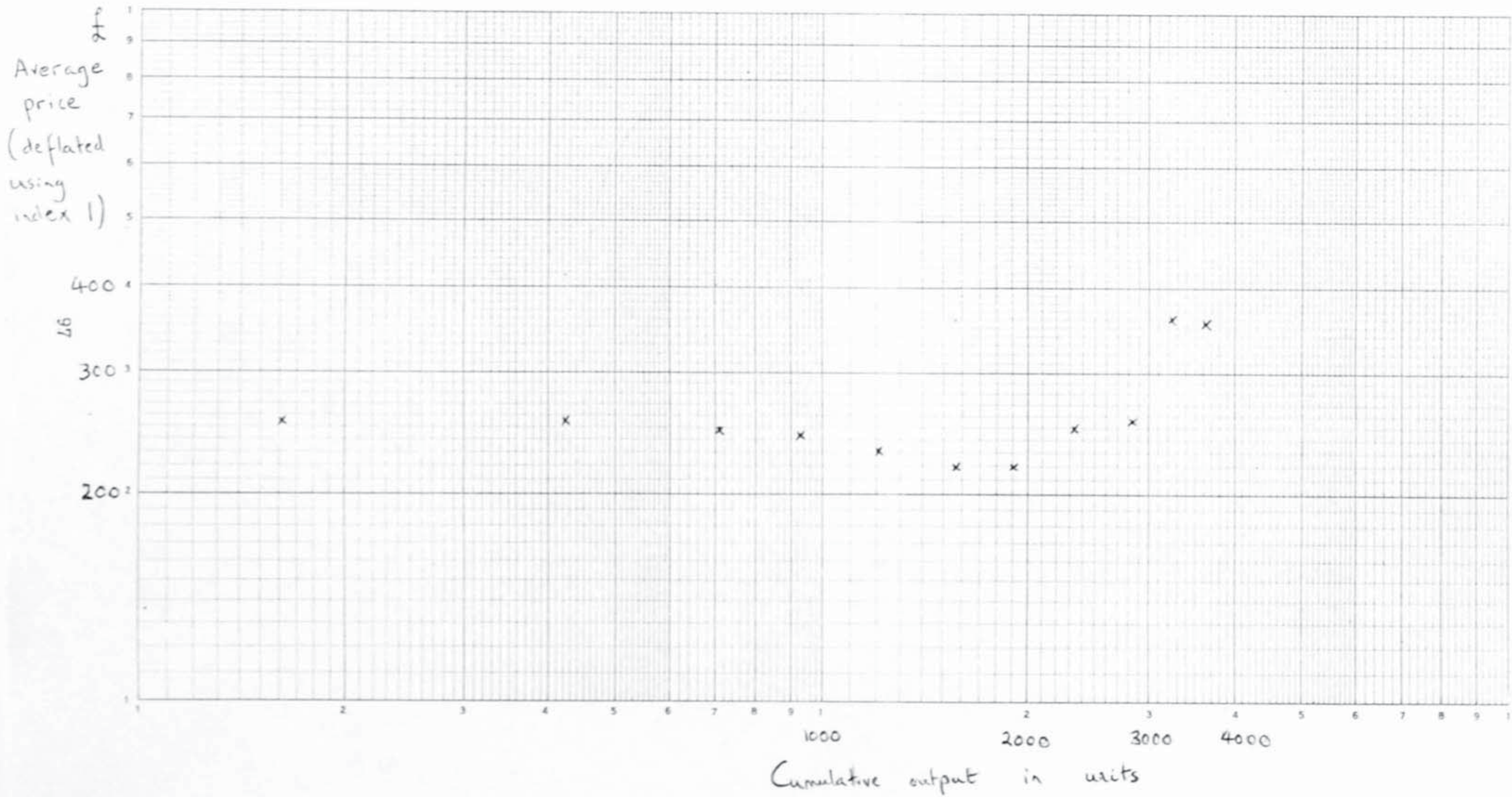
It may be seen from the graph 5.1, that the selling price of this model, the ADR 300, declined steadily over the period 1966/67 to 1971/72, whereas transfer price increases from 1972/73 to 1976/77.

Data for average selling price over the period 1966-1972 supported the assumption of an underlying experience curve model at a 5% level of significance ($R^2$=72%), with estimated experience curve slope of 95.8%.

However, data for the whole period does not support the assumption of an experience curve model, probably due to discontinuities in data for selling price and transfer price. (Appendix C.1.3).

It is interesting to note that the decline in selling price coincided with the period when HWR was a separate company. (2.3.2). Since 1972/73 the company has been wholly owned by BOC AE, and transfer price has risen steadily. Transfer prices of the products are based on standard costs, so this result indicates that either the direct cost of the product has increased, or that standard costs do not represent the real cost of production.

Graph 5.1 Deflated price of an ADR 300 Rectifier




Graph 5.1

5.2.2 Analysis of data on sales of rectifiers, from BEAMA

Annual data for BOC AE and for all subscribing companies for the period 1963-77 was tested for the assumption that average price and cumulative output could be fitted by experience curve models. Separate data for MIG and TIG rectifiers was tested in the same way. (Appendix C.2 for details).

The results are shown in Table 5.1 and graphs 5.2 to 5.6. With the exception of BOC AE data for MIG and TIG rectifiers taken separately, the data supported the assumption of an underlying experience curve model for average price of a rectifier, at significance levels of either 0.1% or 1.0%.

For aggregate company data, the fit of the model was good, with $R^2 = 79\%$ for all rectifiers, and $R^2 = 88\%$ and 90% for MIG and TIG rectifiers, respectively. This can be seen from graphs 5.2, 5.3 and 5.4: the reduction in average price has been fairly steady, particularly in later years.

Data for average price of a BOC AE rectifier showedfar less of a steady reduction, with fairly extreme swings in average price over the period, particularly for TIG rectifiers alone. (Graphs 5.2, 5.5 and 5.6). The average price for MIG rectifiers appears to have increased over this period. (Graph 5.5).

The slopes of experience curve models fitted to the average price of all rectifiers were 81% for aggregated data, (95% confidence limits, 87% and 76%), and 82% for BOC AE data (95% confidence limits, 91% and 74%). (Appendix C. 4 for derivation of confidence limits).

Slopes of models fitted to aggregate company data for MIG and TIG rectifiers separately were 69% and 64% respectively, indicating a higher rate of reduction in average price for TIG rectifiers.

N.B. The 'steepness' of these slopes compared with those for all rectifiers results from the fact that data covers a later time period. This effect was noticed throughout the work, when models were fitted to subsets of data covering different periods of time.

It arises from the fact that, in most cases, data is equally well fitted by a linear relationship between the variables. If this is true, estimates of slopes of experience curve models fitted to such subsets will vary according to the subset chosen. (Appendix D. 1.3.1(c)).

However, conclusions drawn from these results must be modified in the light of certain criticisms of the accuracy of BEAMA data, expressed by personnel at BOC Arc Equipment.

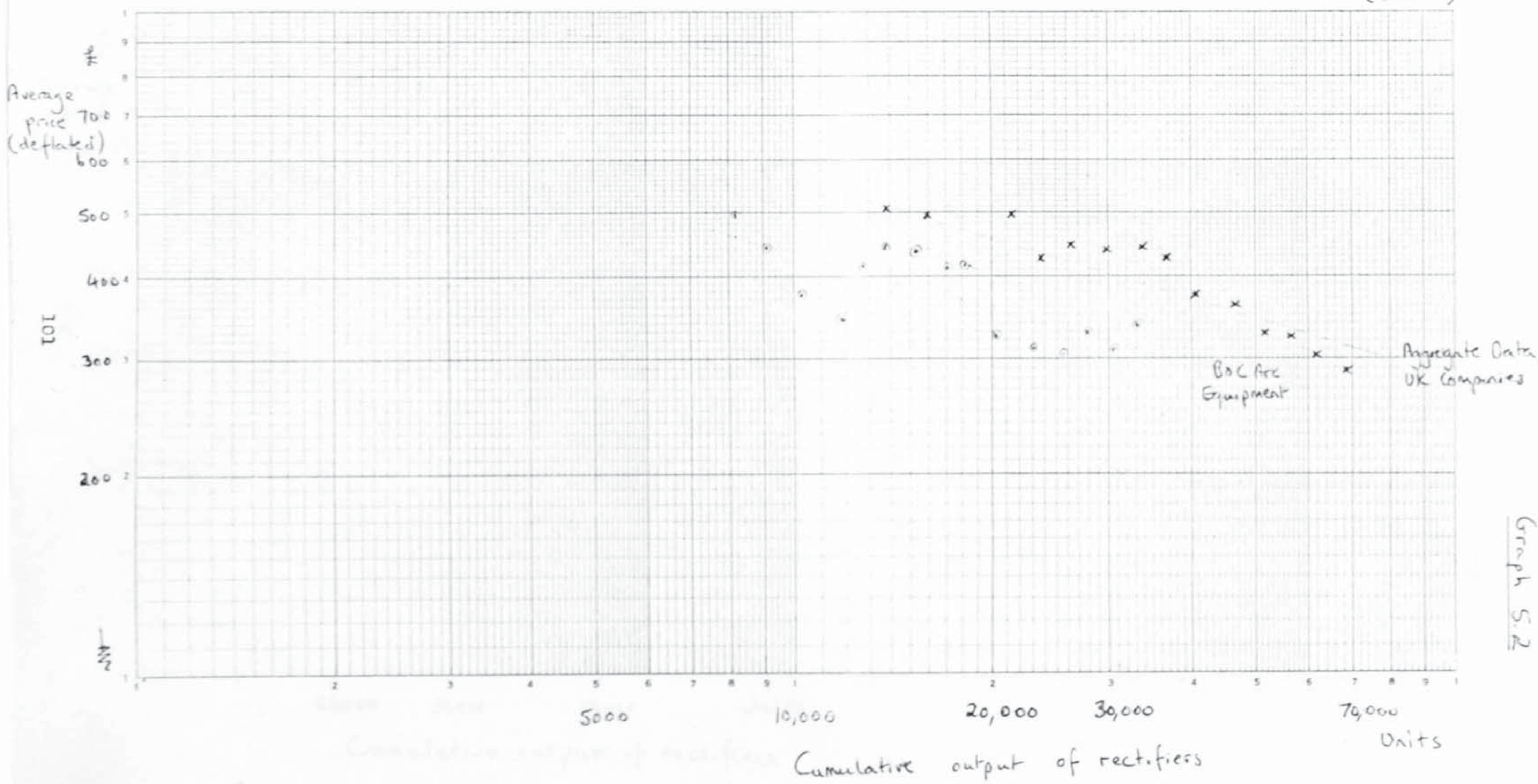
The main fault ascribed to data submitted by BOC AE itself, was that it did not cover all of their rectifier sales. This was confirmed by comparing annual volumes of sales reported to BEAMA with volumes of output of production obtained from HWR: recorded sales formed only 53% of production output. The discrepancy was found to be due partly to sales from BOC to other equipment manufacturers, made directly from HWR, and partly to the many sets which had undergone slight alterations and were then sold under a different part number. (Appendix C. 2.3 for details).

It must be noted that the system of changing the part number when a basic machine was made up into a package, and the amount of part numbers

TABLE 5.1 - Results from testing BEAMA data with experience curve models

| Details of data | | | Results | | | |
|---|---|---|---|---|---|---|
| Dependent variable | Time Period | No. of readings | C | $R^2$ | F (sig. level) | Experience curve slope |
| BOC data, average price of a rectifier | 1963-77 | 15 | -0.77 | 0.59 | 19.4 (0.1%) | 82.4% (95% CL 91%, 74%) |
| BOC data, average price of a MIG rectifier | 1972-77 | 6 | +0.69 | 0.48 | 3.7 (NOT SIG) | - |
| BOC data, average price of a TIG rectifier | 1972-77 | 6 | -0.16 | 0.02 | .10 (NOT SIG) | - |
| Aggregated company data, average price of a rectifier | 1963-77 | 15 | -0.89 | 0.79 | 48.3 (0.1%) | 81.1% (95% CL 87%, 76%) |
| Aggregated company data, average price of a MIG rectifier | 1972-77 | 6 | -0.94 | 0.88 | 30.3 (1.0%) | 68.9% |
| Aggregated company data, average price of a TIG rectifier | 1972-77 | 6 | -0.95 | 0.90 | 40.1 (1.0%) | 64.2% |

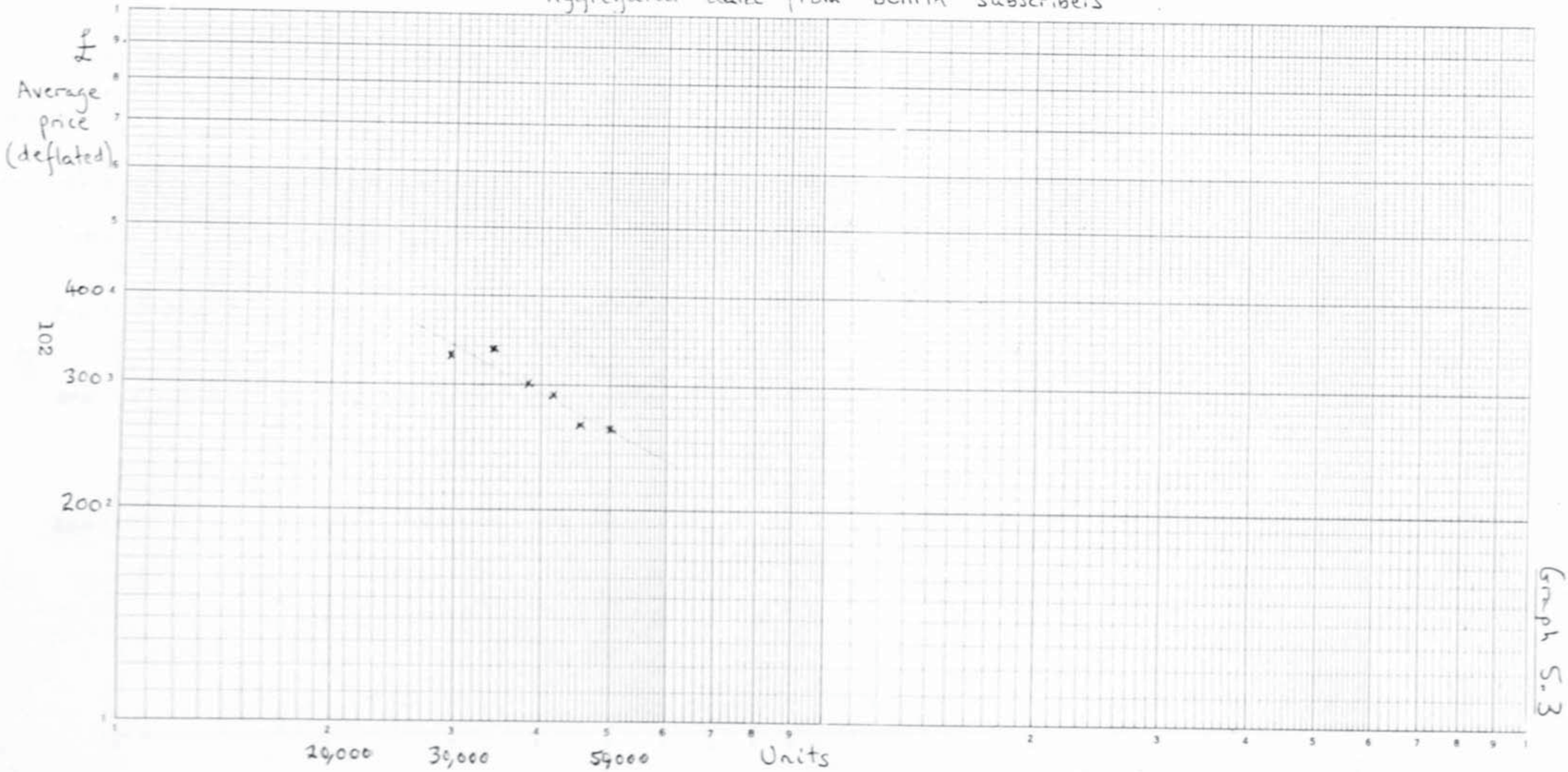
Graph 5.2 Experience curve models for average price of a rectifier, BOC AE and aggregated data (BEAMA)




Source of data ; see Appendix C. 2.1.1

Graph 5.2

Graph 5.3 Experience curve model for average price of MIG rectifiers, 1972-77
Aggregated data from BEAMA subscribers

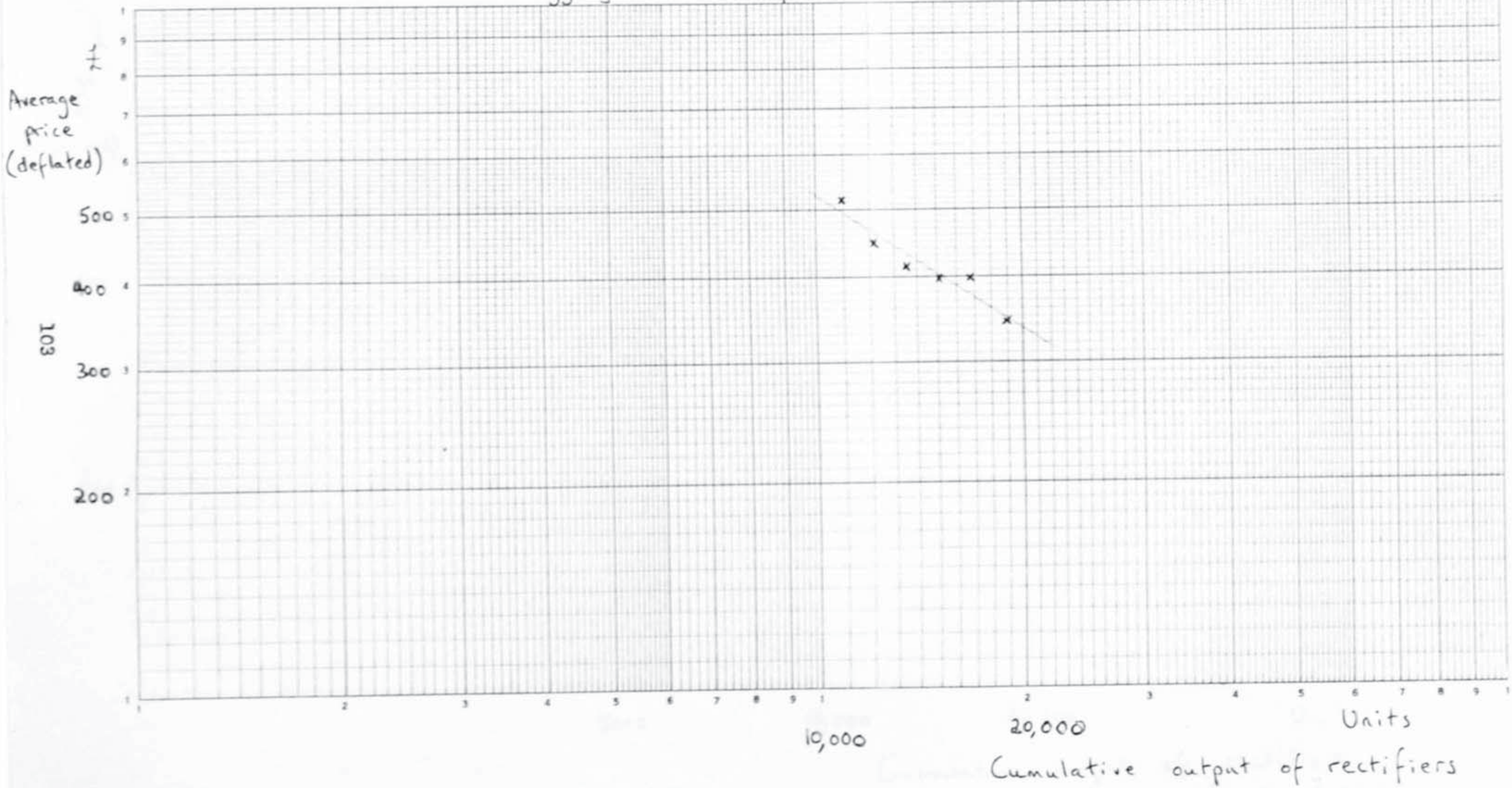



Source of data ; see Appendix C.2.1.1

Graph 5.3

Chartwell Graph Data Ref. 5912 Log 1 Cycle x 2 Cycles

Graph 5.4 Experience curve model for average price of TIG rectifiers, 1972-77
Aggregated data from BEAMA subscribers



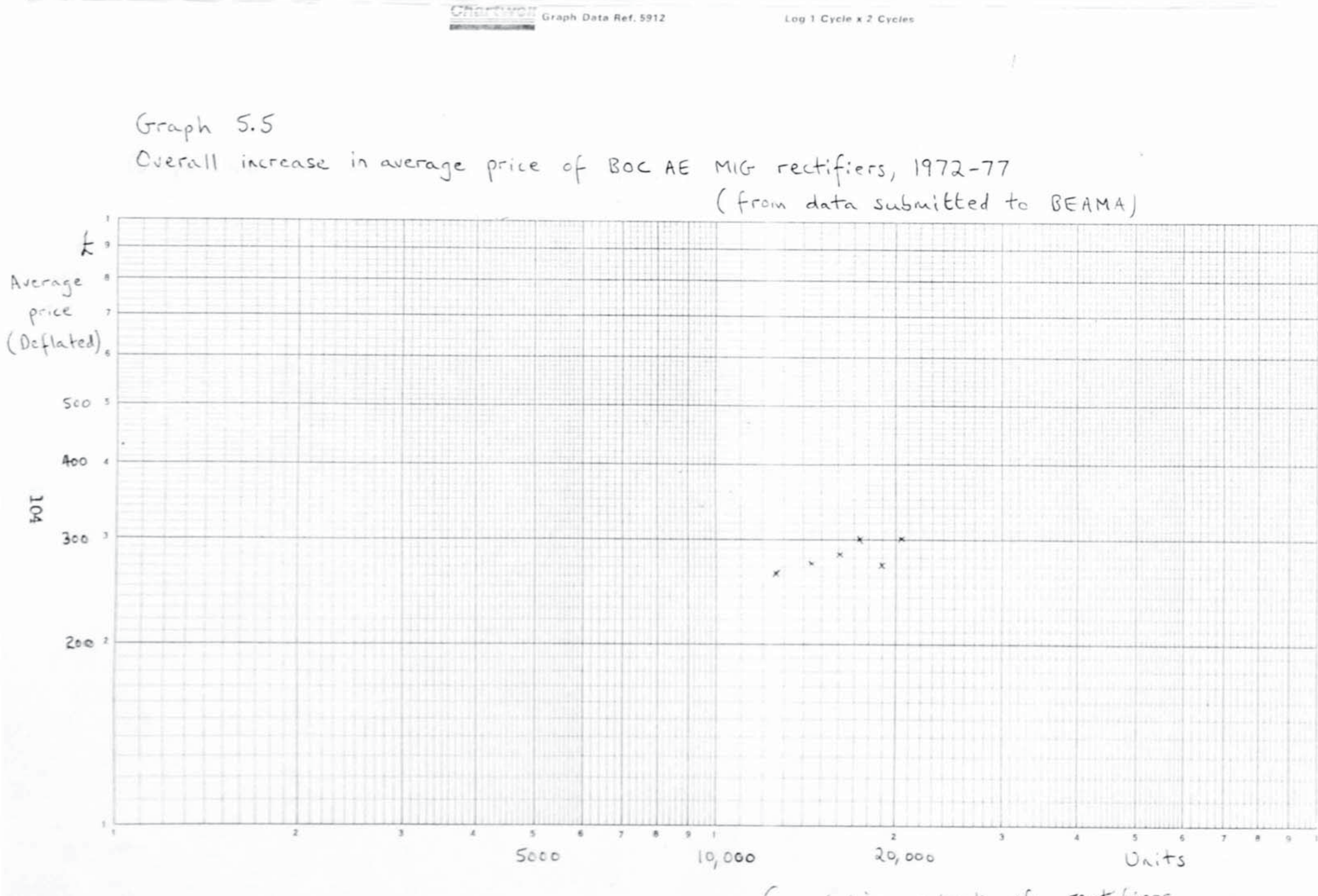

Source of data; see Appendix C.2.1.1

Graph 5.4

Graph 5.5

Overall increase in average price of BOC AE MIG rectifiers, 1972-77

(from data submitted to BEAMA)

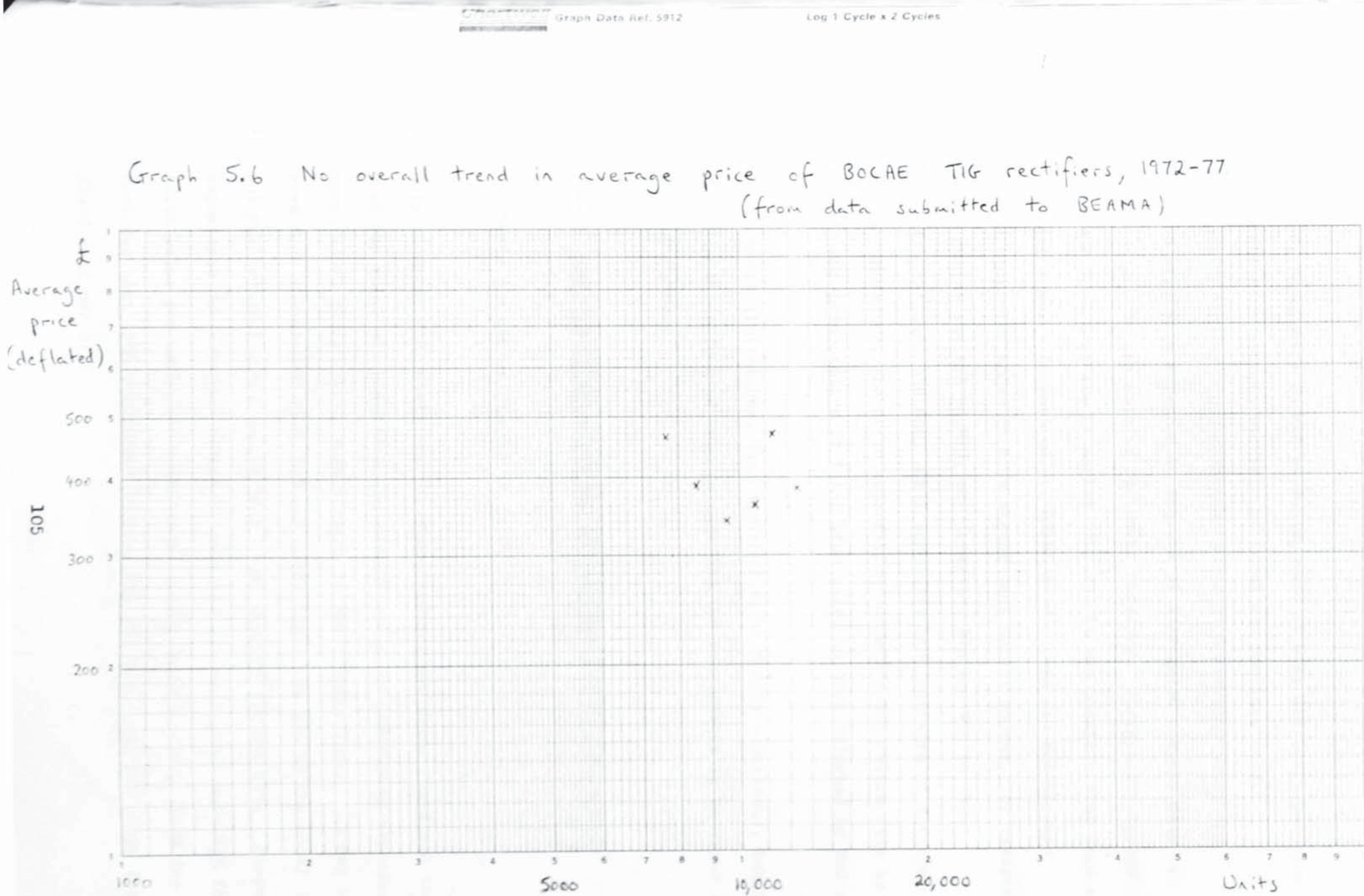



Source of data; see Appendix C.2.1.1

Graph 5.5

Graph 5.6

Graph 5.6 No overall trend in average price of BOCAE TIG rectifiers, 1972-77
(from data submitted to BEAMA)




Source of data; see Appendix C.2.1.1

produced, especially in MIG products, made it very difficult to trace the correlation between machines produced and machines sold.

A second criticism referred to the use of aggregated company data to represent the UK arc welding equipment industry. Originally thought to represent 75-80% of the UK market (2.2.2), it was possible that this was no longer true. In particular, BEAMA subscribers did not include several companies known to have significant market shares, for example Norman Butter and AGA in MIG, and Interlas, AGA and WTC in TIG. They also excluded the many small companies and importers of foreign goods. Moreover, the other subscribing companies may return data as equally unrepresentative of their true sales as that returned by BOC AE.

Within these limitations, data appeared to be fairly consistent, but they should be borne in mind when considering the conclusions to be drawn from these analyses.

### 5.2.3 Analysis of data from BOC AE and HWR

See Table 5.2 and graphs 5.7 to 5.12.

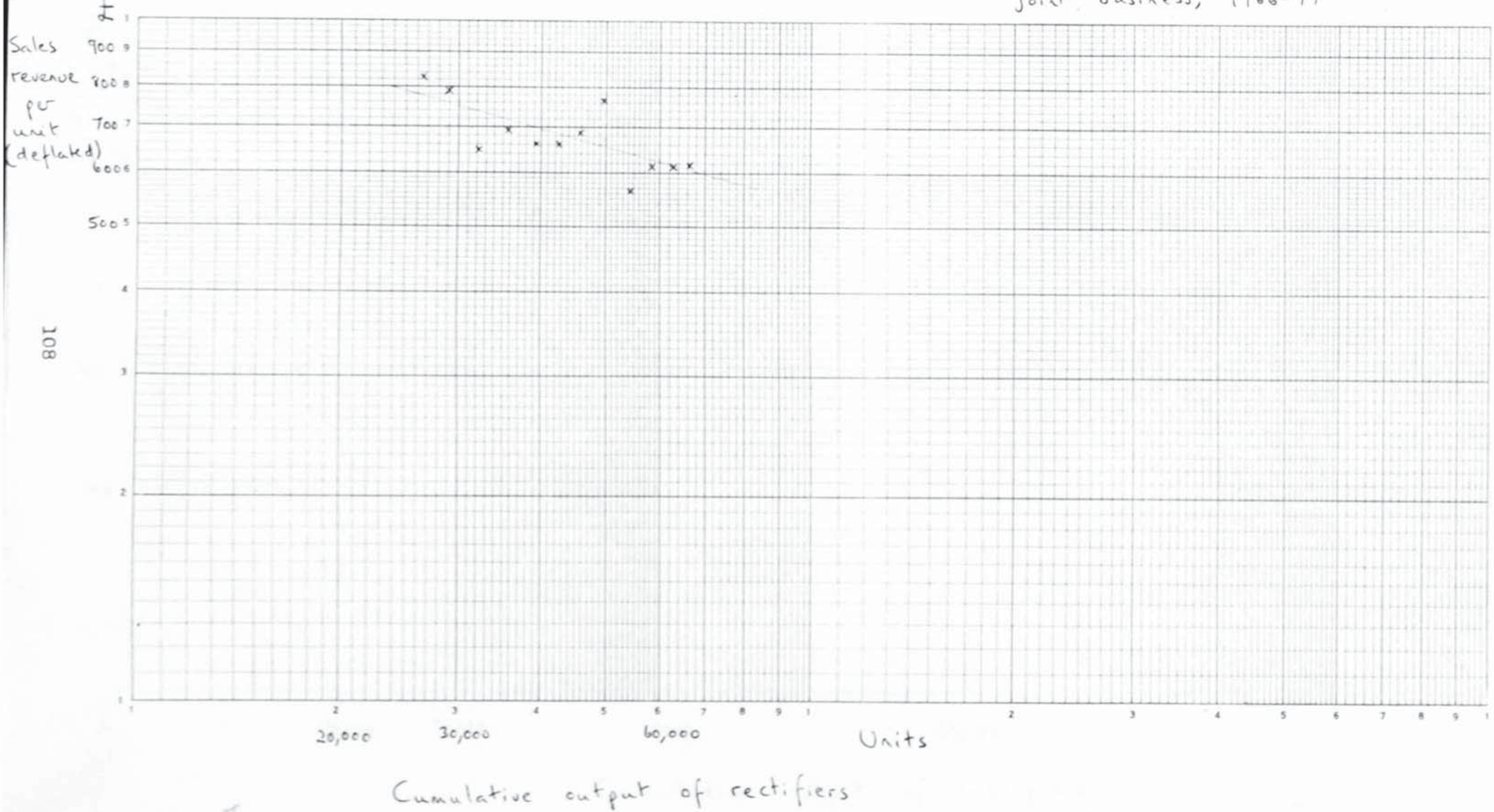
Data covering all rectifiers for sales revenue per unit, fixed and total cost per unit, all supported the assumption of an underlying experience curve model at levels of significance of 5%. (Table 5.2). It may be seen from the graphs (5.7, 5.8 and 5.10), that the fit of the model was not particularly good; values of $R^2$ vary between 37% and 61%. Slopes of experience curve models fitted to data for all rectifiers were 83% for sales value per unit (95% confidence limits, 94% and 73%), 86.5% for total cost per unit (95% confidence limits, 99% and 76%), and 76% slope for fixed cost per unit.

TABLE 5.2 - Results of fitting experience curve model to BOC Arc Equipment data

| Data set * | No.of Readings | C ratio | $R^2$ | F ratio | Significance level | Experience curve slope |
|---|---|---|---|---|---|---|
| <u>All rectifiers</u> | | | | | | |
| (MIG,TIG & PLASMA) | | | | | | |
| Sales value per unit | 12 | -0.72 | 0.52 | 10.72 | 1.0% | 83.0 (95% CL 94%, 73%) |
| Total cost per unit | 12 | -0.61 | 0.37 | 6.03 | 5.0% | 86.5 (95% CL 99%, 76%) |
| Direct cost per unit | 12 | -0.18 | 0.03 | 0.34 | NOT SIG. | - |
| Fixed cost per unit | 12 | -0.78 | 0.61 | 15.91 | 1.0% | 76.0 |
| <u>MIG rectifiers, alone</u> | | | | | | |
| Sales value per unit | 12 | -0.63 | 0.40 | 6.71 | 5.0% | 83.6 |
| Direct cost per unit | 12 | -0.64 | 0.41 | 7.03 | 2.5% | 82.1 |
| <u>TIG rectifiers, alone</u> | | | | | | |
| Sales value per unit | 12 | 0.34 | 0.11 | 1.36 | NOT SIG. | - |
| Direct cost per unit | 12 | -0.17 | 0.03 | 0.29 | NOT SIG. | - |

Graph 5.7

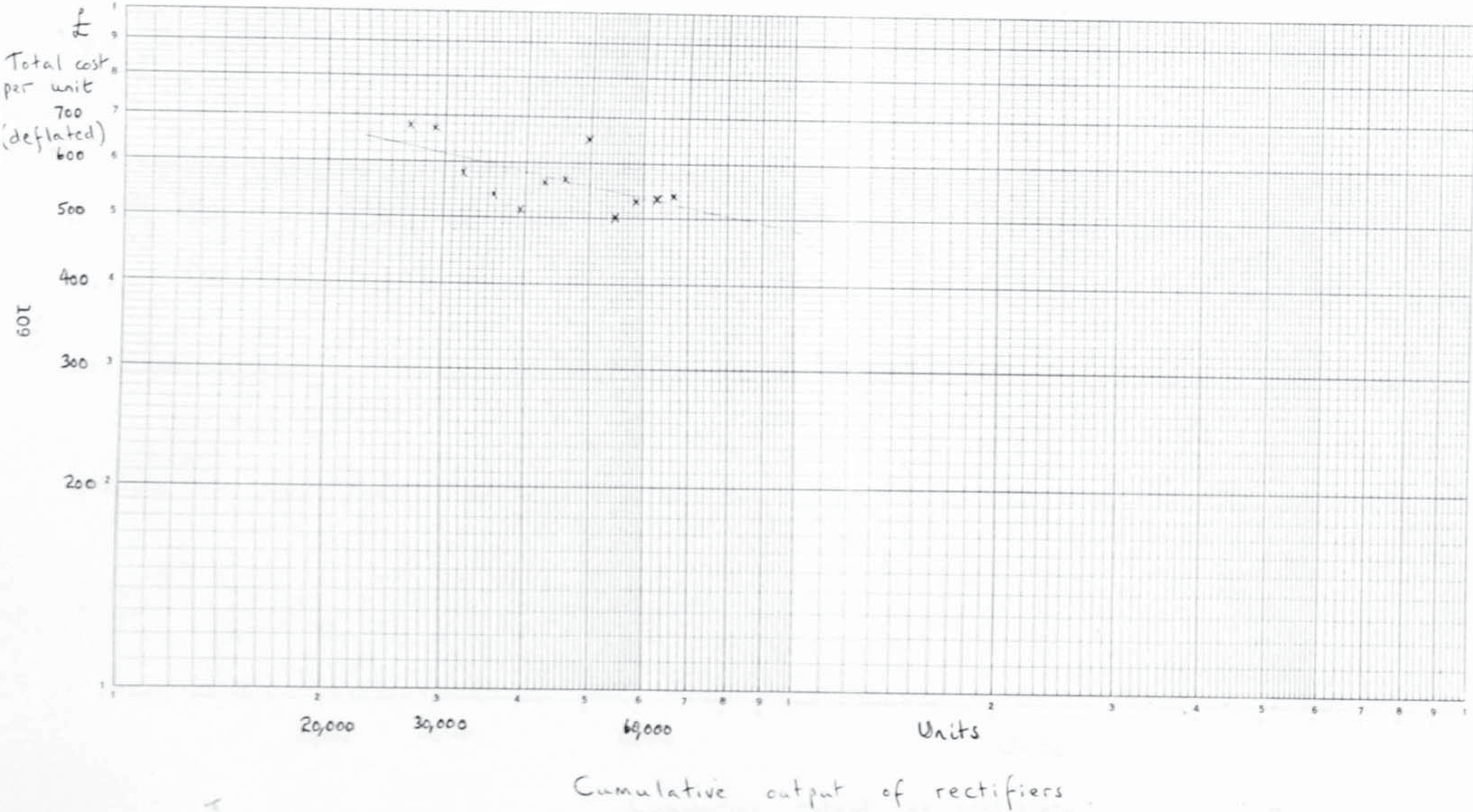
Graph 5.7 Experience curve model for sales revenue per unit, BocAE and HwR, joint business, 1966-77




Source of data ; see Appendix C.3.2

Graph 5.8

Graph 5.8 Experience curve model for unit cost, BOC AE and HWR joint business, 1966-77

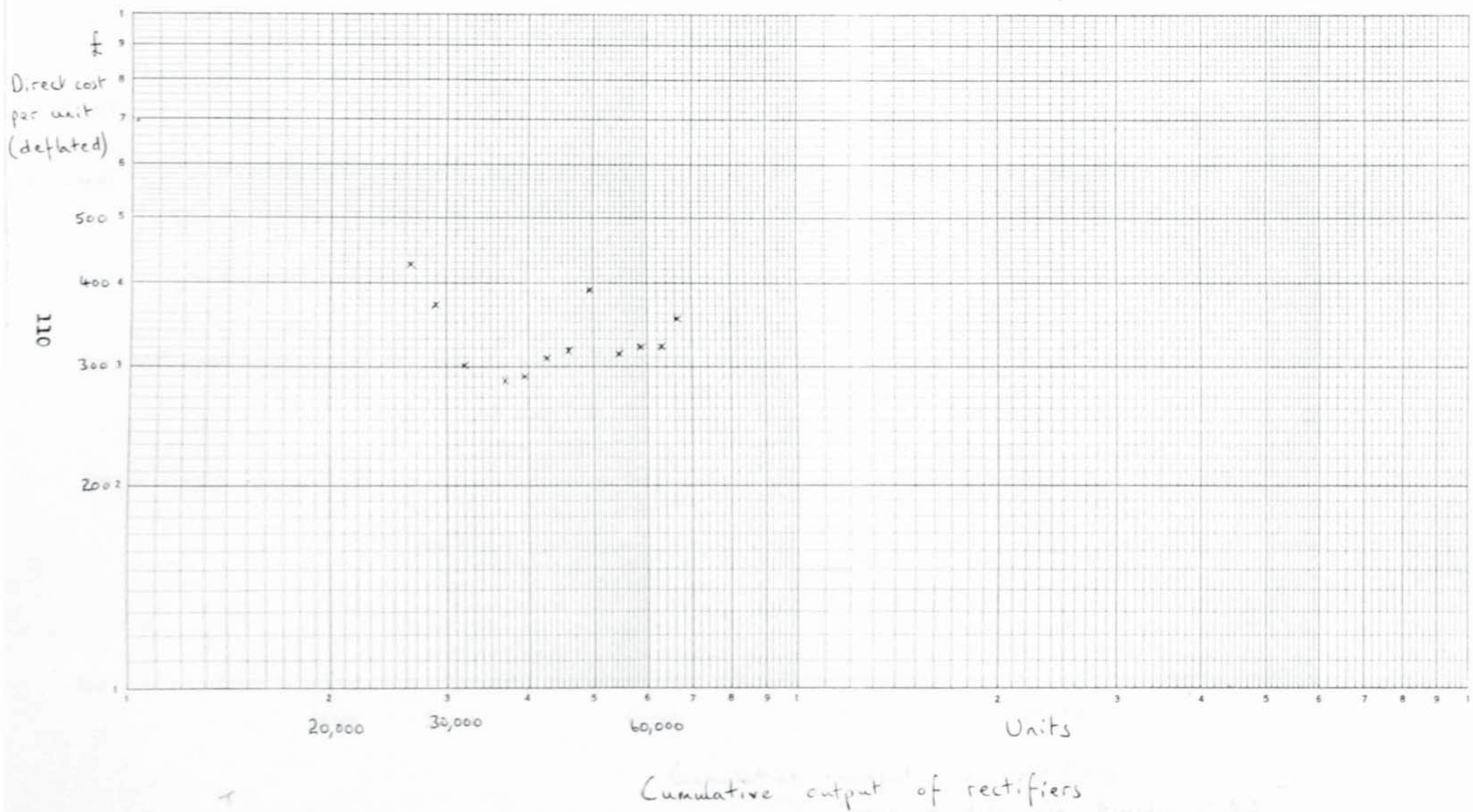



Source of data; see Appendix C.3.2

Graph 5.9



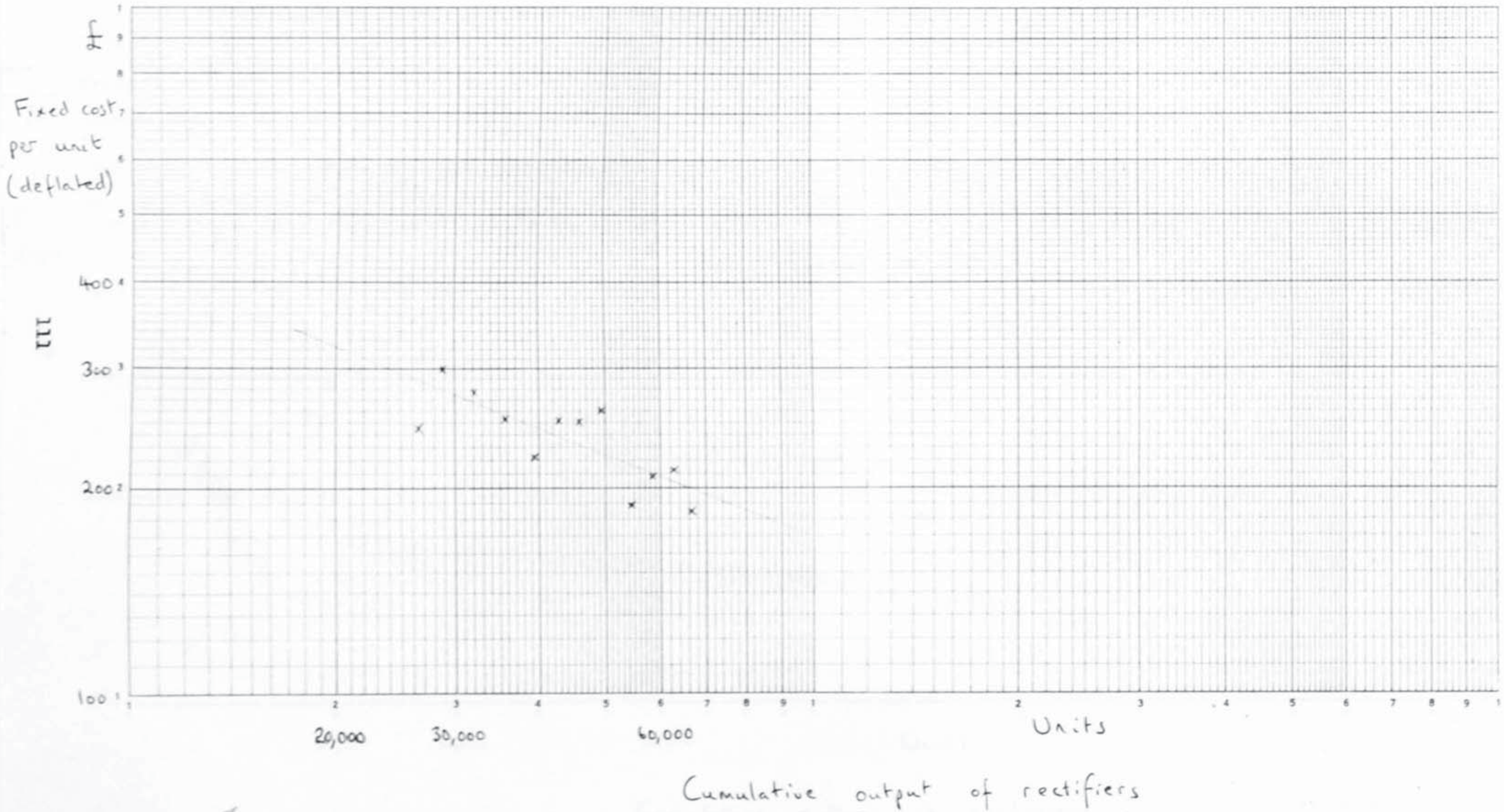
Graph 5.9 Direct cost per unit for BOCAE and HWR joint business, declines 1966-69 then rises 1969-77




Source of data; see Appendix C.3.2

Graph 5.10

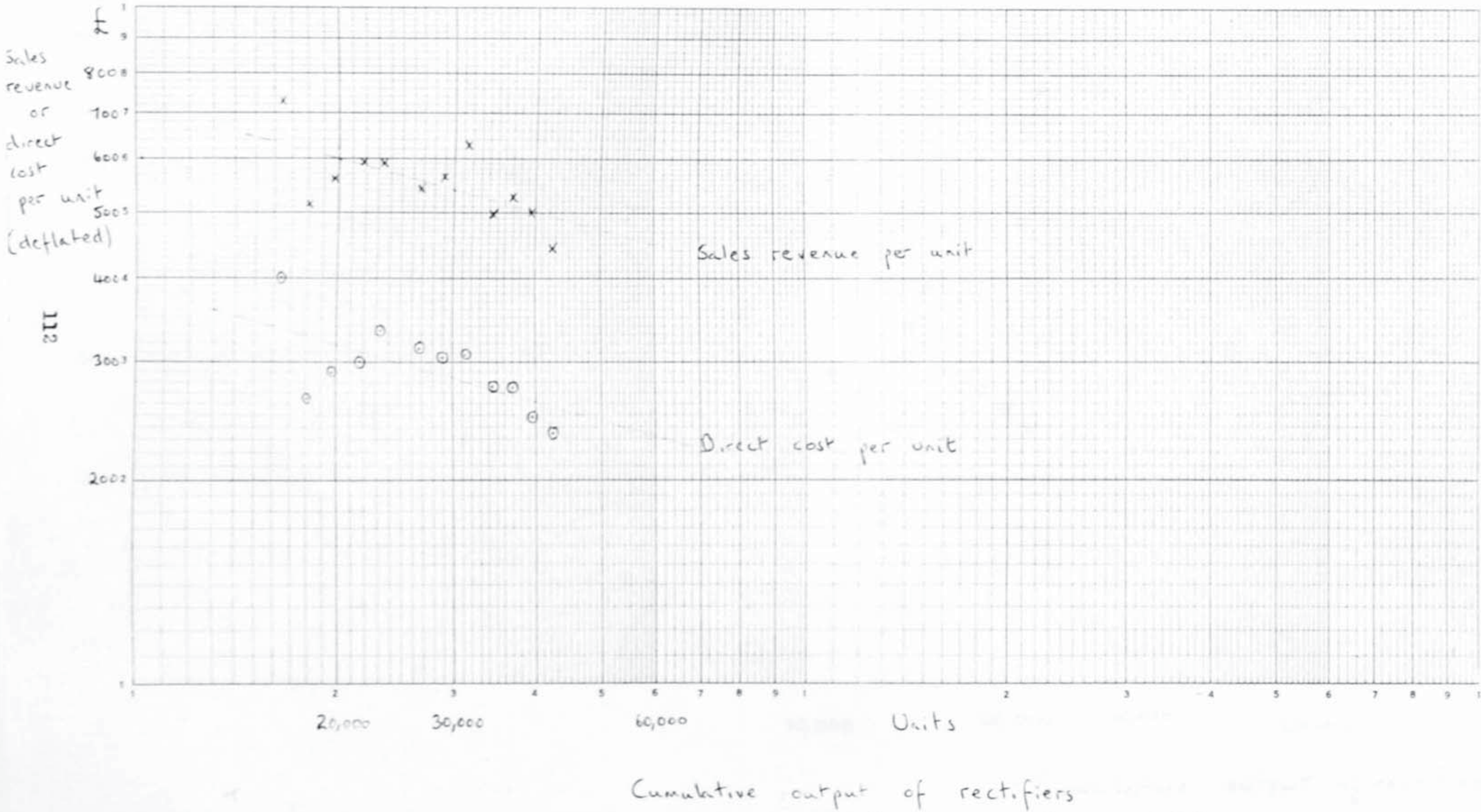
Graph 5.10 Experience curve model for fixed cost per unit, BOC AE and HWR joint business, 1966-77




Source of data; see Appendix C.3.2

Chartwell Graph Data Ref. 5912 Log 1 Cycle x 2 Cycles

Graph 5.11 Sales revenue and direct cost per unit for MIG rectifiers, BOC AE and HWR joint business, 1966-77

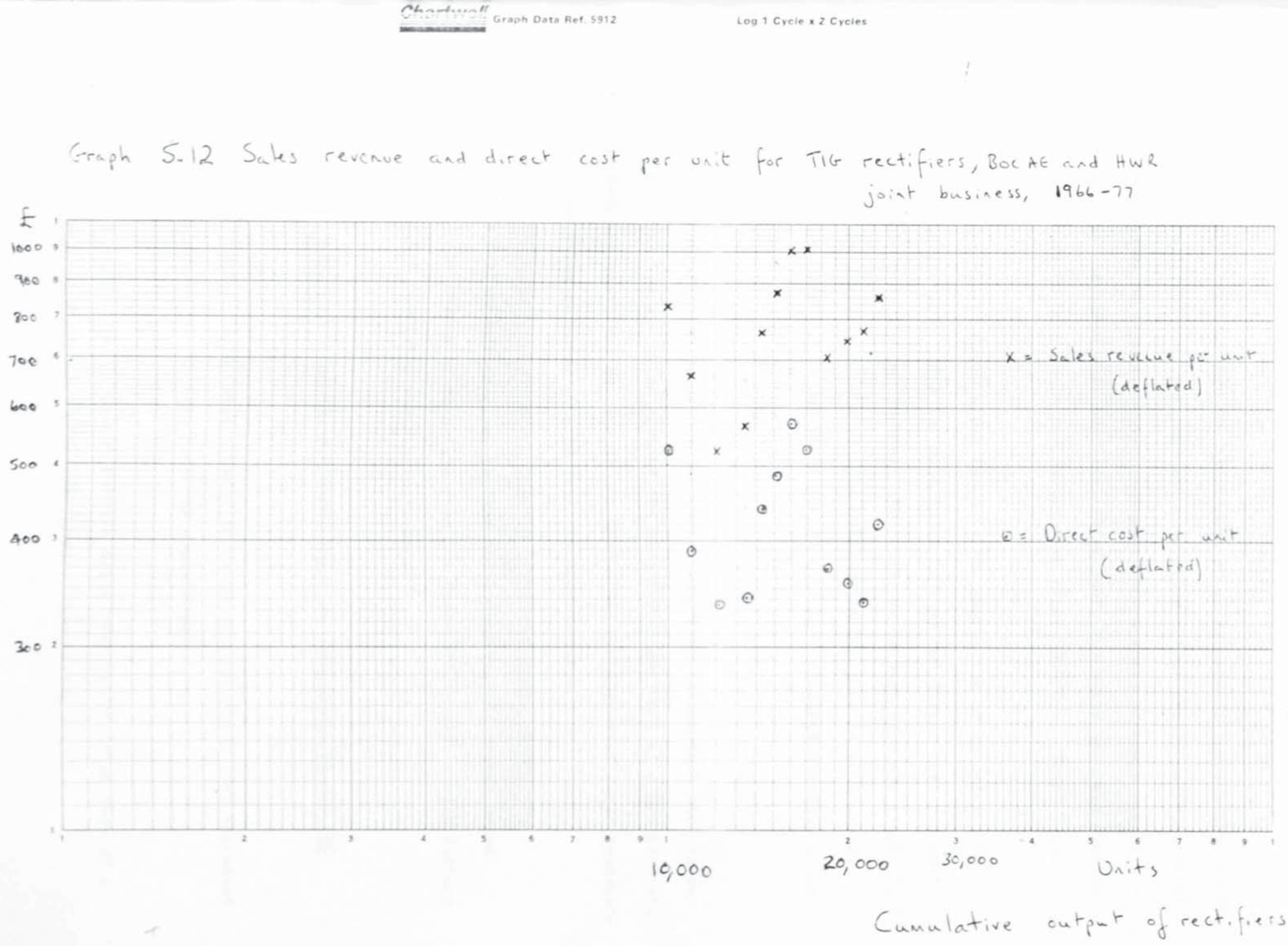



Source of data; see Appendix C.3.2

112

Graph 5.11

Graph 5.12 Sales revenue and direct cost per unit for TIG rectifiers, BOC AE and HWR joint business, 1966-77




Source of data; see Appendix C.3.2

Graph 5.12

Analysis suggested that the hypothesis of an experience curve relationship between direct cost per unit and cumulative output should be rejected at a 5% level of significance. The graph shows that, although direct cost per unit declined over the first three years for which data was available, it had risen more or less steadily ever since 1968/69. (Graph 5.9).

Data for MIG products alone supported the assumption of an underlying experience curve model for both sales revenue and direct cost per unit, at 5% levels of significance. Again it can be seen from the graph (5.11) that the goodness of fit of this model was rather poor in both cases, although direct cost per unit did seem to have declined steadily since 1969/70.

The graph for TIG data (5.12) showed the enormous swings that have taken place in average sales revenue and direct cost per unit of a TIG product. Analysis confirmed this, with the hypothesis of experience curve relationships being rejected at a 5% level of significance.

Before drawing any conclusions from these results, the trends noted during the course of these analyses are discussed, together with further work which confirmed their significance.

## 5.3 SIGNIFICANT TRENDS IN AVERAGE PRICE AND UNIT COST FOR BOC ARC EQUIPMENT

The following trends were thought to be so important that they warranted investigation of their statistical significance.

a) A decline in the margin between sales revenue and total cost of a rectifier produced by BOC Arc Equipment. (Graph 5.13).

When annual difference between average sales revenue per unit and total cost per unit was plotted against elapsed time, this apparent trend even more clear. (Graph 5.14).

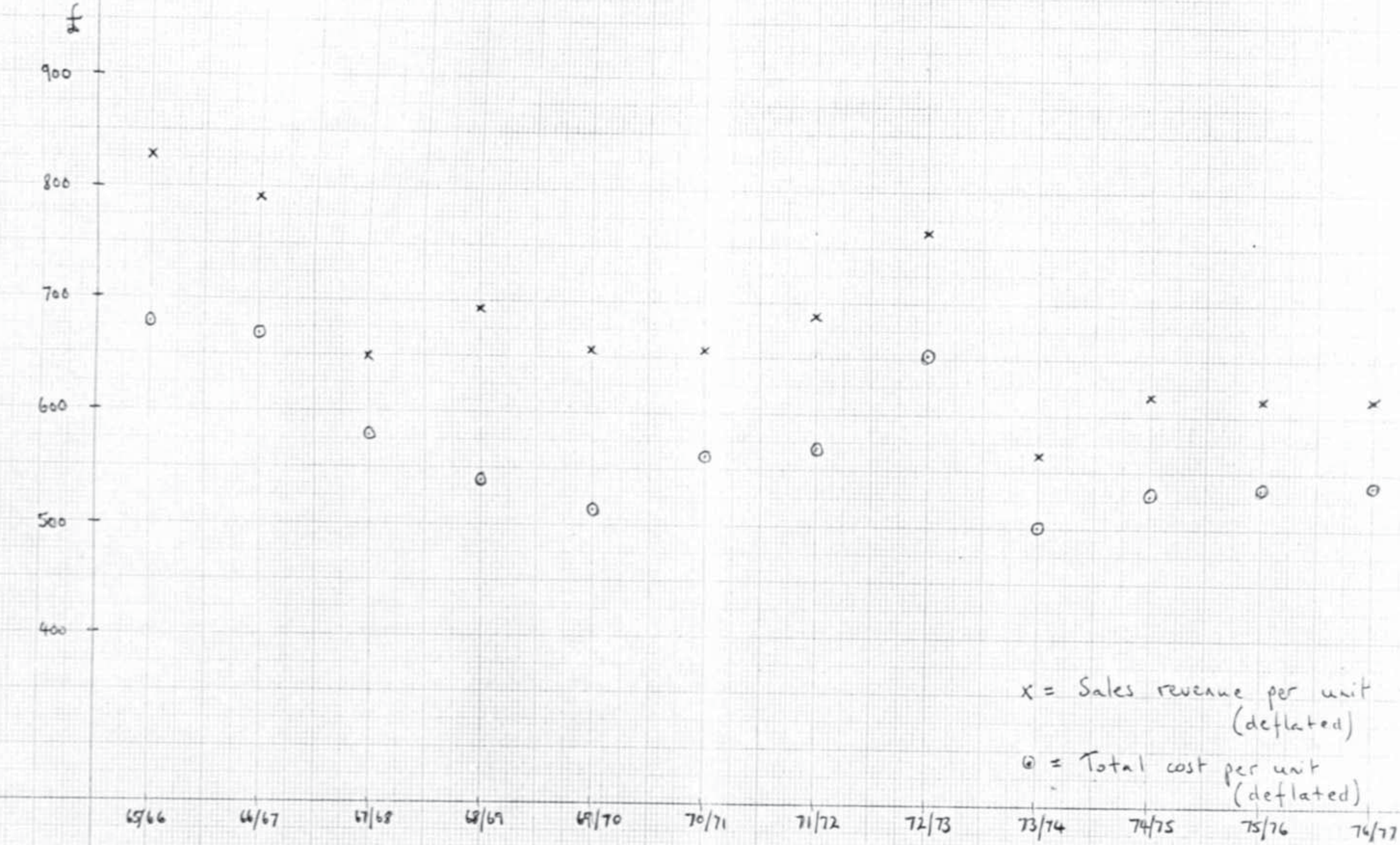
This difference, here referred to as 'profit margin per unit' was not directly connected with the profit margin appearing in accounts for BOC Arc Equipment, since figures for cost used in the analyses explicitly exclude central costs, depreciation etc. However, as a trading profit margin on the manufacture and sales of rectifiers, it must be important for the business.

The significance of the trend was investigated two ways. (Appendix C. 3.3.2(a) and 3.4.1(a) and (b) for details). Although analysis of variance techniques indicated that there was no significant difference between the parameters of b for models fitted to data for sales revenue and cost per unit, regression techniques showed that there was a significant decline in profit margin per unit, at a 5% level of significance. The average compound rate of decline over the period 1965/66 to 1976/77 was estimated to be approximately 5.5% per annum. (Appendix C. 3.4.1(b)).

b) Average price of a rectifier sold by BOC AE appeared to have declined at the same rate as the average for aggregated data from companies subscribing to BEAMA (Table 5.1). If both are plotted on a linear scale against elapsed time, it can be seen, however, that relative to the industry average, the BOC price had risen over the last three years 1975-77. This trend was pronounced in both MIG and TIG product groups, although the average price of a BOC TIG rectifier did fall in 1976/77. (Graph 5.15).

c) Although the total unit cost of a rectifier manufactured by BOC AE had declined over the period 1965/66 to 1976/77, it may be seen from the graph that there had been no real decline in the last eight years of this period.

Graph 5.13 Comparison of sales revenue per unit and total cost per unit for all rectifiers, BOC AE and HWR joint business, 1966-77

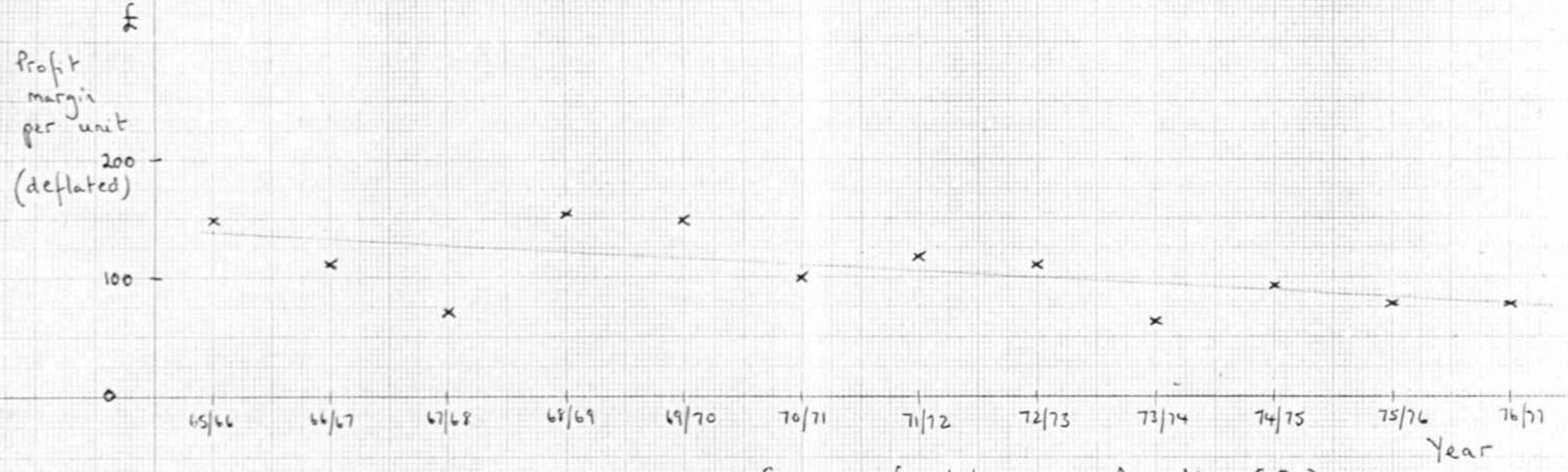



Source of data; see Appendix C.3.2



Graph 5.13

Graph 5.14 Decline in profit margin per unit (sales revenue - total cost, per unit) for BOC AE and HWR joint business 1966-77



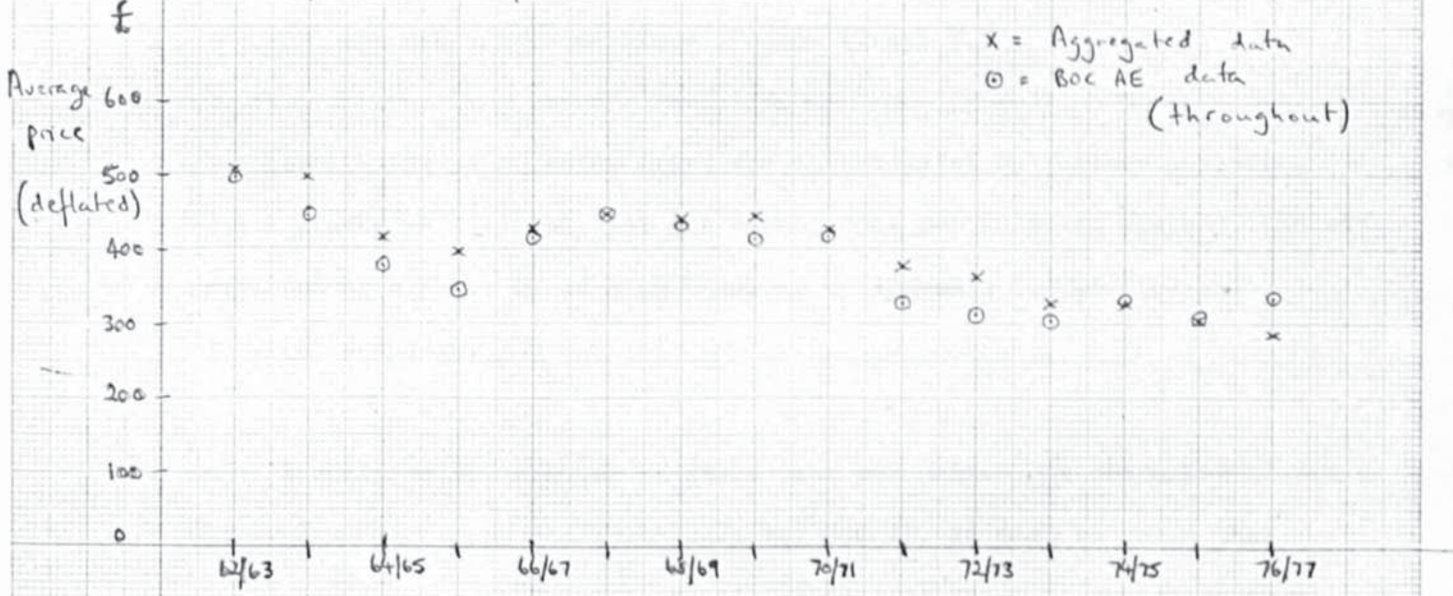

Source of data; see Appendix C.3.2



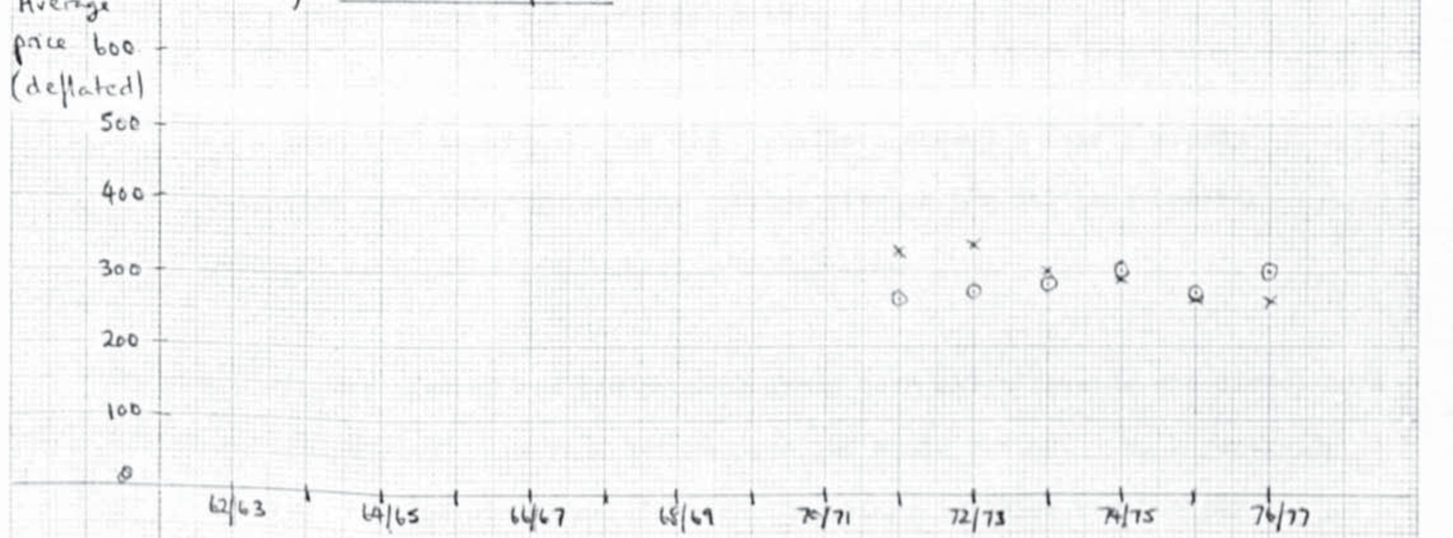
Graph 5.14

Graph 5.15 Comparison between average price of a rectifier for BOC AE and aggregated company data (all BEAMA data)

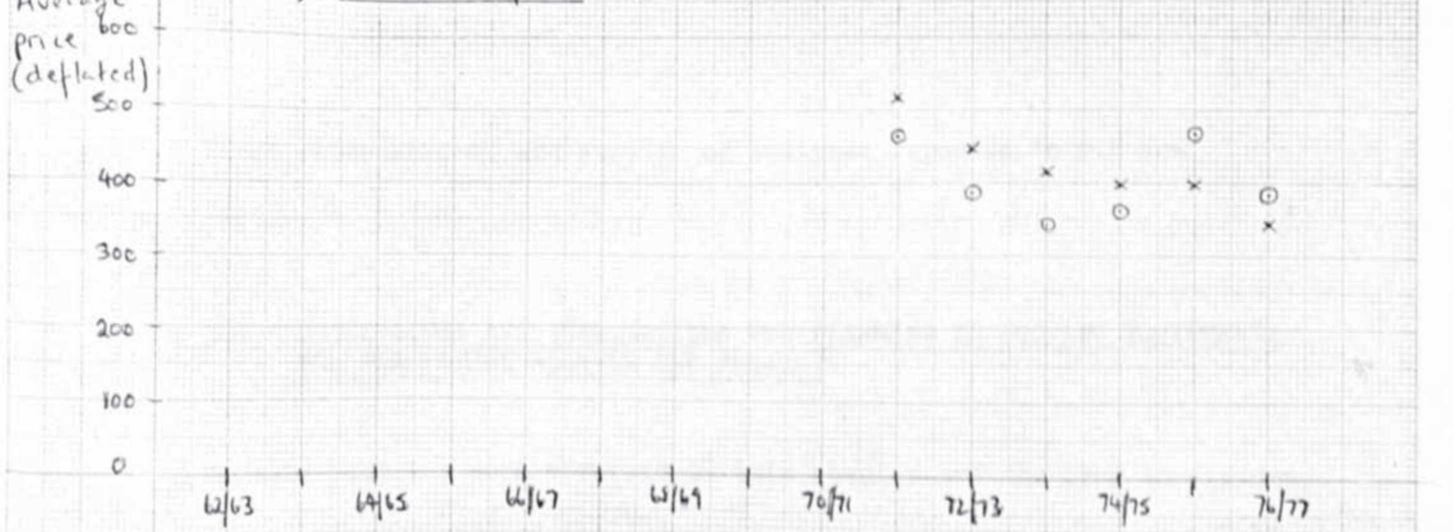
a) All rectifiers 1963-77




b) MIG rectifiers




c) TIG rectifiers




Source of data; see Appendix C.2.1.1

In fact unit cost rose steadily from 1973/74 to 1976/77. (Graph 5.11).

d) Direct cost per unit had not declined over the period 1965/66 to 1976/77, and had increased since 1968/69 (Graph 5.9).

The possibility of a linear trend was investigated by further analysis, but a linear relationship between direct cost per unit and elapsed time was rejected at a 5% level of significance. (Appendix C. 3.3.2(b) and 3.4.1(c) for details).

e) A satisfactory decline in fixed cost per unit. In comparing slopes of experience curves fitted to data for BOC AE, it must be noted that fixed cost per unit enjoyed one of the fastest rates of reduction over the period. (Table 5.2 and Graph 5.10).

f) Direct cost per unit for MIG rectifiers showed a fairly steady reduction from 1969/70 onwards. Sales revenue per unit had however suffered some extreme swings. (Graph 5.11).

g) In the case of the TIG product group both sales revenue and direct cost per unit showed extreme swings over the whole period. Both generally movedin the same direction although the swings in sales revenue per unit were more extreme. Neither set of data appeared to have an underlying trend. (Graph 5.10).

These observations, and results of analyses reported in 5.2 are discussed in 5.4.

## 5.4 CONCLUSIONS AND IMPLICATIONS FOR PLANNING IN BOC ARC EQUIPMENT, AND FOR FUTURE WORK IN THE PROJECT.

Results from the work reported in this chapter are now used to discuss the goodness of fit of the experience curve model to data from BOC AE and the UK arc welding equipment industry. (5.4.1). This includes attempts to answer the original problems posed by planners in the company.

Trends noted during the analyses, and confirmed by further tests, were of equal or even greater importance for planning in BOC Arc Equipment. These are discussed in 5.4.2., and implications of the findings for future work of the project, in 5.4.3.

### 5.4.1 Validity of the experience curve as a model for the business of BOC Arc Equipment; answering the initial problem posed by the company

In terms of the statistical significance of a specified relationship tested on relevant data, the assumption of an underlying experience curve model was supported by data for the average price of a rectifier in the UK, and for total cost per unit of manufacture of a rectifier at BOC Arc Equipment. (5.2.2 and 5.2.3).

However, when BOC AE data for direct and fixed costs was tested separately, fixed cost per unit did support the assumption of an underlying experience curve model, whereas direct cost per unit did not, in fact showing no significant trend over the period in question. (5.2.3 and 5.3(d)).

There was little similarity between the behaviour of average prices of MIG and TIG rectifiers from data submitted to BEAMA, and that estimated from BOC AE accounting figures for sales of MIG and TIG products (Graphs 5.5 and 5.6, 5.11 and 5.12), although TIG prices did show roughly the same movements. The only sets of data showing steady reduction in average price were those from aggregated BEAMA data, MIG and TIG (5.2.2), and BOC AE data for sales and direct costs of MIG products. (5.2.3). Due to the general limitations of BEAMA data (5.2.2) and the differences between results from different sources of data, no conclusions have been drawn concerning the existence of experience curve models for MIG and TIG as separate groups of rectifiers.

However, the evidence provided by data for rectifiers as a whole did appear to support the validity of the experience curve model for this business, on the grounds of the statistical significance of the relationships found between average price or unit cost, and cumulative output of production.

Actual choice of a model may depend on the fit of alternative models to this data, and several other factors to be considered (4.4.2): this will be discussed at the end of Chapter Six when some alternative models will have been tested.

With reference to the original questions posed by BOC Arc Equipment (1.2), these will be answered in the order given.

It must be noted that, whilst confidence limits express the range in which parameters of the true underlying model may be expected to lie, sample estimates of these parameters may be used to describe what actually happened over the period in question.

Question (a) (1.2): <u>Was the BOC AE business still on the 83% slope curve estimated by BCG in 1972?</u>

Estimates for slopes of models fitted to data for the average price of a BOC rectifier were 82.4% for data submitted to BEAMA (95% confidence limits, 91% and 74%), and 83.0% for estimates of average price from sales revenue figures (95% confidence limits, 94% and 73%). Estimated slope for average total cost per unit was 86.5% (95% confidence limits, 99% and 76%).

These results providedno evidence that the slope of true underlying model, for either unit cost or average price, had changed from the original estimate of 83%. It must be pointed out however, that over the period 1966-77, although the rate of reduction in average price was almost exactly in line with this estimate, the rate of reduction in unit cost was actually lower.

(b) <u>Was the rest of the UK industry on the same slope curve?</u>

Evidence from estimated slopes of experience curve models fitted to data for BOC Arc Equipment, and to aggregated data from companies subscribing to BEAMA suggestedthat the average price of a BOC rectifier was on the same slope curve as the UK industry, in so far as this could be represented by BEAMA members. (See 5.2.2 for limitations of this data). However, although the average rates of reduction represented by the slopes of the curves were remarkably similar, 81-83%, it must be pointed out that in recent years BOC AE average price had risen, whilst that of aggregated data continued to fall.

(c) & (d) <u>Was there evidence of a price 'umbrella', and if so, could a price break be forecast?</u>

Since the rate of reduction in unit cost of a rectifier manufactured by BOC AE had not been as high as that of average price, there was no evidence of a price umbrella operating for the company. (See 1.2 for definition of price 'umbrella').

As far as the UK arc welding equipment industry was concerned, the only data available was for average price, and that only for members subscribing to BEAMA. The average price calculated from aggregated data had fallen at approximately the same rate as that for BOC AE, leading to three possibilities:

i) Other companies had similar patterns of unit cost to BOC AE and were experiencing reducing profit margins.

ii) Other companies had a better rate of unit cost reduction than BOC AE, in which case a price umbrella may have been operating.

iii) The data supplied by subscribing members to BEAMA did not represent what was really happening in the UK industry. Since subscribers were all large well-established companies, excluding some producers known to have growing market shares, and importers of cheaper goods, the average price of a rectifier represented by BEAMA members may give no indication of impending changes in market conditions.

Unfortunately, due to a lack of availability of further data, no conclusions could be reached on which was the true state of affairs.

However, BOC Arc Equipment appeared to have other problems of more immediate importance, which will be discussed in 5.4.2.

### 5.4.2 Adverse trends apparent in the company

Over the period 1966-77 BOC Arc Equipment had experienced declining margins between the average revenue and total cost per unit for every rectifier produced. (5.3(a)).

Since reduction in the average price of a BOC rectifier had apparently kept pace with that of the UK market, the conclusion was that either all companies were experiencing reducing margins, or that BOC AE had failed to reduce its unit costs at the same rate as other companies. The UK market was represented by members of BEAMA: it may well have been the case that these more established companies were in the same position as BOC AE, and that the market price had been forced down by smaller manufacturers with lower overhead costs, or imports of cheaper foreign goods.

In any case, BOC Arc Equipment was clearly in an uncompetitive and unprofitable position, and this trend could not be allowed to continue. Since the company already priced in the upper quartile of the market (2.3.1), the recent policy of relative price rises was likely to make them even more uncompetitive. (5.3(b)).

One area where the fault was thought to be, was in direct cost per unit, where no significant reduction had been experienced over the period 1966-77. (5.3(d)). The split of data into MIG and TIG product groups indicated that the problem may be in the TIG range of products. (5.3(f) & (g)).

However, further analysis was required to ascertain whether these were the only, or the most important areas where cost reduction had not been controlled.

### 5.4.3 Implications for the next stage of the project

The completion of work testing data from BOC Arc Equipment and the UK industry for the assumption of underlying experience curve models marked the end of the first stage of the project, in which the company's initial problems were investigated. These concerned the validity of the experience curve model which they were using to plan their business. (1.2). The importance of this issue for the company had been evaluated: both the validity and accuracy of estimated parameters of the model were crucial factors in their strategic decision making. (3.3). A review of other work in this field had shown that a steady reduction in unit costs, in constant value terms, could be found in a wide variety of industries, and that this reduction could be related to cumulative output of production and modelled by an experience curve. (4.4.1). Results of work reported in this chapter showed that available data for BOC AE and the UK industry supported the assumption of underlying experience curve models for both unit cost and average price of a rectifier. The analyses also enabled the original questions of the company to be answered, where possible.

However, this research had also indicated further problems of critical importance for the company's future. These fell into two categories:

a) The use of the experience curve model for strategic planning.

Although the model had been found to fit data for BOC AE and the UK industry, discussions in the literature on the subject suggested that its use for derivation of strategy should be critically examined on other bases. (4.4.2). Alternative models may fit the data equally well or better: this could have important implications for strategic planning. (4.3(c)). Authors have also suggested other factors which should be included in the consideration and evaluation of plans. (4.4.2).

Thus, one direction for future work in the project, arising from the results of the first stage, was to test available data for the fit of alternative models for unit cost or average price. The strategic plans of the company should then be evaluated in the light of these findings and of the other factors which should be considered.

b) Failure of the company to reduce unit costs in line with market price.

The adverse trends between unit cost of a BOC AE rectifier and the UK market price were clearly of crucial importance for the company. At this point the findings were discussed informally with the managers. Evidence of these trends had confirmed many hunches that 'things were not going well'. It was agreed, however, that without some indication of underlying causes, actions intended to remedy the situation could be misplaced. Since data on the factory costs was readily available, this could be analysed in order to identify major elements of production costs, and those which were giving rise to concern. Research into factors which may be influencing these costs (such as costs of materials, labour, range of models in production, etc.) could be used to indicate those areas of production where remedial action would be most effective.

This line of investigation formed an alternative option for future work in the project which was of more immediate importance for the company. The further analyses of production costs and major contributory factors were started at once.

Some results from this work were included in the first official report to BOC AE management. This not only summarised initial findings on the fit of the experience curve model to price and cost data, but also pointed out implications of the adverse trends discovered during the course of this work, with references to the main areas for concern in unit cost reduction at BOC AE. (Appendix G.1).

The report also included a paper on alternative directions for the future of the project, giving eight options ranging from construction of a full corporate planning model to evaluation of cost reduction opportunities in the company. (Appendix G.2). These suggestions were discussed individually with each manager, and a revised list presented at the next board meeting in August 1978. (Appendix G.3). During these discussions managers agreed that unit cost reduction was probably not in line with that of other U.K. manufacturers, and that product design, management of the Thanet factory, and investment in future expansion were probably the three key contributory factors. However they felt that further validation of the experience curve models was required, including investigation of alternative models. They suggested comparing trends in unit costs at BOC AE with similar data from AIRCO, SOCOMÉ and CIG, the BOC or BOC-related arc welding equipment manufacturers in USA, France and Australia, respectively. Trends in U.K. average price could be compared with those of the French and German markets. At the same time, the fit of alternative models could be tested on available data, which would incorporate research into the issue described under (a) above. The best fitting model could then be used to set the targets for cost reduction required to restore BOC AE to a competitive position.

Thus, stage II of the project consisted of research into both of the main alternative options arising directly from the results of stage I. Further analyses of unit costs of production were in fact tackled concurrently with collection of data for further investigation and comparisons of models for unit cost/average price. Although the work on model testing took a longer time to complete, it will be reported first (Chapter Six), as it marks the completion of research into models for BOC Arc Equipment.

Analyses, results and conclusions concerning production costs at the factory will be reviewed in Chapter Seven.

# CHAPTER SIX

## INVESTIGATION OF ALTERNATIVE MODELS FOR UNIT COST AND AVERAGE PRICE

As discussed in Chapter Four, a full evaluation of the planning model being used by the company, at that time, should include the testing of both existing and alternative models for the business. (4.4.2)

The work reported in Chapter Five covered the first stage in this process, whereby experience curve models were fitted to data for BOC Arc Equipment and the UK arc welding equipment industry.

This Chapter is concerned with the second stage, in which a variety of models were tested on a range of sets of data, including data from BOC AE.

As before, the investigation was designed to cover specific questions posed by BOC AE planners; these had arisen from results of the work on the experience curve model. Data for average price of a rectifier in the UK had been fitted by an experience curve model with a slope of approximately 81%. (5.2.2). This prompted planners in the company to ask if such a model was typical of other countries in which they traded; they could then compare movements in price between the UK and these countries and use the information in marketing decisions. In addition, managers at BOC AE were concerned about the company's poor record of reduction in unit costs; they would have liked to be able to compare BOC AE trends with those in companies with similar manufacturing operations. This would enable planners and managers to judge the scope for improvement in cost reduction at BOC AE. (5.4.3(b)).

In order to cover these questions, the investigation was designed to include as many sets of data as possible from arc welding equipment industries of other countries, and from other UK manufacturing industries. Although data collection presented some problems, thirty-two sets of data were obtained. Unfortunately, there was insufficient time to collect enough data from other industries to be able to evaluate the trend in cost reduction at BOC AE, and data from the other BOC arc welding equipment manufacturers was not available.

However, this range and extent of data made it possible to test a more general hypothesis concerning the goodness of fit of the experience curve and alternative models to data for average price or unit cost. This would enable results to be extended to other industries.

The methods used in all of the investigation are described in 6.1, results and conclusions for models to be used by BOC Arc Equipment in 6.2, and on the fit of alternative models in general, in 6.3. Some additional observations on the experience curve model are discussed in 6.4, and the main conclusions are summarised in 6.5.

## 6.1 DESIGN OF THE INVESTIGATION

The analyses were designed to investigate the fit of alternative models to data for BOC AE and the UK arc welding equipment industry, and to answer some of the questions described above. At the same time, the data was used to test the hypothesis that the experience curve was universally the best model for unit cost or average price, in terms of the goodness of fit to the data concerned.

### 6.1.1 Data, models, and methods used in initial analyses

Models were to be tested on as many sets of data as possible, including data from BOC AE, arc welding equipment industries of the UK and other countries, and also from UK manufacturing operations.

Data

Data from BOC AE and the UK arc welding equipment industry had already been collected and partially analysed. (5.2.2 and 5.2.3).

Data from arc welding equipment industries of other countries presented more problems. Typically, it either covered too wide a category of welding equipment, or categories were changed so frequently as to give only short runs of consistent data. Eventually, at least one set of data was obtained for each of France, Germany, Sweden, Belgium and the Netherlands, Japan, and the USA. (See Appendix D.1.2 for details of data and problems).

Comparison of trends in unit cost between BOC AE and other UK manufacturing operations required cost data from other companies; this is rarely available. For this reason, the opportunity was taken to use data from another BOC operating company, although neither their products, soda syphons and bulbs, nor their manufacturing operation were similar to those of BOC AE.

Data was also collected from the Government statistics, published in Business Monitor, on volume and value of sales of six categories of products for which annual output volume and average price of the product were similar to those for arc welding sets. Unfortunately, changes in category again produced only short runs of consistent data. (Appendix D.1.3.2 for details).

In addition, data was obtained for sales value and volume of four-door passenger cars in the UK, since this was available for a long period of time, and covered a fairly consistent product category.

This produced thirty-two sets of data suitable for inclusion in the initial analyses. (Table 6.1).

Models and Analyses

The models were those suggested by the study of other research in this field, being those most frequently found to fit data for average price or unit cost. (4.2.2).

In each case, the dependent variable was either average price or some category of unit cost, depending on the availability of data, each deflated using an appropriate index. The independent variables consisted of cumulative output, annual volume of output, and elapsed time. Different forms of relationship between the variables tested in this exercise were those of log/log, linear, and log/linear forms. (4.1.3 (c) ).

However, the constraints of time and computer expense meant that not all models could be tested on all sets of data, and a method was developed to give maximum information with a minimum of analyses.

Data for BOC AE and the UK industry was tested with all combinations of models described above, in order to be able to select the best-fitting ones for use in planning the business. In addition, this data was tested using partial correlation analyses, to determine how much of the correlation between two variables was due to correlation between each, and a third variable. (Appendix D. 1.1.1(d) for details).

All other sets of data were tested with a subset of models in the following way:

a) The experience curve was tested on all sets of data.

b) If results from (a) were not statistically significant, then annual volume of output was the only other variable to be tested, either by a visual scan of the graph, or by testing in a linear model.

NB. Since cumulative output and elapsed time are both monotonically increasing, they were invariably strongly correlated with each other; hence when tested as independent variables on the same set of data, either both were statistically significant, or neither.

c) If results from (a) were statistically significant, then a multiple regression analysis was used to test for the inclusion of each variable, and for more than one variable, in a linear form of the model. This enabled comparisons to be made both between independent variables, and between the experience curve (log/log model) and a linear model relating cumulative output to the dependent variable.

### 6.1.2 Methods used in evaluating results

Results obtained from some of the data sets were thought to be due to inadequacies of the data. (Appendix D.1.4). These were excluded from the next stage, leaving eighteen sets of results for evaluation of alternative models.

However, although in each case it was possible to pick out the best-fitting model in terms of $R^2$, there was evidently no overall best model for all cases. (Table 6.2). Also, it was not possible to determine by inspection alone whether differences in the fit of alternative models were important. The effect of choosing a uniform model, such as the experience curve, might have caused so little deterioration in the overall goodness of fit that its use could be recommended.

The criterion used in testing this possibility was the percentage worsening of error caused by selecting one uniform model over the best-fitting one, for each set of data included in the evaluation. Results for each choice of model were then averaged over all sets of data. (Appendix D.2 for details).

In assessing these results, it is possible that more weight should have been given to sets of data which were more reliable or more relevant, but there was little basis for evaluating these factors, particularly in combination with each other.

### 6.1.3 Methods for determining the effect of errors in volume prediction on the predictive accuracy of models for BOC AE and the UK industry.

Since any volume-related model would depend on estimates of volumes, errors in these estimates would affect the accuracy of unit costs or average price predicted by the model. In order to be able to recommend the most reliable model for this type of use in BOC AE, it was necessary to estimate the effect of such errors in their use of the volume-related model.

The method adopted was to compare confidence limits for predicted values of unit cost at the end of a five year period, based on an assumed volume growth rate, with a range of errors in predicting these volumes. (Appendix D.3 for details).

NB. It must be noted that no work was done on testing the predictive accuracy of any model, for example by comparing the cost or average price predicted from a model fitted to data for the first half of the period, with actual values obtaining in the second half. This was again due to lack of time, plus increasing pressure from the company to help them with their shorter-term planning problems. (8.4).

### 6.1.4 Methods used in examining characteristics of the experience curve model

Planners in BOC AE were enthusiastic about comparing 'slopes' of experience curve models fitted to different sets of data. One factor involved in fitting this model, and obtaining estimates of the slope, is in the estimation of cumulative output for the beginning of the period. The method used in this estimation is described in Appendix C.2.1.2. Effects of a ±50% error in this estimation were simulated for eight sets of data including BOC AE unit cost, and price data for the UK and other arc welding equipment industries. (Appendix D.4.1 for details).

In addition, the opportunity was also taken to investigate some factors considered to affect the suitability of the experience curve model in differing market conditions (4.3). Since some of the sets of data covered a long period of time, these could be used to examine the behaviour of average prices during periods with different types of volume growth.

Each set of data was divided into periods with differing volume growth (assessed from the graph), and analysed for each sub-period separately, to find rate of volume growth and the slope of the experience curve model fitting the data. (Appendix D.4.2).

## 6.2 RESULTS AND CONCLUSIONS CONCERNING MODELS FOR USE BY BOC ARC EQUIPMENT

Planners in BOC Arc Equipment wanted to be able to compare their rate of reduction in unit cost with that of average price in the UK and other major markets in which they traded, both currently and as predicted over the next five years. Consequently they required models for each type of data.

### 6.2.1 Unit cost/average price of a rectifier manufactured by BOC AE.

Results obtained from testing alternative models on data for BOC AE show that each independent variable tested was significantly correlated with either unit cost or average price, whichever form of relationship was used in the model. (Table 6.2).

However, for both unit cost and average price, annual volume of output gave the best goodness of fit, in terms of values of $R^2$. This choice of independent variable reduced the error of fit of the model by an average of 34% over cumulative output or elapsed time. (Table 6.3).

The choice of form of relationship to be used in the model was not so critical; for volume data the log/log form gave slightly better results, but reduced the average error of fit over log/linear or linear models by only 1.7% (Table 6.3).

Partial correlation analysis showed that correlation between unit cost and output volume had a significant element which was independent of the correlations between output volume and either cumulative output or elapsed time. The same result was found for BOC AE average price. (Appendix D. 1.1.2(d) and D. 1.1.3(d) for details).

These results implied that, on the grounds of statistical evidence, the best-fitting model for average price or unit cost of a rectifier manufactured by BOC AE was one relating log average price (or unit cost) with log of output volume. This model would give 95% confidence limits of (+28%, -22%) for the predicted value of unit cost after a five year period. (Appendix D. 3.1 Table 36).

However, the accuracy of prediction from this model relied on the accuracy of prediction of volumes of output. Simulation of the effect of errors in volume prediction showed that with errors of $\pm 20\%$, a model depending on cumulative output or elapsed time would give more accurate results. If errors are likely to exceed $\pm 30\%$, then a time-related model would be the safest one to use. (Appendix D. 3.1 for details).

Conclusion

Recommended choice of a model for unit cost or average price of a rectifier at BOC AE depends on the probable accuracy of their volume predictions. If these are likely to be correct within $\pm 10\%$, then a volume-related model will give better results. If errors are likely to be between $\pm 10\%$ and $\pm 30\%$, then either cumulative output or elapsed time may be used; if errors are likely to exceed $\pm 30\%$ elapsed time would give more reliable estimates.

### 6.2.2 Average price of a rectifier in the UK market

BOC AE wanted to compare their rate of unit cost reduction with the rate in reduction in average price of a rectifier in the UK industry.

The model which best-fitted BEAMA data for average price was a linear relationship with cumulative output. (Table 6.2). In this case, choice of linear model was important, since it reduced the error of fit over the log/log or log/linear models by 11-13%. (Table 6.3). The resulting model explained approximately 84% of the variation in average price. (Table 6.2).

In no case did inclusion of a further variable significantly improve the fit of the model.

The accuracy of predicted values of average price at the end of 5 years was indicated by 95% confidence limits of (-28%, +40%). (Appendix D.3.2).

In this case choice of a model would not be affected by errors in volume prediction.

6.2.3 <u>Average price of a rectifier in other countries</u>

Planners at BOC AE had hoped to be able to use the experience curve model to compare its rate of unit cost/average price reduction with those of other countries, using the measurement of 'slope' derived from the parameters of respective experience curve models.

Results of fitting experience curve models to the relevant sets of data produced estimates of slopes for each set which varied from 24% to 161%. (Table 6.2).

One reason for this could have been in errors in estimating cumulative output for the beginning of each period of data. However, a simulation exercise showed that errors of $\pm$50% in estimating this quantity would have produced average errors of 11-12% in estimating the slope of the curve. (Appendix D. 4.1). This would not be sufficient to account for the wide range in estimated slopes.

The inadequacy of the data prevented any further conclusions to be drawn concerning differences between the slopes of respective models. However this alone indicated that attempts to use the experience curve model in this way were unlikely to be useful.

## 6.3 RESULTS AND CONCLUSIONS FROM TESTING ALTERNATIVE MODELS ON ALL SETS OF DATA

Thirty-two sets of data were tested in the initial analyses. In fifteen cases there was no significant correlation between the dependent variable and any of the independent variables tested. (Table 6.1). However, in most of these cases the data was unsatisfactory in at least one respect (Appendix D. 1.1.4), and fourteen of these sets were omitted when evaluating the results.

Results from the remaining sets of data are summarised in Table 6.2.

In considering these results, the main point of note is that, in most cases, unit cost or average price was significantly correlated with more than one of the independent variables tested in the models. In almost half of all cases, the dependent variable was significantly correlated with all three.

This points to the underlying relationship between the independent variables; it is evident that volume of output and cumulative output will be related in some way, and the relationship between elapsed time and cumulative output has already been noted. (6.1.1).

However, the goodness of fit provided by the different models did tend to differ, more between the independent variables than between different

TABLE 6.1 - Summary of results from all sets of data

| | Country | DATA | | Test of indep.variables | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Source | Category of product | Dependent Variable | Cum output | Output Volume | Elapsed Time | Included in final analysis |
| 1) | UK | BEAMA | Rectifiers 1965-77 | Average price | SIG (0.1%) | SIG (0.1%) | SIG (0.1%) | YES |
| 2) | " | BOC AE | " | " | SIG (1.0%) | SIG (0.1%) | SIG (1.0%) | YES |
| 3) | " | " | " | Unit cost | SIG (5.0%) | SIG (1.0%) | SIG (5.0%) | YES |
| 4) | FRANCE | Statistique du Commerce Exterieur de la France | Rectifiers 1972-77 Imports | Average price | NOT SIG at 5% | NOT SIG at 5% | - | NO (Few data points) |
| 5) | " | " | Rectifiers 1972-77 Exports | " | NOT SIG at 5% | - | - | NO (Few data points) |
| 6) | " | EEC NIM EXE | Arc welding m/cs 1966-71 Imports | " | NOT SIG at 5% | - | - | NO (Wide category) |
| 7) | " | " | Arc welding m/cs 1966-71 Exports | " | SIG (5.0%) | NOT SIG at 5% | SIG (5.0%) | YES |
| 8) | " | SNS | MIG sets 1968-77 | " | NOT SIG at 5% | - | - | NO (Doubtful data) |
| 9) | " | " | TIG & DC MANUAL sets 1972-77 | " | NOT SIG at 5% | - | - | NO (Few data points, data doubtful) |
| 10) | GERMANY | Statistiches Bundesamt Wiesbaden | Electric welding m/cs 1962-69 | Average price | SIG (1.0%) | NOT SIG at 5% | SIG (2.5%) | YES (NB declining volume of sales) |
| 11) | " | " | Rectifiers 1970-77 | " | SIG (1.0%) | NOT SIG at 5% | SIG (0.1%) | YES (declining sales) |



Cont'd.

TABLE 6.1 Cont'd.

| | Country | DATA | | Test of indep.variables | | | | Included in final analysis |
|---|---|---|---|---|---|---|---|---|
| | | Source | Category of product | Dependent Variable | Cum Output | Output Volume | Elapsed Time | |
| 12) | GERMANY | EEC NIM EXE | Arc welding m/cs, 1966-71 Imports | Average price | NOT SIG at 5% | - | - | NO (wide category) |
| 13) | " | " | Arc welding machines 1966-71 Exports | " | NOT SIG at 5% | - | - | NO (wide category) |
| 14) | USA | US Bureau of Census 1972 | Arc welding Equipment 1958-72 | Value added per value of shipment | SIG ( 0.1%) | SIG (1.0%) | SIG ( 0.1%) | NO (Dubious meaning of data) |
| 15) | JAPAN | Japanese Welding News | Arc Welders 1946-70 | Average price | NOT SIG at 5% | NOT SIG at 5% | NOT SIG at 5% | YES (long run of data) |
| 16) | " | " | DC Welding sets 1965-76 | " | SIG (5.0%) | NOT SIG at 5% | SIG (5.0%) | YES |
| 17) | SWEDEN | Produktion av varor ochjunster | Welding & cutting equipment 1973-76 | Average price | NOT SIG at 5% | - | - | NO (wide category, few data points) |
| 18) | NETHER-LANDS | EEC NIM EXE | Arc welding m/cs 1966-71 Imports | Average price | SIG ( 2.5%) | SIG ( 1.0%) | SIG ( 5%) | YES |
| 19) | " | " | Arc welding m/cs. 1966-71 Exports | " | SIG (1.0%) | NOT SIG at 5% | SIG (1.0%) | YES |
| 20) | BELGIUM-LUXEMBOURG | EEC NIM EXE | Arc welding m/cs, 1966-71 Imports | Average price | NOT SIG at 5% | - | - | NO (wide category, few data points) |

Cont'd.

TABLE 6.1 Cont'd.

| | Country | DATA | | Test of indep.variables | | | | Included in final analysis |
|---|---|---|---|---|---|---|---|---|
| | | Source | Category of product | Dependent Variable | Cum Output | Output Volume | Elapsed Time | |
| 21) | BELGIUM-LUXEMBOURG | EEC NIM EXE | Arc welding m/cs 1966-71 Exports | Average price | NOT SIG at 5% | - | - | NO (Few data points, wide category) |
| 22) | UK | BOC Sparklets Ltd. | Syphons | Average price | SIG ( 0.1 %) | SIG ( 0.1%) | SIG (0.1 %) | YES |
| 23) | " | " | " | Unit cost | SIG ( 0.1%) | SIG ( 2.5%) | SIG (0.1 %) | YES |
| 24) | " | " | Bulbs | Average price | SIG ( 0.1%) | SIG ( 0.1 %) | SIG ( 0.1 %) | YES |
| 25) | " | " | " | Unit cost | SIG ( 1.0%) | SIG ( 1.0%) | SIG ( 1.0%) | YES |
| 26) | UK | Business Monitor | Drilling Machines 1972-77 | Average price | NOT SIG at 5% | - | - | NO (Few data points) |
| 27) | " | " | Sawing & Cutting m/cs | " | NOT SIG at 5% | SIG at 10% | NOT SIG at 5% | YES |
| 28) | " | " | Turning m/cs 1972-77 | " | NOT SIG at 5% | - | - | NO (Few data points) |
| 29) | " | " | Pumps I 1972-77 | " | NOT SIG at 5% | - | - | NO (Few data points) |
| 30) | " | " | Pumps II 1972-77 | " | NOT SIG at 5% | SIG ( 2.5%) | NOT SIG at 5% | YES |
| 31) | " | " | Bending & forming m/cs 1972-77 | " | NOT SIG at 5% | - | - | NO (Few data points) |
| 32) | " | " | Passenger cars 1954-77 | " | SIG ( 2.5%) | NOT SIG at 5% | | YES |

## TABLE 6.2 - ANALYSIS OF DATA: SUMMARY OF STATISTICAL RESULTS

| Type of Industry/ Company | Product Category | Dep. Variable Time Period | No.of Data Points | Experience curve test | | | Multiple Regression Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Corr. Coeff. | Sig^ence level % | Slope of curve | Form | Elapsed time | | Volume | | Cum.Output | | More than one Variable (SIG level 5% unless stated ) |
| | | | | | | | | % $R^2$ | % Sig.level | % $R^2$ | % Sig. | % $R^2$ | % Sig. | |
| UK arc welding equipment industry | Rectifiers | Ave. price 1965-77 | 18 | -0.89 | 0.1 | 81.1% | Linear | 80.3 | 0.1 | 79.7 | 0.1 | 83.9 | 0.1 | NOT SIG. |
| | | | | | | | Log/ linear | 63.7 | 0.1 | 78.3 | 0.1 | 79.9 | 0.1 | NOT SIG. |
| | | | | | | | Log/log | 65.0 | 0.1 | 76.5 | 0.1 | 79.4 | 0.1 | NOT SIG. |
| BOC AE data | Rectifiers | Ave. price 1965-77 | 12 | -0.72 | 1.0 | 83.0% | Linear | 51.3 | 1.0 | 70.8 | 0.1 | 50.0 | 2.5 | NOT SIG. |
| | | | | | | | Log/ linear | 59.7 | 1.0 | 71.8 | 0.1 | 53.6 | 1.0 | NOT SIG. |
| | | | | | | | Log/log | 51.7 | 1.0 | 73.0 | 0.1 | 53.9 | 1.0 | NOT SIG. |
| BOC Arc Equipment data | Rectifiers | Total cost per unit 1965-77 | 12 | -0.61 | 5.0 | 86.5% | Linear | 35.1 | 5.0 | 62.4 | 1.0 | 34.2 | 5.0 | NOT SIG. |
| | | | | | | | Log/ linear | 48.0 | 2.5 | 66.1 | 1.0 | 38.9 | 5.0 | NOT SIG. |
| | | | | | | | Log/log | 36.6 | 5.0 | 67.1 | 1.0 | 39.6 | 5.0 | NOT SIG. |
| French welding Equip. Industry (EEC NIM EXE Exports) | Arc welding machines | Ave. price 1966-71 | 6 | -0.78 $R^2$=60.8% | 5.0 | 78.0% | Linear | 64.6 | 5.0 | 17.8 | NOT SIG at 5% | 65.1 | 5.0 | NOT SIG. |

Cont'd.

TABLE 6.2 Cont'd.

| Type of Industry/ Company | Product Category | Dep. Variable Time Period | No.of Data Points | Experience curve test | | | Multiple Regression Analysis | | | | | | | More than one Variable (SIG level 5% unless stated) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Corr. Coeff. | Sig level % | Slope of Curve | Form | Elapsed time | | Volume | | Cum.Output | | |
| | | | | | | | | % | % | % | % | % | % | |
| | | | | | | | | $R^2$ | Sig.level | $R^2$ | Sig. | $R^2$ | Sig. | |
| German Welding Equipt. Industry Statistiches Buidesant | Electric welding machines | Ave. price 1962-69 | 8 | +0.85 $R^2$=72.2% | 1.0 | 137.5% | Linear | 69.6 | 2.5 | 5.43 | NOT SIG at 5.0 | 71.6 | 1.0 | Volume of output with cum.output (1.0) |
| " | Rectifiers | Ave. price 1970-77 | 8 | -0.88 $R^2$=77.4 | 1.0 | 24.5% | Linear | 83.7 | 1.0 | 33.8 | NOT SIG at 5.0 | 77.4 | 1.0 | NOT SIG. |
| Japanese Welding Equipment Industry | DC Welding Sets | Ave. price 1965-76 | 9 | -0.74 $R^2$=54.8 | 5.0 | 73.7% | Linear | 54.9 | 5.0 | 2.12 | NOT SIG at 5.0 | 54.8 | 5.0 | NOT SIG. |
| " | Arc Welding machines | Ave. price 1946-70 | 25 | - | NOT SIG at 5.0 | - | Linear | 3.74 | NOT SIG at 5.0 | 3.67 | NOT SIG at 5.0 | 2.27 | NOT SIG at 5.0 | NOT SIG. |
| Belgium Luxem- bourge EEC NIMEXE Exports | Arc Welding machines | Ave. price 1966-71 | 6 | - | NOT SIG at 5.0 | - | Linear | 2.0 | NOT SIG at 5.0 | 75.7 | 2.5 | 0.64 | NOT SIG at 5.0 | Incl of time with volume of output |

Cont'd.

TABLE 6.2 Cont'd.

| Type of Industry/ Company | Product Category | Dep. Variable Time Period | No.of Data Points | Experience curve test | | | Multiple Regression Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Corr. Coeff. | Sig^ence level % | Slope of curve | Form | Elapsed time % | % | Volume % | % | Cum.Output % | % | More than one Variable |
| | | | | | | | | $R^2$ | Sig.level | $R^2$ | Sig. | $R^2$ | Sig. | |
| Netherlands EEC NIMEXE Imports | Arc welding machines | Ave. price 1966-71 | 6 | -0.87 $R^2$=75.7% | 2.5 | 71.6% | Linear | 73.8 | 5.0 | 79.2 | 2.5 | 77.3 | 2.5 | NOT SIG. |
| Netherlands EEC NIMEXE Exports | " | " | 6 | +0.90 $R^2$=81.0% | 1.0 | 161.5% | Linear | 82.6 | 2.5 | 9.4 | NOT SIG at 5.0 | 79.0 | 1.0 | Incl of cum.output with elapsed time |
| SPARKLETS Ltd. | Syphons | Ave. price 1956-77 | | -0.94 $R^2$=88.4 | 0.1 | 82.4% | Linear | 92.9 | 0.1 | 62.6 | 0.1 | 97.4 | 0.1 | NOT SIG. |
| " | Syphons | Unit cost 1956-77 | | -0.92 $R^2$=84.6 | 0.1 | 88.3% | Linear | 58.2 | 0.1 | 26.2 | 2.5 | 69.4 | 0.1 | NOT SIG. |
| " | Bulbs | Ave. price 1956-77 | | -0.92 $R^2$=84.6 | 0.1 | 93.2% | Linear | 89.3 | 0.1 | 89.5 | 0.1 | 73.3 | 0.1 | NOT SIG. |
| " | " | Ave. price 1956-77 | | -0.62 $R^2$=38.4 | 0.1 | 95.8% | Linear | 36.6 | 0.1 | 45.8 | 1.0 | 34.1 | 1.0 | NOT SIG. |

Cont'd.

TABLE 6.2 Cont'd.

| Type of Industry/ Company | Product Category | Dep. Variable Time Period | No.of Data Points | Experience curve test | | | Multiple Regression Analysis | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Corr. Coeff. | Significence level % | Slope of curve | Form | Elapsed time % | % | Volume % | % | Cum.Output % | % | More than one Variable |
| | | | | | | | | $R^2$ | Sig.level | $R^2$ | Sig. | $R^2$ | Sig. | |
| Other UK industry Source: (Business Monitor) | Sawing & cutting off machine | Ave. Price 1972-77 | 6 | -0.26 $R^2$=6.76 | NOT SIG at 5% | - | Linear | 5.0 | NOT SIG at 5% | 60.8 | 10% | 6.9 | NOT SIG at 5% | NOT TESTED |
| " | Pumps, single stage | Ave. price 1972-77 | 6 | 0.67 $R^2$=44.9 | NOT SIG at 95% | - | Linear | NOT | TESTED | 83.7 | 2.5 | 45.0 | NOT SIG at 5% | NOT TESTED |
| " | Passenger cars (4 wheel) | Ave. price 1954-77 | 9 | 0.76 $R^2$=57.8 | 2.5% | 102.3% | Linear | | | 2.2 | NOT SIG at 5% | 56.9 | 2.5% | NOT TESTED |

Number of tests where elapsed time is significant = 13 (giving highest value of $R^2$ = 3)
" " " " output volume " " = 11 ( " " " = 8)
" " " " Cumulative output " = 14 ( " " " = 6)
" " " " all three are significant = 8

(All out of a total of 18, where U.K. average price, BOC AE average price and unit cost each count as one test).

TABLE 6.3

Percentage worsening of error caused by choosing uniform model over best model in each case.

| | Independent Variable | | |
|---|---|---|---|
| | Time | Volume | Cumulative Output |
| a) BOC AE data for unit cost | | | |
| In choice of independent variable | | | |
| Linear model | 31.5 | - | 32.3 |
| Log/linear model | 23.8 | - | 34.4 |
| Log/log model | 38.7 | - | 35.4 |
| In choice of form of model | | | |
| Linear over log/log (best) | 1.26 | 6.79 | 4.38 |
| Log/linear over log/log | -9.4 | 1.39 | 6.43 |
| b) UK industry data for average price | | | |
| In choice of independent variable | | | |
| Linear model | 10.7 | 12.2 | - |
| Log/linear model | 24.8 | 4.0 | - |
| Log/log model | 30.4 | 6.8 | - |
| In choice of form of model | | | |
| Log/linear over linear (best) | 25.9 | 3.6 | 11.7 |
| Log/log over linear | 33.3 | 7.8 | 13.2 |

TABLE 6.4 - Details of error of fit in each case

$E = \sqrt{1-R^2}$ where R is the proportion of sum of squares due to the regression.

Standard deviation of error =

$$\frac{\text{Total } 5.5 \times \sqrt{1-R^2}}{n-2}$$

Thus E is sufficient for comparing the ratio of standard deviation of error from one variable to another. % worsening of error of variable $v_i$ over 'best', say $v_b$

$$= \frac{E_{vi}-Ev_b}{Ev_b} \times 100$$

$$= \frac{\text{Increase in standard dev}^n \text{ of error using vi over } v_b}{\text{Standard dev}^n \text{ of error of } v_b}$$

| | E = Error | | | % worsening over best | | |
|---|---|---|---|---|---|---|
| | Time | Volume | Cumulative Output | Time | Volume | Cumulative Output |
| UK price log/lin | .495 | .532 | .402 | 10.7 | 12.2 | 0 |
| BOC price log/log | .695 | .520 | .679 | 33.6 | 0 | 30.6 |
| BOC cost log/log | .796 | .574 | .777 | 38.7 | 0 | 35.4 |
| France | .594 | .907 | .591 | .5 | 53.5 | 0 |
| Germany weld.m/cs | .551 | .972 | .533 | 3.2 | 82.4 | 0 |
| " DC Rectifiers | .404 | .814 | .475 | 0 | 101.5 | 17.6 |
| Japan DC welders | .672 | .989 | .672 | 0 | 47.2 | 0 |
| Japan Arc w.m/cs. | .981 | .981 | .989 | 0 | 0 | .8 |
| Belge-Lux Exps. | .990 | .493 | .997 | 100.8 | 0 | 102.2 |
| Netherland Imps. | .512 | .456 | .476 | 12.3 | 0 | 4.4 |
| Netherland Exps. | .417 | .951 | .458 | 0 | 128.1 | 9.8 |
| Syphons Price | .266 | .611 | .161 | 65.2 | 279.5 | 0 |
| Syphons Cost | .646 | .860 | .553 | 16.8 | 55.5 | 0 |
| Bulbs Price | .327 | .324 | .517 | .925 | 0 | 59.6 |
| Bulbs Cost | .796 | .736 | .812 | 8.15 | 0 | 10.3 |
| Sawing & cutting off machines price | .964 | .626 | .964 | 54.0 | 0 | 54.0 |
| Pumps | .741 | .404 | .741 | 83.4 | 0 | 83.4 |
| Cars | - | .989 | .650 | - | 52.1 | 0 |
| | | | Total | 429.375 | 811.6 | 408.1 |
| | | | Average | 23.85 | 45.09 | 22.67 |

forms of relationship tested in the models. Although volume of output was least likely to be significant, it gave the highest value of $R^2$ in more cases than either of the other two. Conversely, elapsed time was more frequently correlated with the dependent variable, but gave the highest value of $R^2$ in only three cases. Cumulative output was the most frequently significant, giving highest values of $R^2$ in half of the cases.

These results demonstrate that, even in the rather limited sample of data, there was considerable variation in choice of a 'best' model based on the respective value of $R^2$. In fact, the penalties for selecting a uniform model for all sets of data were severe. The average percentage worsening of error caused in this way would be 45% for output volume, 24% for elapsed time, and 23% for cumulative output. (Table 6.4).

The limited testing of different forms of relationship meant that here conclusions were less general. Comparison of the log/log with linear models for cumulative output showed that the log/log model gave higher values of $R^2$ in slightly more cases, although the difference was usually marginal. The lack of distinction between the forms of model used is demonstrated in the more extensive testing of data for BOC AE and the UK industry. Here choice of a specific uniform relationship over the best one for each set of data caused an average percentage worsening of error of fit of only 9%. (although reaching rather high values for a time related model for U.K. price). (Table 6.3).

Conclusions

The main conclusion to be drawn from these results is that the evidence does not support the hypothesis that the experience curve is always the best model for average price or unit cost.

In fact, the evidence suggests that there is no uniformly best model, and that choice of such a model in the absence of statistical evidence could result in extreme penalties with respect to the goodness of fit of the model to the data.

Thus, any company engaged in choosing this type of planning model is recommended to test all models on the data concerned.

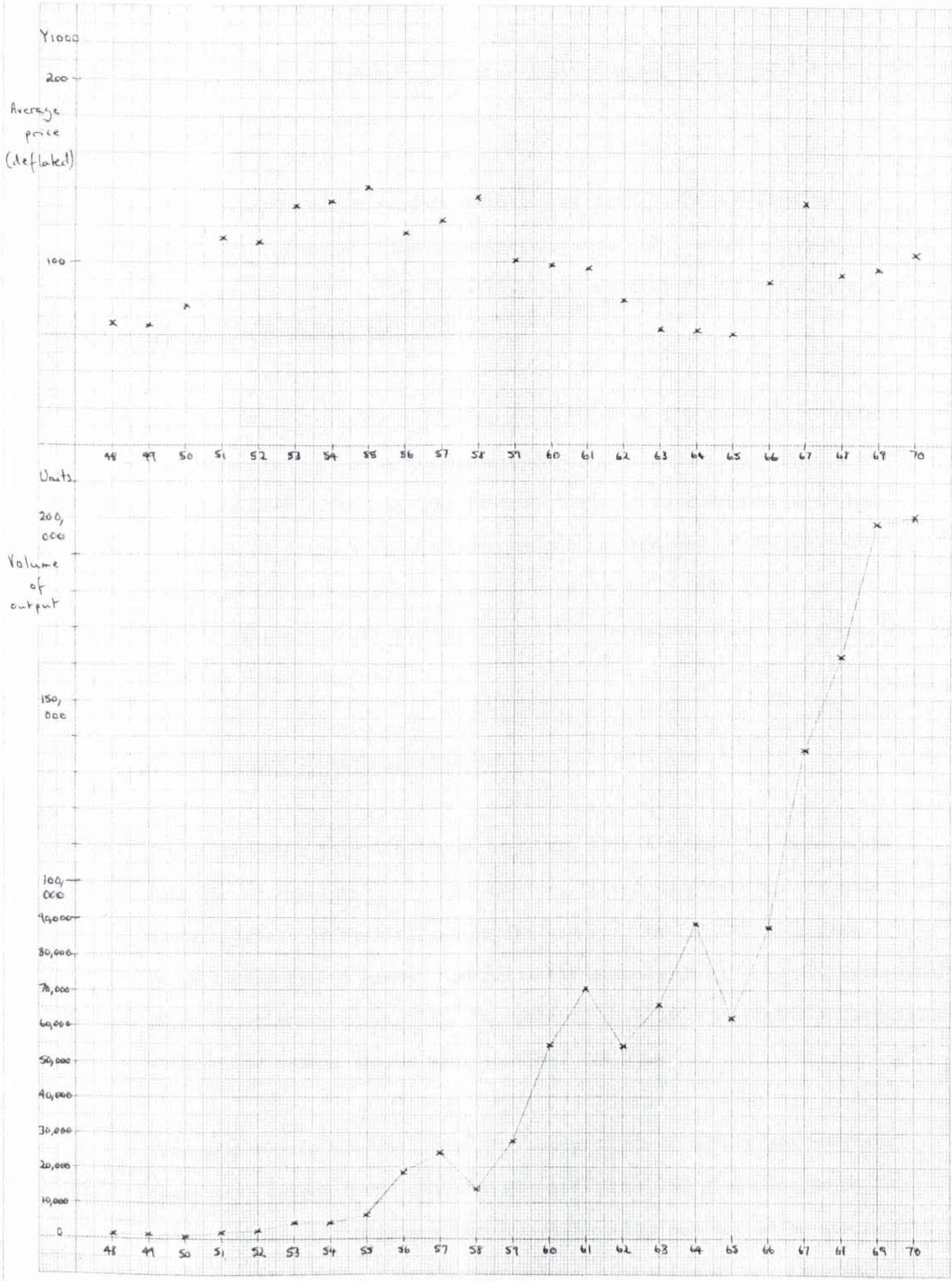
## 6.4 OBSERVATIONS ON THE EXPERIENCE CURVE MODEL IN GENERAL

Some authors have put forward the view that a strategy based on the experience curve model is only applicable in certain circumstances, one of these being that the market for the product should be in a high growth phase. (4.3 (a) and (d)).

The five sets of data which spanned periods of at least 15 years were used to investigate behaviour patterns of average price or unit cost occurring in periods with radically differing volume growth. No clear pattern emerged from this investigation. Although the analysis showed that successive periods with differing volume growth could have radically different behaviour in average price, there was no consistent link between high volume growth rates and steadily declining prices. (Appendix D. 4.2).

An example of this is found in data for sales of arc welding machines in Japan, from 1948-1970. During the period of steady growth, 1948-1955, the average price (in constant value terms) rose by over 100%. During 1955-65, volume growth was a little higher, and the average price declined fairly steadily (fitted by an experience curve model with slope 81%). From 1965-67 however, volumes of output more than doubled, but so did the average price. Then, from 1967-70, growth continues steadily and average price falls then rises. (Graph 6.1).

Graph 6.1


Y1000
200
Average price (deflated)
100
48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70
Units
200,000
Volume of output
150,000
100,000
90,000
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0

These results, although from rather limited data, can be used to demonstrate two important points.

Firstly, periods of steady or high volume growth are not always accompanied by a reduction in average price. Secondly, a change in volume growth rate can be associated with an extreme change in the behaviour of average price.

This has crucial implications for derivation of the strategy of market share maximisation from the experience curve model. Even if the model fits data over a certain time period, there is no guarantee that the behaviour of average price will continue in this way if the rate of volume growth is changed. Since a strategy of market share maximisation implies such a change, the results of this strategy cannot be predicted from use of this model.

## 6.5 SUMMARY OF MAIN CONCLUSIONS

One of the main points arising from this work was that, in most cases, data for average price or unit cost was fitted by more than one model, at similar levels of statistical significance. Whilst the dependent variable was almost always significantly correlated with cumulative output in an experience curve model, it could be equally significantly correlated with output volume and/or elapsed time. (6.3).

This arises from the fact that the independent variables are related. Cumulative output increases with elapsed time, and also depends on output volume, although the latter relationship may not be so strong if volumes vary widely. Similarly, output volume itself may increase steadily with elapsed time, or may be more independent.

In spite of the dependence between the variables, for each set of data, the fit of models based on different variables differed greatly. Since no one variable always gave the best model, choice of a uniform model such as the experience curve resulted in considerable overall worsening of the error of fit. It must be noted that, in general, the form of relationship between the variables was not so critical; although different relationships gave a better fit in individual cases, the differences were small.

Moreover, the evidence indicates that, over a long period of time, behaviour patterns of average price vary greatly. In particular, trends in price can vary over successive periods for which the volume growth rate is quite different. (6.4) An experience curve model with slope of 80% may fit data for one period of time and then be totally inappropriate in the next period. What is more, the type of gradual decline modelled by such a curve is not necessarily associated with periods of high volume growth rate, as suggested by Jain. (1975, see 4.3(a)).

Clearly, these conclusions have implications both for the choice of a model and for derivation of strategy from the experience curve model.

On the basis of statistical evidence, specific models can be recommended for unit cost of a rectifier manufactured by BOC AE, and for the average price of a rectifier in the UK. (6.2.1 and 6.2.2). However, the range of slopes of experience curve models fitted to data for arc welding equipment industries of other countries varied widely. (6.2.3). Since this could be due to inadequacies and vagaries of the data, and errors in estimating initial values of cumulative output, as well as actual differences between price movements, use of the model to compare price movement is not practicable.

The implications from all of this work for planning in BOC Arc Equipment are discussed in Chapter Eight.

However, some of the recommendations reported in Chapter Eight were also based on another piece of work which investigated trends in costs in the company, in more detail. This work was carried out concurrently with the examination of alternative models, and will be reported in Chapter Seven.

# CHAPTER SEVEN

## FACTORS CONTRIBUTING TO TRENDS IN UNIT COST AT BOC ARC EQUIPMENT

In the analyses of unit cost and average price of a rectifier produced by BOC Arc Equipment, it was noted that the margin between average revenue and average cost, per unit, was declining at a significant rate. (5.3(a)). Since their average price was keeping pace with the UK market price, as represented by members of BEAMA, profitability could only be improved by reducing unit costs. (5.3(b)).

Further analysis suggested that the main areas where costs had not declined was in the direct cost per unit, particularly in the TIG group of products. (5.4.2).

Although some action was taken on the basis of this evidence alone, (8.2) more information was required concerning the particular areas where costs were too high, and also the critical factors underlying these costs. This would enable managers to decide on priorities for cost reduction efforts.

For this more detailed analysis, data for costs of production at the factory provided consistent records of materials, labour, and factory overhead costs incurred in the manufacture of MIG, TIG, and DC Manual arc welding sets.

The major elements of production costs were identified, and tested for any significant change in the proportion which they form of the total. (7.1).

Possible factors associated with the behaviour of unit production costs were investigated where the availability of data makes this possible. (7.2).

Results and conclusions are discussed in 7.3.

## 7.1 ANALYSIS OF PRODUCTION COSTS 1965/66 - 1976/77

For details of data, analyses and results see Appendix E section 1.

The annual costs of material consumed, direct labour used, and the various categories of overhead costs were extracted from the annual profit and loss account of the factory. Each was then deflated and divided by the corresponding volume of output to give annual cost per unit in constant value terms.

The statistical significance of any apparent trends in the various categories of unit cost, and in the proportion which each formed of the total, was tested using the linear regression techniques described previously. (4.2.1).

### Results

The results are given in tabular form. Table 7.1 shows the proportions formed by the major elements of costs over the period 1965/66 to 1976/77, and Table 7.2 the average compound growth rates of the total and component costs per unit, and the significance of any apparent trends.

These results show that the average factory cost of producing a rectifier, in constant value terms, had actually risen over the period 1965/66 to 1976/77, with an average compound growth rate of 5% p.a. (Graph 7.1).

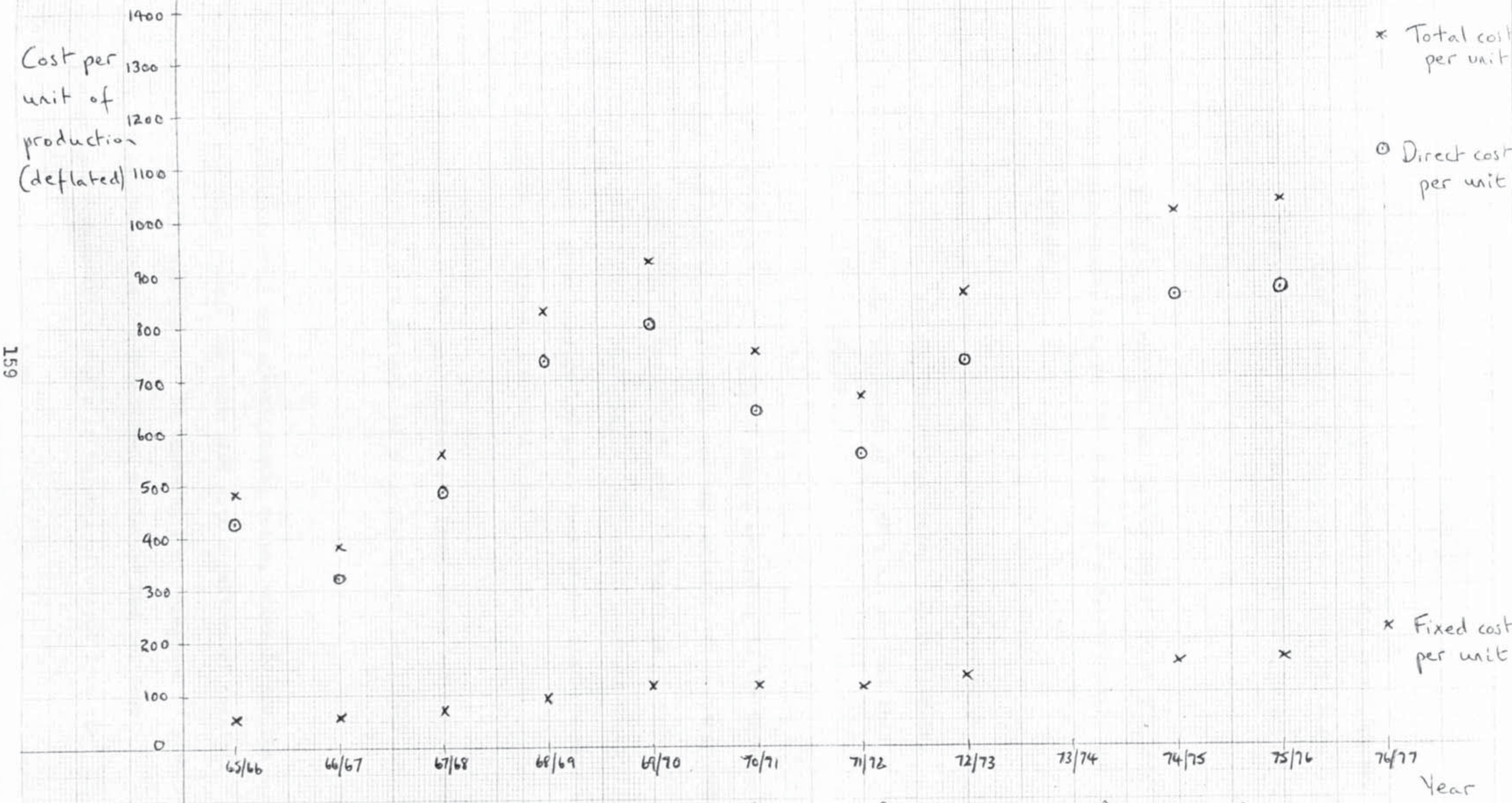
TABLE 7.1 - Proportions formed by major items of costs at the factory.

| | Proportion of total costs | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 65/66 | 66/67 | 67/68 | 68/69 | 69/70 | 70/71 | 71/72 | 72/73 | 73/74 | 74/75 | 75/76 | 76/77 |
| Materials | .78 | .71 | .71 | .71 | .72 | .69 | .68 | .71 | | .71 | .68 | .68 |
| Labour | .11 | .15 | .17 | .17 | .15 | .15 | .16 | .13 | | .13 | .15 | .15 |
| Salaries, staff pensions Employee services | .05 | .08 | .06 | .05 | .06 | .09 | .10 | .10 | | .10 | .12 | .12 |
| Remainder of admin. | .01 | .01 | .01 | .01 | .01 | .01 | .01 | .01 | | .01 | .01 | .01 |
| Rates, fuel, light, power | .01 | .01 | .01 | .01 | .01 | .02 | .02 | .02 | | .01 | .02 | .01 |
| Establishment maintenance, services, & insurance | .01 | .01 | .01 | .02 | .01 | .01 | .01 | .01 | | .01 | .01 | .01 |
| Financial/ Professional | .01 | .01 | .01 | .01 | .02 | .01 | .005 | - | | .01 | - | .01 |
| R & D | .01 | - | - | - | - | - | - | .01 | | - | - | - |
| Carriage | .01 | .01 | .01 | .01 | .01 | .01 | .01 | .01 | | .01 | .01 | .01 |
| Other | - | .01 | .01 | .01 | .01 | .01 | .005 | - | | .01 | - | - |

TABLF 7.2 - Results from linear regression analysis and estimated average compound growth rates of unit costs at the factory

| Set of data | Regression line | C | F (Sig level) | A.c.g.rate % p.a. |
|---|---|---|---|---|
| Material cost/unit | y=123.96+5.846x | .77 | 13.4 (99%) | 3.725 |
| Labour cost/unit | y=25.227+1.196x | .70 | 8.8 (97.5%) | 3.741 |
| Total direct cost/ unit | y=149.092+7.101x | .79 | 15.1 (99%) | 3.755 |
| Administration cost/unit | y=7.963+2.146x | .97 | 150.0 (99.9%) | 11.573 |
| Establishment cost/ unit | y=4.010+0.334x | .89 | 34.6 (99.9%) | 5.735 |
| Financial/profess[1] cost/unit | y=3.405-0.253x | NOT SIG. | | Decline |
| 'Other' cost/unit | ) Clearly no trend | | | |
| Carriage cost/unit | ) | | | |
| Total fixed cost/ unit | y=21.040+1.515x | .90 | 37.0 (99.9%) | 5.159 |
| Total fixed+ direct cost/unit | y=170.131+8.6172 | .84 | 20.9 (99%) | 3.943 |
| **Analysis of proportions formed by various costs** | | | | |
| Direct/total cost | y=0.884-0.00475x | .67 | 8.1 (97.5%) | - |
| Admin./total fixed cost | y=0.518-0.197x | .86 | 26.6 (99.9%) | - |
| Material /total factory cost | y=0.740-0.00523x | .68 | 7.79 (97.5%) | - |
| Labour/total factory cost | y=0.147-0.0000133x | .03 | 0.008 NOT.SIG | - |
| Salaries, staff pensions, employee services/total factory cost | y=0.0451+0.00629x | .89 | 32.7 (99.9%) | - |

Graph 7.1 The rise in unit costs of production at the factory over the period 1965/66 to 1976/77




Source of data; see Appendix E.1.1

Materials, labour, administrative, and establishment costs (rent, rates, fuel, etc.), formed the main elements of total cost. Each of these, per unit of production, had risen over the period in question, although at slightly differing rates.

The direct costs per unit of material and labour had risen at slightly less than the average rate, but, at 83% of total costs, were still the dominating constituents.

Highest growth rates had occurred in the factory overhead costs which were mainly establishment and administration costs. In particular, administration costs per unit had grown at 11.5% p.a., so that they formed 13% of total costs by 1976/77.

Further analysis of the value of fixed assets according to the balance sheet of HWR (Appendix E.2), revealed constant additions to property and plant over the period 1965/66 to 1972/73, and the beginning of work on the new factory in 1976/77. Their value, deflated to constant money terms, had increased at an average 13% p.a., much higher than the rate of increase in volume of output. (Appendix E.2.3).

These analyses suggested that both direct and fixed costs had contributed to the rise in factory cost per unit of production over the period in question.

The rise in administration and establishment costs, which formed the majority of the fixed costs, had coincided with a pattern of constant additions to property and plant. It appeared that expansion of premises, production facilities, and organisational structure had not been accompanied by a commensurate growth in volumes of output from the factory.

The rise in the direct costs per unit of materials and labour required further investigation.

## 7.2 FACTORS AFFECTING PRODUCTION COSTS

The direct cost of making a rectifier depends on the cost of the raw materials and labour, and the design of the product.

However, the overall direct cost would also be affected by the efficient utilisation of materials and operators, so production efficiency should be an important factor.

Effective utilisation of fixed production facilities may be related to the rate of output, and the number of different products in production, and thus, to a certain extent, on market demand.

The average cost of a rectifier may also depend on the product mix and specification of the average product, again influenced by the perception of the market being served, and its needs.

In the particular manufacturing operation of BOC Arc Equipment some or all of these factors may have been important; identification of the most important would indicate areas where action could be taken, and where it would be most effective.

Each group of factors was considered in turn. Analytical investigation was not always possible, but results are given where appropriate.

### 7.2.1 Cost of raw materials and labour, and the design of the product (Appendix E.3 and 4)

At that time, the constituent raw materials of the average rectifier formed the following approximate proportions by value:

| | |
|---|---|
| Copper | 38% |
| Laminations | 32% |
| Electrical parts, consumables | 18% |
| Other metal parts | 12% |

Thus, the market price of copper was an important factor. However, the evidence showed that the average price had declined over the period 1968-77, compared with the usual index of inflation, and this trend was corroborated by the standard costs of copper used by BOC for costing, 1974-77. Moreover, the factory manager for the period 1965-72 prided himself on his skillful buying of this commodity, frequently buying in excess of his needs and subsequently selling at a profit. (E.3.3(a) & (b)).

The rise in BOC standard costs for laminations and steel sheet, 1974-77, would have been balanced by this decline in copper prices, to give no overall net increase in total material costs. (E.3.3(c)).

Analysis of the annual average hourly rate of pay for a factory operator from 1968/69 to 1976/77 showed a rise followed by a decline, with no overall significant trend. (E.3.3(d)).

Hence the data provided no evidence of a rise in the absolute cost of raw materials or labour over the period in question, relative to the inflation index used throughout the analyses.

The effect of the design of the product on unit costs was difficult to establish, due to the scarcity of data on costs of individual models. (Appendix E.4.1 & 4.2).

In fact, there had been few changes to existing models, with most of the design resources put into replacement and new models.

During the period 1965/66 to 1974/75 the design effort was centred on extending the range for MIG, the newer process. Although some individual models were replaced with less costly ones, the general effect was of an average increase in unit cost. The models which were retained were the older, costly type, presumably produced to satisfy customer demand.

Later, when the range was rationalised, a more cost-oriented approach to product design produced less costly models in the middle of the range, but failed to reduce direct cost in the heavier models. (E.4.3).

The main bulk of the TIG range remained unchanged until 1975/76, with the addition of a few models in the lower amps and cost range of the market. However, with the rationalisation of the range, TIG products in general become more highly specified and thus more costly. (E.4.3).

To summarise, until recent years, design effort had concentrated on fulfilling the perceived market requirements, by extending the range in MIG, and increasing the sophistication of TIG sets. Both of these actions tended to increase the average cost of production per unit. In the last two years design had become more cost conscious, but with little impact on average direct cost per unit, so far. (E.4.4).

### 7.2.2 Production efficiency, rate of output, and width of range (Appendix E.5 and 6)

Production efficiency involves the optimal use of labour and machinery, minimal wastage of time and materials, effective supply of materials, use of appropriate production methods, and good organisation.

Two important factors affecting production efficiency are the rate of output and the number of different models in production. This was particularly true in the batch-type production used by BOC Arc Equipment.

Although the number of models in the range more than doubled between 1965/66 and 1972/73, whilst cost per unit was increasing, in later years the number of models declined, whilst unit cost continued to increase. Overall, the width of the range was not significantly correlated with the cost per unit of manufacture, either for the factory alone, or for the whole business. (Appendix E.6).

Tests of correlations between the rate of output as measured by the annual volume of output, and the various categories of unit costs, produced surprising results.

Costs per unit at the factory, particularly direct costs, were positively correlated with output volumes. Thus, an increase in output volume was associated with a rise in production cost per unit. (Appendix E.5).

This result suggested that, in this operation, an increase in volume of output did not bring the expected economies arising from more efficient buying and supplying of materials, more effective use of labour and facilities, use of optimal batch sizes.

In discussing these results with BOC AE personnel, several reasons were suggested to explain this phenomenon. These included a lack of gearing-up to the new levels of production, inability of the system and organisation to cope with the increased volumes, and a negative attitude towards efficiency and cost reduction in the good times, when production levels are high.

### 7.2.3 Product mix and specification (Appendix E.7 and 8)

The mix of products manufactured by BOC Arc Equipment was considered on the basis of three criteria:

a) The proportions by volume of MIG and TIG sets in the mix of rectifiers produced. (Appendix E.7)

Since the average cost of a MIG set was approximately 60% that of the average TIG set, a different in the proportions of MIG and TIG in the rectifier mix would certainly have affected the overall average cost of a rectifier. However, analysis of the numbers of each produced over the period 1965/66 to 1976/77 showed a slight increase in the proportion of MIG, although this trend was not statistically significant. (Appendix E.7.3(a)).

The conclusion is that there had been no significant change in the proportions of MIG and TIG which would contribute to an increase in average cost of production of a rectifier.

b) The proportion by value of rectifiers in the mix of all equipment

Since the cost data included the cost of all welding equipment, any change in the proportion of rectifiers to other types of equipment would have affected the average cost per rectifier produced.

Again analysis showed no significant trend over the period in question, either for all sets or for MIG and TIG sets taken separately. (E.7.3(b)).

c) The proportion, by volume of sets in different ranges of output current.

Sets were produced in the light, medium, and heavy ends of the range. These terms refer to approximate categories of output current, light to under 200 amps, medium 200-400 amps, and heavy, over 400 amps. A change in product mix towards the lighter or heavier ends of the range could affect the average cost of production. (E.7.3(c)).

In this case, analysis produced positive results. There had been a significant decline in the proportion of sets in the 200 amps and under range, and an increase in those of over 400 amps. The proportion of sets in the middle ranges remained unchanged.

Since the cost of a set is not necessarily directly proportional to its output current, assessment of this trend required some consideration of the models contributing towards the trends.

The swing away from the light end of the range is due to a fall in the proportion of sets in the low amp ranges of MIG. In general models had been replaced by ones with a higher current rating, resulting in a higher average unit cost. (E.7.4).

The TIG range showed an increase in the heavier end of the range, mainly due to the replacement of the old MNR range by TA DC 525 and 825, at slightly higher average cost.

Hence, the trend of a swing away from the light end, and towards the heavier end of the range would tend to increase the average cost of the product.

However, the cost of a rectifier depends not only on the process and the current rating, but also on sophistication or complexity. It was alleged by many BOC personnel that the average BOC set had increased in sophistication, particularly in the TIG process, relative to the rest of the market. (See introduction to Appendix G).

Each model was given a complexity rating, and the average number of complexity units per rectifier produced was calculated for each year of the period in question. Analysis of this data produced surprising results. (Appendix E.8).

The general trend of a significant increase in average complexity per unit was due to an increase in that of MIG, rather than TIG. (E.8.3).

This was again explained by looking at the models concerned.

In MIG, the introduction of the SMR range and of the Autolynx and Lynxpak models produced a general increase in complexity per unit.

Although the new TIG models were of a higher complexity rating, particularly the TT DC 250, production volumes of the more complex sets had declined. This produced an overall decline in the average complexity of a TIG rectifier. (E.8.3).

However, the combination of higher unit cost and lower volumes of the more sophisticated TIG sets had probably contributed heavily to the overall increase in factory costs per unit.

## 7.3 CONCLUSIONS

Results from these analyses provided further insight into the trends in unit cost at BOC AE described at the beginning of this chapter.

In constant value terms, production costs per unit had actually increased over the period 1965/66 to 1976/77.

These costs were mainly composed of the direct costs of materials and labour, salaries and other administrative costs, and the costs of running the establishment. Each of these elements had contributed to the overall rise in total production cost per unit. (7.1).

Evidence from further analyses pointed to three underlying causes for these trends.

Firstly, the whole scale of operation appeared to have grown at a rate which was not justified by a commensurate increase in volumes of output. In particular, the administrative costs per unit had grown at the highest rate of all. (7.1).

In addition, unit costs were positively correlated with the rate of output. (7.2.2). That is, production efficiency declined when volumes of output were high. This indicated a lack of control over the utilisation of resources, and so over the costs of production.

The third main cause of rising unit costs lay in the change in the products over this period. MIG products had been successively upgraded, and both MIG and TIG sets had increased in complexity and sophistication. Design effort had concentrated on the needs of the market, as they were perceived, rather than on cost control or reduction.

By this stage in the project, it was evident that the company had several major problems in its planning and its operations. These problems had been clearly exposed by the analyses of trends in unit costs and average price, and the evidence was presented formally in a report to the BOC Arc Equipment management board. (Appendix G.1).

However, as they arose, these results had also been discussed with various managers in the company. Consequently, evidence provided by the research had already begun to influence plans, decisions, and actions taken in managing the business.

In addition, several changes had taken place in BOC Arc Equipment which, together with the managers' new perception of the business and its problems, had a major effect on the future of the project. This interaction between the project and the company, at a stage which was of crucial importance for both, will be described in Chapter Eight.

# CHAPTER EIGHT

## IMPLICATIONS FROM STAGES I & II, AND THE DEVELOPMENT OF STAGE III OF THE PROJECT

As described in Chapter One, the project developed in stages, each of which depended both upon the results from the previous stage, and on the requirement and needs of the company. (1.3).

The first stage was concerned with use of the experience curve model as a basis for planning in BOC Arc Equipment. Having evaluated the importance of the problems described by planners in the company (3.3), and considered results and discussions from other research in this field (4.4), this stage culminated with the fitting of experience curve models to data for BOC AE and the UK arc welding equipment industry (5.4.1).

At this interim point of the project, the next stage was envisaged to lie in further help with the corporate or strategic planning of the company. Specific suggestions covered the development of more extensive models, improvement of the current information system for corporate planning, evaluation of the current basis for strategic planning and comparison with other methods, and the way that departmental plans interacted with the overall strategic plan. There were also some ideas for helping with marketing strategy, and with cost reduction opportunities. (Appendix G.1).

However, before considering these alternatives in any detail, two issues remained outstanding from the results of phase I. (5.4.2). Firstly, further information was required on the adverse trends in unit costs, so that the management could take remedial action. Secondly, results from other research in this field showed the necessity of testing the fit of alternative models to the type of cost behaviour modelled by the experience curve, and of evaluating this model with respect to other critical factors. (4.4.2).

These issues were felt to be so important for both short and long term planning in BOC AE, that their investigation must come before consideration of the other aspects of strategic or corporate planning previously suggested. This work formed stage II of the project, as reported in Chapters Six and Seven.

Results from stage II again led to several alternatives for remaining work. However, one of the main characteristics of the IHD scheme is that each project takes place in a real business situation. This provides a dynamic environment which interacts with the development of the project.

In this case, results of the work already done had provided evidence of several problem areas in BOC Arc Equipment, the effects of which were beginning to be felt. This in itself influenced the choice of work for the third phase, since it became imperative that the project responded to the short term needs of the company.

The implications arising from the first two stages are discussed in 8.1, and the incorporation of this work in strategic plans for 1979/84, in 8.2. Changes inside and outside the company which affected the development of the project are described in 8.3. Details of resulting plans for stage III are given in 8.4.

## 8.1 IMPLICATIONS AND RECOMMENDATIONS ARISING FROM STAGES I AND II

The investigation of alternative models for unit cost or average price tested correlations of each with cumulative output, rate of output and elapsed time as independent variables, in a variety of relationships. (6.1.1). Evidence from this research suggested that there is no uniformly best model for unit cost or average price, and that the best-fitting model should be chosen in each case. (6.3). These results also have implications for the logical validity of deriving a strategy of market share maximisation from the experience curve model. In most cases, unit cost or average price was significantly correlated with more than one of the independent variables tested, and in many cases, with all three (6.3). If any decline in unit cost is significantly related to elapsed time, as well as to cumulative output, there is no basis for supposing that an increase in market share (with consequent increase in cumulative output), would affect the rate of decline. This point is included in a later discussion of the general validity of strategic planning based on the experience curve model (13.1.2).

BOC AE had more immediate problems. The analyses of costs incurred in the manufacture of rectifiers provided evidence that the strategy was not having the expected results. In testing the experience curve model on direct and fixed costs, as well as on total unit cost, it became apparent that the overall decline in total unit cost was due entirely to that in fixed costs per unit. Since this depended only on the increase in volume of output being greater than the increase in total fixed costs, the result was not surprising. Direct cost per unit had shown no significant reduction over the period in question (1965-77), and had in fact increased over the later years, 1974-77. (5.3(d)). These findings were confirmed by analyses of production costs, which showed that the production cost per unit had actually increased over this period, with a growth rate of 5% p.a. (7.1).

These results implied that, in BOC AE, the margin between average price and unit cost of a rectifier was declining, and that the business was becoming unprofitable. The recommendations were obvious, but their statement and justification important in the rather confused situation in the company (8.3). Future survival of the business would depend on the successful control of unit costs.

The report issued to BOC AE managers (Appendix G.4), whilst summarising results from the investigation and comparison of alternative models, made the following points:

i) The main tactical alternatives were to reduce fixed costs, improve performance in cutting direct costs of the product, or increase volumes of sales with control of both overhead and production costs. (G.4, 6.12).

ii) In comparison with the need to control unit costs, choice of a model for long term planning in the company was relatively unimportant. (G.4, 6.11).

Some actions had already been taken to assist with plans for cost reduction, as agreed at the board meeting in August 1978 (5.4.2(b)) and Appendix G.3). The models already fitted to data for BOC AE and the U.K. industry were used to estimate the cost reduction required for the company to achieve its strategic aims.

## 8.2 TARGETS FOR COST REDUCTION 1979/84

By January 1978 it was recognised that the poor levels of economic activity had affected the demand for arc welding equipment. As a result, strategic plans for 1978/83 contained a change in direction.

The strategic aim for plans of 1977/82 had been that of 'hold with some growth', with targeted growth in market share from 39% to 45%. (3.1.2).

In plans for 1978/83 this was revised to a policy to maintain competitive position with respect to market share. Some growth was allowed, in order to provide the new factory with sufficient throughput to make the investment profitable, but this was to be in line with market growth.

Four main goals were specified to help the company to achieve this aim. These consisted of determined marketing, modified product design, reduced product cost, and improved production techniques.

In June 1978, the first report from the work of the project was issued to BOC AE managers. This contained results from fitting experience curve models to data for BOC AE and the UK industry, and described the adverse trends between average price and unit cost of a rectifier manufactured by the company, including some of the investigations of production costs. (Appendix G.1, dated April 1978 but presented to BOC AE management board in June 1978).

These results were incorporated into strategic plans for 1979/84, affecting the selection of goals, quantification of targets, and choice of tactics. (Appendix F).

Although the strategic aims were the same as those adopted for 1978/83, most of the emphasis was placed on action plans for unit cost reduction, which became the primary goal for 1979/84.

For the first time, targets for unit cost reduction were quantified, using experience curve models fitted to the relevant data. These were used to simulate the relative rates of unit cost reduction between BOC AE and a major competitor, under varying assumptions about their relative sizes and rates of growth. The differentials between them could then be projected for the five year planning horizon. These figures were then used to calculate the target cost reduction required for BOC AE either to maintain current (1978) differentials, or to match competitors costs by 1984. (Appendix F.1 for details).

The models were also used to evaluate the effect of specific plans for reducing unit costs, and to compare results with the target reduction required. (Appendix F.2 & F.3).

These plans had already been influenced by results of the analyses of costs undertaken in the project.

A program for the design of new products, incorporating a reduction of 30% in direct costs, was planned for completion by 1981/82. This was to be achieved both by reducing material costs and by designing for ease of assembly and components compatible across the range.

There were also plans for cost reduction using industrial engineering, improved buying performance, reduction of lead times and optimised quality to reduce time spent in testing, inspection, and rectification.

## 8.3 CHANGES IN BOC ARC EQUIPMENT OVER THE PERIOD 1977-79

The year 1977/78 had been a difficult one for BOC Arc Equipment. It included the opening of the new factory, acquisition of a French company, Societe Nouvelle Socomé, and the adverse effect of the worsening economy on the arc welding equipment market.

Operational problems in the new factory resulted in low volumes of output combined with high overhead costs. In turn, the poor supply of the product caused bad relationships with the sales personnel in gases division, as well as with customers, and a reputation which outlasted the problems.

The French company, S.N.S., manufactured manual arc welding sets, and had been acquired by BOC AE to boost their AC Manual product group. (3.1.2). However, in the period preceding the takeover, the S.N.S. operation had been allowed to run down, and was then at a low ebb with low output, depleted levels of personnel, and poor morale. Attempts to restore S.N.S. to a profitable operating position required a great deal of time and effort from managers of BOC AE, at the expense of managing the UK business.

Effects resulting from these problems, combined with the worsening economy, were evident in the trading figures for 1977/78. Volumes of production had declined by over 20%, and although sales revenue had risen slightly, contribution had fallen and fixed costs had increased. The net result was a trading loss for the business.

During the year a new General Manager had taken over the running of BOC AE. He was an ex-accountant, and had been put in this position in an attempt to bring the financial state of the business under control. In fact, his style of leadership and management was a complete contrast to the previous G.M. whose marketing background had led to the concentration on the strategies of growth and expansion of the business discussed in Chapter Three. (3.1.4).

However, by mid 1978/79 the business was needing vast injections of funds from the parent company. Heavy pressure was put on the management team of BOC AE, including the new general manager, to turn the business around as soon as possible.

The first report issued in June 1978 (Appendix G.1) was of immense benefit to the new G.M., providing him not only with concrete evidence of the major problems with costs of the products, but also some indication of specific areas which required attention. At the same time, the analyses of costs at the factory, breakdown of the product range, etc., all gave him a valuable insight into the business. The findings expressed in this report had an immediate effect on plans, decisions and actions taken by the managers at BOC AE. (12.1).

## 8.4 PLANS FOR STAGE III OF THE PROJECT

The second report to managers at BOC AE, containing results, conclusions, and recommendations from stages I and II of the project, was issued in June 1979. (Appendix G.4).

By this time, the financial situation in the company had become acute. No naturally occurring vacancies were to be filled, and the G.M. was under pressure to reduce his 'head count' still further.

From the company's point of view, the work initially envisaged to form the main part of the project had been completed. Further research on aspects of long term planning in BOC Arc Equipment could not be justified at that time. In order that the project should continue it was essential to find an area of work which would satisfy two criteria. It must help to solve the short term problems of the company, and still be a logical extension from stages I and II.

The answer lay in the different levels of planning. Instead of continuing research at the strategic level, the project could turn to the tactical level of planning. If the next stage of work could help with tactical plans for achieving the recommendations made as a result of phases I and II. (8.1.3), then the above criteria would be fulfilled.

These recommendations were considered in turn:

a) <u>To reduce fixed costs</u>

This was an area where help could be given.

One of the greatest problems for any general manager is the allocation of available resources in order to achieve his plans. In the case of BOC AE, it would have been useful to know in what areas of the business expenditure would result in an overall reduction of unit cost. This would require an understanding of the relationships between fixed costs and total product cost.

b) <u>Reduce the direct cost of the product</u>

As reported in 8.2, programs to reduce the direct costs of the product were already underway, having been prompted by the first report on adverse trends and contributory factors. Further help in this area was felt by BOC AE managers to be outside the scope of the project.

c) <u>Increase volumes of sales with control of fixed costs</u>

Success in this area would depend both on improving the product supply, and on increasing BOC's share of a market for which the overall growth rate was declining.

Efficient and reliable output of the product involved solving the production problems and increasing efficiency in the production area. However, once again the management of BOC AE felt that this would be outside the scope of the project.

Improving market share in a rather slow market would require a much better knowledge of market segments, any where growth was taking place, their requirements, and factors which would influence sales.

Marketing plans would then have to be closely based on this knowledge.

These alternatives led to the consideration of two ways in which the project could offer practical help.

Firstly, it could try to provide a better understanding of fixed costs in the company, and the relationship between expenditure and total product costs. This was done by further analysis of fixed costs, and by talking to department heads about their costs, and how they were affected by the actions of other departments. Whilst not being entirely successful in achieving the objective, this work did result in an extensive list of suggestions for cost reduction. This work formed part of stage III, and is reported in Chapter Nine.

For the second part of stage III, the work of the project assisted with improving the market knowledge of the company, and contributed to the design of realistic marketing plans for achieving the required increase in volumes of sales. This is described in detail in Chapter Ten.

# CHAPTER NINE

## SCHEMES FOR COST REDUCTION

Research undertaken in phases I and II of the project had demonstrated the need for BOC AE to reduce its total unit costs of production. (8.1). The company was recommended to lower its fixed costs, reduce direct costs of the products, and/or to increase volumes of sales with control of associated costs.

Phase III consisted of various contributions to tactical plans for achieving these goals. Work on actual schemes for cost reduction is discussed in this chapter, and research which helped with plans for increasing volumes of sales is reported in Chapter Ten.

The schemes for cost reduction were actually produced as a by-product of an attempt to provide BOC AE managers with more information about relationships between expenditure and costs in their business. Several existing plans for cost reduction would involve expenditure, as in the development of lower cost products. In order to make the best use of available resources, such schemes needed to be evaluated; in some cases relationships between expenditure and ultimate savings were not clear. For example, investment in systems analysis to improve the efficiency of the organisation would be difficult to evaluate.

Further analysis of various categories of costs provided a current picture of the composition of total unit cost, together with historical trends and changes in this mixture. (9.1). This did enable managers to evaluate the direct effects of cost reduction in any department on total unit cost.

In the second part of this work, heads of department and other key personnel in the company were asked to discuss the effect of extra expenditure in their department on unit costs as a whole. In practice, this had to be related to definite schemes for cost reduction. (9.2).

Whilst not being entirely successful in its general objective, the interviews produced a prolific response in terms of ideas and schemes for cost reduction. (Appendix I ). Personnel were usually able to identify relevant costs and savings either in their department or in the direct cost of products. However, few were able to evaluate the effect of such changes on costs of other departments, or on the total unit cost. The reasons for this are discussed in 9.3.

All of the suggestions, together with detailed evaluation of the major schemes and some general comments, were presented to BOC AE managers in a report. (Appendix I ).

Analysis of fixed and total product costs is given in 9.1, an account of the collection and evaluation of cost reduction ideas in 9.2, and a discussion of the conclusions and success of the experiment in 9.3.

## 9.1 ANALYSIS OF FIXED COST EXPENDITURE AND TOTAL UNIT PRODUCT COST, 1965/66 to 1977/78. (Appendix H for details).

The sources of data, and adjustments necessary to make categories of costs consistent over the period in question, were those used in previous work, described in 5.1.2 and Appendix C.3. Data for 1977/78 was adjusted in the same way. (H.1).

Although categories of fixed costs used in trading accounts had changed over the years, in each year they could be allocated into five main types:

a) Manufacturing and distribution costs, including factory fixed costs, operations, and carriage costs.

b) Marketing costs, including export and warranty costs. Compensation was made for transfer of the selling function and associated costs to gases division, in 1974. (Appendix C.3.2.3(f) for details).

c) Publicity

d) Research and development (R&D)

e) Other costs, mainly administration, including data processing and corporate planning.

The proportion which each of these formed of the total trading costs of the business is shown in Table 9.1 and in graph 9.1. These were tested for any significant trend over the period, using techniques of linear regression. (H.2).

Results showed that there had been significant changes in the composition of total costs, and hence in total unit product cost, over the period 1965/66 to 1977/78. (H.3).

The proportion formed by direct cost (average 59%), had not signficantly changed, - although it did appear to have increased since 1968.

The fixed cost element had changed, with more being spent on administration, less on manufacturing costs, and far less on research and development.

Between 1965/66 and 1971/72, the main changes consisted of an increase in the proportion spent on marketing costs, and a decline in that spent on research and development. These trends were possibly consistent with the facts that the product was established but the market still growing.

Since 1971/72 however, the increase had been in the proportion spent on administrative costs, with a corresponding decline in proportion spent on manufacturing and marketing, with an even further decline in that spent on R & D.

Between 1972 and 1977/78, expenditure on administration increased from 3% to 9% of total costs, forming 25% of all fixed costs.

These results indicate that the allocation of resources in administration should be critically examined. At the same time there should be an evaluation of possible benefits to be gained from increasing resources in the other areas, particularly in manufacturing and R & D.

This broad analysis of fixed costs was followed by examination of costs, and ideas for cost reduction, at departmental level.

## 9.2 SURVEY OF DEPARTMENTAL COSTS AND IDEAS FOR COST REDUCTION

The aim of the survey was to contribute to plans for cost reduction in two ways:

a) To provide managers with a better understanding of the relationships between expenditure and costs in the company.

b) To collect and evaluate suggestions for ways in which costs may be reduced.

The survey consisted of the collection and compilation of information and ideas from key personnel in BOC Arc Equipment. The methods used are briefly indicated in 9.2.1.

As has already been mentioned, the results did not contribute greatly towards an understanding of the relationships between expenditure and costs, for reasons discussed in 9.3.

The collated ideas for cost reduction, together with evaluation of some of the major suggestions, are reviewed in 9.2.2.

However, the interviews also produced a great deal of information on the organisation of the company, which prompted several observations on reasons for its current problems. These are discussed in 9.2.3.

### 9.2.1 Methods used in conducting the survey.

By the time that the survey took place, in March 1979, the financial situation in the company, and the policy of non-reappointment of personnel (8.3.4) had combined to put pressure on remaining members. They were required to improve the efficiency of their operation, frequently with less staff or resources at their disposal.

For this reason, the interviews were designed to obtain the maximum co-operation from personnel, and to make the most efficient use of available time.

Each interview began with a summary of the results of the project indicating the adverse trends in the company, and the targets for unit cost reduction required by current strategic plans. (8.2). This provided an introduction to the objectives of the survey, aroused the interest and sympathy of the person being interviewed, and also spread the urgency of the need for cost reduction throughout the company.

The main part of the interview, although informal, was structured with a list of questions. These requested the main function of their department (or section), links with other departments and how successful these were, and any current plans for cost reduction. Participants were then asked for any ideas for improving the efficiency of the current operation, and to estimate the effect of changes on the costs of all departments involved. Finally, they were invited to give any ideas for cost reduction by changes in their department, other departments, or in any other way.

### 9.2.2 Ideas for cost reduction

One hundred and ninety-four different ideas were put forward, ranging from closing down the factory to replacing china with paper cups to improve efficiency on the trolley round. (Appendix I).

The ones selected for detailed evaluation were those which would make a major impact on the company and its costs. Remaining ideas were listed at the end of the report. (Appendix I).

Suggestions fell into five main categories:

a) Combining all departments of BOC AE onto one geographical site.

This was the most common suggestion; the site to be retained varied according to the location of the contributor.

At that time, the departments of the company were spread between sites in Milton Keynes and Ramsgate. (2.3.3). It was evident from peoples' comments that combining these functions onto one site would make improvements in many aspects of the business.

One obvious saving would result from eliminating current duplication of functions such as buying, supply, test and inspection, despatch and warehousing, accounts and personnel.

Avoiding the need for communication between the sites would affect the costs of telephones, telex, postage etc. More importantly, it would reduce delays, misunderstandings, and a lack of cohesion between different departments. For example, product quality should improve from the closer links between inspection and rectification, and production, which were then on different sites.

Improved liaison between product development and design should ultimately increase production efficiency.

Further cost saving should result from the reduction in transport requirements, in loading and unloading, and in the risk of transit damage.

Lastly, the opportunity could be taken to strengthen management of the production function. These and other improvements should improve product supply, with resulting benefits to relations with sales personnel and customers.

The scheme was evaluated with respect to these potential benefits, and the costs associated with moving onto one site, either at Milton Keynes or at Thanet. (Appendix I, 1 & 2). This came out in favour of the Milton

Keynes site, where savings of over £300K p.a. were estimated for the long term.

However, since the evaluation included many subjective judgements on possible disruption to sales, product development etc., it was intended to be used as an example of the type of calculations which should be done as a basis for making the decision.

b) <u>Product design</u>

There were two important suggestions concerning the design of the product. One related to the current program for developing new low-cost products, and the other to cost reduction on existing products.

The progress of the development program was being affected by the current restriction of resources. It was suggested by the technical department that recruitment to the original or slightly revised plans would produce a net saving by 1981. (See Appendix I, 6, assumptions (c) & (d)). Continuation with current resources would result in a delay in the introduction of new products, and no savings by 1981 (assumption (a)). A 10% reduction in resources would result in the additional loss of income due to the need to curtail work being done for another BOC company, (assumption (b)).

A further suggestion concerned the implementation of the many ideas for cost reduction to existing products. There was an existing system for dealing with these ideas, but they rarely survived the second stage, that of detailed evaluation. This was apparently partly due to lack of time available for the evaluation, and partly to a lack of confidence in the ability of the production department to cope with changes. Personnel in both technical and industrial engineering departments thought that effective implementation of these ideas could result in considerable savings in the direct cost of existing products. (I.7).

c) Organisation of the company

There were many complaints about the organisation of the company, concerning its use of personnel, systems and communications.

The definition of areas of responsibility had become blurred, with a resulting general lack of implementation of agreed actions, duplication of activities throughout the company, and in some cases, a considerable lack of co-operation between departments.

Solution of these problems could produce an estimated 5% increase in productivity. (I.6).

Systems, both at Milton Keynes and Thanet required a complete overhaul. The main faults were an excessive flow of paperwork, duplication of manual and computer systems, computer reports which were not used or did not supply information in the right form, and a lack of information for management control.

An estimated potential saving of 10% of administrative personnel and salareies could result from improvements to these systems. (I.9(b) and 10).

d) Production

Suggestions for improving the efficiency of the production department mainly concerned the systems.

They covered an improved production control and scheduling system (I.9(a)), a stock policy system and supplier analysis to aid buying efficiency (I.11), and the introduction of a BRISH system for part numbering, to help in the standardisation of components. (I.12).

e) <u>Other</u>

Other major ideas not falling into any of the above categories, were as follows:

i) Buy machine tools for the special products department to increase productivity (I.13).

ii) Stop paying commission to defunct export commission agents (I.14).

iii) Increased clerical assistance to give key personnel time to investigate and implement ideas for cost reduction (I.15 & 16).

iv) The setting up of an in house packing function with ultimate savings in packing changes (I.18).

v) Abandoning the added value scheme which takes up a lot of the financial accountant's time.

vi) Tightening up on control of post, use of telephones etc.

vii) Shipping to Europe direct from Thanet (I.21).

Further ideas which have not been evaluated due either to lack of time or to difficulties in obtaining estimates were given at the end of Appendix I, in order that they may be available for use at a future date.

The frequency and generality of many of the comments prompts the following observations on the current problems of the company.

### 9.2.3 Observations on the problems of the company

The company appeared to have major problems in their ability to get things done, particularly if it involved any type of change. This resulted in unreliable product supply, with adverse effects on relations with customers and sales force. Through the ineffective use of resources, the general inefficiency also contributed to the lack of cost reduction.

Various reasons for this state of affairs were made apparent from a consensus of opinion throughout the organisation. The underlying inadequacies, together with recommendations for their rectification, fall into four main categories:

a) Production inefficiency

Monthly production schedules in the factory were rarely completed within the time scale; estimates of the average percentage completion rate vary from 50-70%. The main causes for this inefficiency were given as archaic production methods, poor labour relations, an inadequate ordering system and no stock control system. Other contributory factors were the wide range of products with little compatibility between components, designs using components with unique suppliers, and the continued production of older models in very small quantities.

Recommendations

It is evident that the whole production system should be examined and overhauled; suggestions made in 9.2.2(d) only cover a part of the problem.

b) Communication

Communication between departments, and between different levels in the management structure was generally bad. The rather complicated hierarchy involved 3-4 levels of managers and was structured by the six main functions, subdivided into departments. Since information did not pass down the vertical lines in the structure and there were no links between departments at lower levels, personnel at these levels did not know how their own tasks, let alone those of people in other departments, fitted into the overall plan.

The effects could be seen in a lack of co-operation between departments, typified by hoarding of information, uninformed decision making, lack of motivation or any intention to implement agreed actions, and low morale in general.

Recommendations

Communication should be much more open; the departmental structure should be examined and possibly revised to include more lateral relations.

c) Accountability and control

The lack of accountability and control was probably the most important factor in the failure of the company to implement action plans. The most widely quoted example of this organisational weakness was in the continual failure to complete plans for bringing out new products within the given time scale. Time and time again pre-arranged promotional launches for new products took place, and the new model would not yet be in production.

Recommendation

Areas of responsibility must be clearly defined, including delineation of responsibility for specific actions. There should be well-defined systems for accountability with time scales.

Criteria for monitoring the progress of any plan must be specified at the outset, and progress regularly reviewed. A better information system would help in the monitoring and control of plans.

d) Liaison between design and production departments

Although already mentioned under (b) above, this particular link was so important as to merit special attention.

One of the main recommendations from previous work was that the unit cost of the product be reduced. This should involve consideration of materials and labour costs, compatibility of components throughout the range, the efficiency and flexibility of purchase of components, and the suitability of the design to production methods and facilities. Resulting improvements would affect not only the direct cost of the product, but costs of stock, WIP, factory overheads and so on.

For this reason, liaison between the development and design departments on one hand, and industrial engineering and production department on the other was of utmost importance. This had to be promoted and encouraged, partly by closing the geographical distance between them.

## 9.3 CONCLUSIONS

The conclusions concerning the plans for cost reduction in the company are discussed in 9.3.1, and the success of the attempt to learn more about the relationship between costs in the company, in 9.3.2.

### 9.3.1 Plans for effective cost reduction

The analysis of unit costs suggested that, since direct costs per unit and administrative costs had increased, whilst expenditure on marketing and research and development had declined, the allocation of resources between the various functions should be examined.

This was very difficult to do in a general way, since relationships between expenditure on different categories of fixed cost, and the unit cost of the product were not known.

However, the various schemes for cost reduction arising from the survey fitted in with these general suggestions very well. They indicated that the main areas for potential cost reduction were in the direct cost of the product, and in the organisation of the company.

Long term plans for developing new low cost products required further investments in order to achieve net savings by 1981. Short term plans for implementing the many suggestions for reducing the costs of current products would produce immediate savings with minimal investment.

At that time, the organisation of the company was fraught with problems which formed the subject of many suggestions to reduce costs.

Reducing the company to one site would have an enormous impact on administrative and other costs, by avoiding duplication of effort and problems of communication and liaison between the sides.

Other suggestions concerned improving the efficiency of the company by changing its structure and systems. The resulting effect on productivity, effective implementation if plans and utilisation of effort would again provide potential for extensive cost reduction.

Although the evaluation of the suggestions was made very quickly, and may have over emphasised certain assumptions and effect of changes, it was evident that there was sufficient potential in these ideas to reduce unit product cost by the required amount.

However, there was one overwhelming problem. Apart from the current development program for low cost products, all the other cost reduction schemes require changes, and hence the capacity to plan and implement change. It has already been pointed out that this capability is one of the weaknesses of the company. (9.2.3).

Thus, the capability of the company to solve its own problems was greatly in doubt.

### 9.3.2 The attempt to investigate relationships between costs in BOC Arc Equipment

Although certain conclusions could be drawn from the analysis of the historical composition of unit costs (9.3.1), it was not possible to provide any further understanding of the relationship between expenditure on fixed costs and total unit product cost, for two main reasons.

Firstly, modelling of these relationships was not possible in the short time available, and probably would have required a longer run of data to give significant results.

Secondly, personnel in BOC AE were unable to estimate the effects of changes in their department or other departments, and vice versa.

This was due partly to lack of knowledge, and partly to lack of concern. It was evident that departmental personnel had little inkling of the impact of actions which were under their control on other remote departments, or on the general efficiency of the company. This parochial outlook was reinforced by the budget system which gave motivation to heads of departments to make their budgets, irrespective of the effect on costs of other departments or total product costs.

### 9.3.3 Presentation of results and plans for future work

The ideas for cost reduction were presented to the managers of BOC AE in a report (Appendix I). They agreed that schemes involving major changes would obviously require further evaluation both by the operating company and by BOC Ltd.

Selection and implementation of the more minor ideas was considered to be the prerogative of line managers.

Consequently, it was left to the company to incorporate these suggestions into plans to reduce costs.

At this time, the opportunity arose for the project to assist in marketing plans for increasing volumes of sales. A market survey had been commissioned, and initial results were already arriving in the marketing department. Help was required in analysing these results in the most effective way.

At the next project meeting, it was decided that research to assist in the production of a realistic and achievable marketing plan would be the most useful work for the remainder of the project.

The various pieces of research which contributed to the marketing plan are discussed in Chapter Ten.

# CHAPTER TEN

## PLANS FOR INCREASING VOLUMES OF SALES FOR BOC ARC EQUIPMENT

The major conclusion arising from the work carried out in stages I and II of the project was that survival of the business would depend on control of unit costs, in order to restore satisfactory profit levels. The company was recommended to reduce the direct cost of manufacture, reduce overhead costs, and increase volumes of sales with control of both fixed and direct costs. (8.1).

In stage III, the project assisted with plans for achieving two of these goals. One part of the research produced a list of ideas for cost reduction, reviewed in Chapter Nine. This chapter reports on ways in which the project helped the company with marketing plans for increasing volumes of sales.

The general approach and definition of the problems involved is discussed in 10.1, and subsequent stages in the work briefly reviewed in 10.2, 10.3 and 10.4. Results from most of the research carried out at this stage were included in a comprehensive report which contained recommendations for ways in which BOC AE could increase its volumes of sales. (Appendix L, Market Survey Report). Implementation of these recommendations, either as direct actions or in marketing and strategic plans, is reviewed in 10.5, with discussion of these plans in 10.6.

### 10.1 DEFINITION OF THE PROBLEM AND STRUCTURE OF THE APPROACH

In order to achieve an increase in volume of sales over and above the market growth rate, in a market fairly mature and already saturated, BOC AE would have to increase its market share. This would require knowledge of the market, its structure, its major suppliers and the factors which influence purchase of arc welding sets. Moreover, such a plan would have to be carefully evaluated in terms of increased revenue, costs, and hence profits, using projections of annual volumes of sales. These would need estimates of market size, current BOC market share, and trends in shares held by the major suppliers.

Previous plans prepared by the company had been based on perceptions of the market and its requirements. Planners had considered the technical specification of the product to be the most important factor, and BOC AE to be market and technological leaders, with market share of approximately 40% in the UK. They priced in the upper quartile and expected the other major suppliers to follow their lead in price rises. (2.3.1). However, there was no factual basis for these perceptions, and the planners had begun to question the accuracy both of market share estimates and of the requirements of the market.

In order to fill some of the gaps in their knowledge, the company had commissioned a survey of the UK arc welding equipment market. The results consisted of a great amount of widely varied information on the MIG, TIG and MMA (manual welding) market in the UK. Although some work had already been done, the main bulk of data required analysing in a firmly structured way, to provide the company with the maximum benefit from the information supplied.

The main contribution of the project was in the structuring and carrying out of the analysis of this data, together with some additional research needed for incorporation of the results into the marketing plans. Extracts from the Market Survey report are included in Appendix L.

Previous marketing plans had all been based on the assumption that the welding rectifier was the main product of the company, and that an increase in volumes of sales of the rectifier should significantly improve the levels of contribution. Although the market survey had actually been designed around this assumption, its validity was critical; if the rectifier was not the main provider of contribution, plans to increase volumes of sales may not have the desired effect on contributions and hence on profits. For this reason, the first piece of work consisted of analysis to determine which product ranked highest in providing contribution, and whether the majority of rectifiers fell into this category. (10.2).

Having established that the rectifier, together with associated equipment essential for its use, was a major provider of contribution, the next stage was to find opportunities to increase the volumes of sales of this product by BOC AE. Analysis of the market survey data was structured to find the sectors with higher than average growth rates in each of the MIG, TIG and MMA markets. It also identified the requirements of these sectors in terms of product requirements, attributes and price of the product, routes to the market and so on. Opportunities for BOC AE to increase volumes of sales in these growth sectors could then be assessed on the basis of the company's ability to meet the customer's requirements. (10.3).

However, plans based on these findings had also to consider whether growth in these sectors was likely to continue, and evaluation of the plans requires estimated of projected annual volumes of sales.

For this reason, the third piece of work consisted of an investigation into possible future trends in the industries using arc welding, and the resulting effect on the future of the arc welding equipment markets. This was used to make projections of annual volumes of sales of MIG and TIG sets, for 1979-84, both for the total market and for BOC sales, assuming that current BOC shares in each sector remained unchanged. The results provided a base line of data for evaluating any plans involving a change in BOC's market share in these markets.

Unfortunately, there was not time for the detailed evaluation of plans to be included in the scope of the project work; the only contribution in this area was in the evaluation of the current market for MIG, TIG and MMA (in 1979), a short account of which is included in part three. (10.4).

This completed the analytical work contributing to the marketing plans. The incorporation of results into both marketing and strategic plans is discussed in 10.5.

## 10.2 ANALYSIS OF CONTRIBUTION BY PRODUCT FOR THE FINANCIAL YEAR 1977/78

Once again discrepancies were found between data produced from differing sources, particularly with respect to figures for volumes of sales. (Appendix J.1). The most accurate source for information on sales was taken to be computer tabulations produced from invoiced sales. These were used to analyse contribution (sales revenue less direct costs) provided by the top ten items in each of the MIG and TIG product groups, the top ten rectifiers including MIG and TIG, and top ten MIG and TIG items for home and export sales taken separately.

Results from this exercise confirmed that items in the MIG and TIG product groups which brought in the most contribution were in fact the ten most popular rectifiers (five MIG, five TIG), plus necessary accessories such as wire feed units, torches, flowmeters etc. Together, the top ten items from each of the MIG and TIG ranges provided almost 40% of total business contribution. These results may be summarised in the following table.

| | MIG | TIG | TOTAL |
|---|---|---|---|
| Rectifiers (5 MIG, 5 TIG) | 8% | 15% | 23% |
| Other items( " ) | 10% | 6% | 16% |
| Total | 18% | 21% | 39% |

There were however a few surprises from the analyses, such as finding that four TIG products considered to be an important part of the TIG range in fact provided only 1% of total contribution between them. (Table J.12, Appendix J.). In addition, it was noted that MIG and TIG products together provided 58% of total business contribution. Since approximately 85% of this was estimated (by the product manager) to come from manufactured products, these produced only 51% of total contribution.

The conclusion was that sales of rectifiers and accessories did provide a significant amount of contribution, and so plans to increase volumes of sales of rectifiers should increase levels of contribution. As long as overhead costs were controlled, this in turn should improve the profitability of the business. However, in view of the fact that manufactured products provide only approximately half of total contribution, it may be that plans for increasing profits should not concentrate solely on this business area.

## 10.3 ANALYSIS OF UK ARC EQUIPMENT MARKET SURVEY DATA

The survey was commissioned by BOC Arc Equipment in October 1979, with the following objectives:

a) To find the size of the UK arc welding equipment market in volume terms for each of MIG, TIG and MMA welding sets.

b) To segment the market by industrial sector and type of company, and to estimate the growth in ownership of sets in each sector.

c) Identify major suppliers and their market shares.

d) Investigate customer attitudes to distribution methods and their reasons for choice of equipment.

The survey was designed by Ken Wilson of the BOC Marketing and Market Research department, in close collaboration with the marketing department at BOC AE. The population consisted of all of the 92,000 establishments engaged in manufacture of any type, transport, general construction, mines and quarries and larger farms of over 500 acres. Establishments were grouped by size, and the sample size varied with the size of the establishment to avoid bias. This resulted in a total of 1,450 establishments being sampled, mainly by telephone interview.

Interviews were carried out between January and April 1979, and, by the time that the survey came into the scope of the project, results had been coded and initial tabulations of data produced by computer.

Estimations of the size and structure of the MIG, TIG and MMA market had already been published in an interim report.

However, this left a large quantity of widely varied information still to be analysed. The main problem lay in finding the best way to structure the analyses in order to best satisfy the above objectives, and provide a basis of information for marketing plans to increase volumes of sales. After consultation with the marketing manager from BOC AE and with the organisers of the survey, it was decided that analyses must be designed to identify the following:

i) Industrial sectors where growth in acquisition of MIG, TIG or MMA sets was higher than average.

ii) The requirements of these sectors in terms of products, routes to the market, after sales service etc.

iii) Market shares held by BOC and major competitors in each sector, with any trends in size of share.

iv) Characteristics of major competitors in terms of product range, routes to the market etc.

Since BOC had only a limited interest in the MMA market, MMA data was not analysed so fully as that for the MIG and TIG markets.

For details of the methods used in analysis of data, see Appendix L.l. Before beginning the analyses, however, it was essential that the data be validated in some way in order that the conclusions drawn from the results of the survey should have credibility both for the company and for the sales team.

### 10.3.1 Validation of the data

The most important data arising from the survey concerned the size of the market. Annual volumes of sales could be estimated from the number of sets of a certain age, as long as this was within the average life of the set.

BOC AE provided the only source of reliable data with which to check the validity of these results. Annual volumes of sales for BOC, estimated from survey data, were compared with the annual volumes of production for the same years, using data obtained from previous work. (Appendix K).

The results were reassuring. With adjustments for differences in the bases of the sets of data being compared, the number of sets from each source were approximately of the same order. In the case of MIG, the average absolute percentage difference was 20% over the last 7 years, but only 10% if differences were summed and then averaged. (See Appendix K for details). Comparison of the TIG data was a little more difficult in that the market survey data included add-on units and excluded DC Manual sets, whereas BOC AE data did the reverse. With adjustment for these differences, the average absolute percentage difference over the last 7 years was 23%, and 11.4% if differences were summed and then averaged.

At a later stage of the work the markets were valued using estimates of market size from the survey. The value of BOC's share of the market estimated in this way corresponded well with their actual revenue from the MIG, TIG and MMA markets. (Appendix L.5).

10.3.2 Results and conclusions

Initial analyses carried out by the BOC Market Research analyst had produced estimates of current volumes growth rate for the MIG, TIG, and MMA markets of 13% p.a., 8% p.a. and 4% p.a. respectively. The higher growth rates in the MIG and TIG sectors were thought to be due to the process change which had been taking place. The older manual metal arc welding process was being replaced by MIG, and to a lesser extent, TIG welding, each of which had advantages over MMA for different applications. (2.2.2).

BOC market share in each of these markets had declined, particularly in MMA and TIG. The company's share of the MMA market had fallen from an estimated 28% to 16% over the previous ten years, and from 44% to 35% of the TIG market. BOC share of the MIG market also showed a slight decline, from 24% to 22%, but this was probably not significant relative to the accuracy of the data. (Appendix L.2).

Even these rather depressing figures did not represent the full situation. Further analyses carried out as part of project work showed that growth sectors in both the MIG and TIG markets were composed of the smaller fabrication or engineering shop, particularly those with less than one hundred employees. In these sectors, purchases were made mainly from distributors, with choice of set depending chiefly on price, followed by performance and reliability, and, in the case of TIG, the size and weight of the set. Generally sets were in the lower amp ranges of 200-400 A. (Appendix L.3.1.1 and 3.1.2). But BOC had only relatively small proportions of sales in these sectors, particularly in MIG; the overall BOC market share figures were due to the company's large share of the sector formed by the larger fabrication and engineering establishments. These sectors were now mature, with process change almost complete, and low growth rates in demand for sets. In their marketing policies, it was the requirements of these sectors to which BOC catered, by developing larger and more complex welding sets, selling directly to the customer, and relying on brand loyalty and after sales service.

As far as the MMA market was concerned, growth sectors were represented by demand from builders, non-metal manufacturers and transport operators. In general, they required small AC sets of under 200A, bought from distributors, and chose the particular brand on the basis of price followed by size and weight of the set, although some required high standards of performance and specification. (Appendix L.3.1.3).

These results, together with some of the more detailed analyses described in the report were used to make recommendations for ways in which BOC AE could increase its volume of sales.

### 10.3.3 Recommendations

These may be summarised as follows (see Appendix L.3 for details).

a) Immediate opportunities for increasing volumes of sales lay in the growing demand for both MIG and TIG sets by small companies engaged in metal fabrication and engineering. BOC AE could offer the TM 225 and TM 350 for MIG welding, and the AC/DC 375 for TIG, with the new TT DC 180 to be ready shortly. However, they would have to change their marketing tactics by selling through distributors, ensuring that sets were widely and readily available, and offering them at competitive prices.

There was some opportunity for the company to increase its volumes of sales in the MMA market, to customers requiring sets in the middle amp ranges, but they could not take advantage of the growing demand for a small reliable AC set since they did not have a suitable product. Again they would have to sell through distributors and would have difficulty in overcoming their reputation for unreliable sets.

b) In the longer term, BOC AE would only be able to take full advantage of the growth sectors in the market if they developed simpler less sophisticated products. As well as satisfying the product requirement of these sectors, less complicated designs should be less costly to produce, and therefore more competitive on price, have improved reliability and ease of after sales service. In particular they needed a reasonably priced DC TIG set in the 200-299 amp range.

c) There were potential opportunities for increasing sales of TIG and MMA sets to growth sectors of the market, but this would require development of a new range of low cost, reliable, small and lightweight sets, in the lower amp ranges for the MMA market and higher amp ranges for the TIG market.

This would appear to be outside the scope of current marketing activities for the company, but may be considered for future development.

The work reported above identified opportunities for BOC AE to increase its volumes of sales. Before incorporating recommendations into actual plans, it was necessary to investigate trends in the arc welding equipment market, in order to be able to judge whether historical trends would continue in the future.

## 10.4 FORECASTS FOR MIG AND TIG MARKETS, 1979-84
(Appendix L.4)

Since most of the opportunities for BOC to increase their volume of sales lay in growth sectors in the MIG and TIG markets, the investigation concentrated on these.

### 10.4.1 An outline of the approach used to make the forecasts

Future growth would depend partly on growth in the consumer industries and partly on the rate of process change from MMA to MIG and TIG welding. The amount of process change would itself depend on changes in technology, use of different materials, different metals and thicknesses of metals, all of which would affect the type of welding required to make joins.

An investigation of historical growth, forecasts of future growth, and the likelihood of process change in the consumer industries were used to project annual growth rates for volume sales of MIG and TIG sets in the corresponding sectors.

These figures formed the basis for forecasts of annual volumes of sales in the MIG and TIG markets, and so, using estimates of current BOC market share in each sector, of annual volumes of sales for BOC, for the period 1979-84.

This work was done in conjunction with the BOC Marketing and Market Research department, who supplied much of the information on trends in process change and use of different metals and thicknesses of metals in the consumer industries.

For details of methods and results see Appendix L.4.

### 10.4.2 Summary of results

In general, the MIG market was expected to be affected by the economic recession until 1981, producing low volume growth rates of 5-6%. Predicted improvement in consumer industries over the period 1982-84 was expected to result in a gradual increase in sales of MIG sets, such that volume growth would reach 10% p.a. by 1984. Growth in demand was expected to be particularly high from manufacturers of agricultural equipment, process plant and mechanical machines.

Since BOC shares of MIG market sectors tended to be higher in lower growth sectors, and low in high growth sectors, their overall share of the MIG market was predicted to decline slightly, from 20% in 1979 to 19% by 1983/84, on the basis of constant shares of each sector.

The TIG market was expected to benefit from further process change to TIG welding, on the basis that the future need to reduce steel consumption would result in a combination of reduced thickness of metal with more use of high alloy steel. Both of these applications require the TIG process for welding. As a result, annual growth rates for the TIG market were predicted to increase from the current low level of 5% p.a. (1979), to reach 10% p.a. by 1983/84. Particular growth in demand was expected in the sheetmetal work and subcontract sectors, since their share of available work should increase during a recession. Projections for BOC share of the total TIG market based on constant shares in each sector resulted in a slight increase of share from 36% in 1979 to 39% in 1983/84.

These projections gave a base line of data for the size of the MIG and TIG markets over the period 1979-84, and volumes of sales which may be expected by BOC AE if market shares in each sector remained constant. Any plans to increase BOC share in any sector of the MIG and TIG markets could then be evaluated in terms of increased revenue, costs, and profits.

The first step in this process was to estimate the value of the current market; results were presented in Appendix C of the Market Survey Report. This exercise provided an additional check on the validity of the market survey data, since estimated value and estimated BOC market share could be used to give estimated current revenue for BOC AE. This was found to tally fairly well with actual revenue. (Appendix L.5).

## 10.5 IMPLEMENTATION OF RECOMMENDATIONS

At intervals during the course of this part of the project, results were discussed at meetings between the BOC AE marketing manager, Ken Wilson from the BOC Marketing and Market Research Department, and the author. In particular, any implications for marketing plans and tactics were discussed in detail. As a result, some of the recommendations were implemented immediately (10.5.1), whilst others were incorporated into strategic, marketing or sales plans (10.5.2).

Results from all of the analyses were compiled into a report, with an executive summary containing major conclusions and recommendations. (Market Survey Report).

### 10.5.1 Direct action resulting from the recommendations

Two of the recommendations concerned the route to the market and revision of the product range to meet the requirements of growth sectors in the MIG and TIG markets. (10.3.3(a) and (b)). Immediate action was taken on the basis of these recommendations.

Firstly, the requirement for increasing sales through distributors was communicated to marketing personnel in BOC gases division, who were also responsible for sales of arc welding equipment. They responded with a change of policy; by introducing a new discount policy they made it more advantageous for the BOC sales force to sell through distributors.

Secondly, immediate plans were made to revise the product range in the light of market requirements. During October and November 1979, the author took part in a series of meetings designed to overhaul the MIG and TIG product ranges.

### 10.5.2 Incorporation of results into strategic, marketing, and sales plans

The improved knowledge of the market, together with recommendations reviewed above (10.3.3) were used at three levels of planning, in strategic plans for BOC AE 1980-84, in marketing plans containing tactics for achieving market share objectives, and in the sales plan, the plan of action for the sales force.

In strategic plans for 1980/84, the main objective was to produce profits (instead of losses) within three years. One of the means by which this was to be achieved was a planned increase in market share in each of the MIG, TIG and MMA markets, so that overall BOC share reached 40% by 1982/83. These objectives were quantified for each year of the plan, using projections for MIG and TIG markets 1979/84 (10.4). The MMA market volumes were projected using a constant market growth rate of 4% p.a. Strategic plans could then be evaluated using projected volume of sales for BOC AE to estimate revenue, costs, and profits.

Tactics for achieving these market share objectives were proposed in the marketing plan. These were mainly based on results of the market survey, with plans to rationalise the product range to meet market requirements, improve product supply, adopt an aggressive pricing policy, and improve after sales service. The only part of the plan not based on the survey concerned improvements in product and training support for salesmen and potential customers.

The sales plan instructed the sales force on the growth sectors of the market, distinguishing between direct and distributor markets. Tactics for improving distributor sales included increased training support, promotional leaflets, wall charts etc. The sales force were given targets and pricing guidelines for more aggressive pricing.

## 10.6 DISCUSSION

This concluded the contributions made by the project to the company's plans for increasing volumes of sales, in which identification of growth sectors and their requirements were used to recommend marketing and sales tactics for increasing sales in these sectors. (10.3.3).

These results and recommendations were incorporated into strategic plans designed to achieve a market share of 40% by 1983/84. However it must be noted that these market share objectives were very ambitious, requiring BOC shares of the MIG and MMA markets to be almost doubled by 1983/84, with a slight increase in the TIG share.

This would need not only a realistic marketing plan and sales tactics tailored to the requirements of the market, but also the ability to successfully implement the plan. The company must be able to improve the supply of the products in order to make them easily available, to direct the sales force to take advantage of the opportunities in the growth sectors, to reduce product costs so that prices may be reduced to a competitive level, and to ensure the reliability of the product and of the after sales service.

In addition, as noted in the original broad recommendation, it was essential that increases in volumes of sales be achieved with control of fixed costs, otherwise the results may not be a net increase in profits.

Whether the company is capable of achieving these goals remains to be seen. Further discussion of the success of these plans, and the future of the company, will take place in Chapter 12.

# CHAPTER ELEVEN

## IMPLICATIONS AND RECOMMENDATIONS FOR PLANNING IN BOC ARC EQUIPMENT

Contributions to the company's marketing and sales plans for 1980/84 were completed in January 1980, and formed the final work to be done interactively with the management team of BOC Arc Equipment.

The original brief for the project was to investigate the validity of the planning model being used in the strategic planning of the company's business. (1.2). Initial analyses led to identification of various problems concerning not only the validity of the model, but also the ways in which it was being applied, and the overall effectiveness of planning based on this model. Since solution of these problems was crucial for the survival of the business, the project became involved with the ways in which they could be solved. This part of the work led to specific recommendations and help with short term plans. Results from this work are briefly reviewed in 11.1.

Once contributions to short term plans were completed, the opportunity could be taken to review long term planning in the company, to consider the success of methods used in the past, and make recommendations for the future. Implications for long term planning in BOC Arc Equipment are discussed in 11.2, and a general comment made in 11.3.

### 11.1 REVIEW OF CONTRIBUTIONS TO SHORT TERM PLANS

Phase I of the project was designed to investigate the validity of the experience curve as a planning model for BOC AE. During this work, analyses of costs and prices over the period 1965-77 produced evidence of adverse trends which, if allowed to continue, would affect the future profitability of the business. In constant value terms, the average price of a rectifier was declining at a faster rate than the total unit cost. As a result, the true value of the profit margin per unit was also declining, at a rate of 5% per year. (5.3(a)). When costs were broken down into direct and fixed components, it was evident that the direct cost of the product had not declined over this period, but had in fact increased since 1968/69. (5.3 (d)).

The initial report on this work (Appendix G.1), whilst giving the results of fitting experience curve models to this data, pointed out the implications of these trends, and recommended further investigation of production costs and the associated efficiency of production.

As a part of phase II, this recommendation was carried out, and specific areas for concern were identified. Research into the causes of increasing production costs isolated the main contributory factors. The increasing complexity and sophistication of the products, an increase in scale of operation not accompanied by a corresponding increase in volumes of output, and overall inefficiency in production indicated that management effort should be concentrated on these areas. (7.3).

The other part of phase II consisted of research in which different models for unit cost and average price were compared across a range of countries and industries. (Chapter Six). In reporting on this work to BOC AE management, conclusions on choice of a planning model could not be stated without reference to the problem which was more crucial in the short term. Survival of the company would depend on control and monitoring of unit costs. The choice of model for long term planning was insignificant compared with the consequences which would ensue if unit costs were not reduced. Although obvious, the main alternatives had to be stated. The company had either to reduce fixed costs, successfully implement plans to reduce the direct cost of the product, or increase volumes of sales with control of fixed costs. (Appendix G.2, 6.10-6.12).

These alternative options were not mutually exclusive, and in the third phase of the project, help was given with plans for achieving two of these objectives.

Suggestions for cost reduction were collected from key personnel in BOC AE, and formed into specific schemes. (Ch.9). Although the many ideas given covered all aspects of the business, the most common could be grouped into four major categores:

a) Combining all departments and functions of the company onto one site. Savings would be both direct, by eliminating duplication of functions, transport and communication between sites etc., and indirect from improvement in efficiency, liaison between departments, and strengthening management of the production operation. (9.2.2 (a)).

b) Product design for reduced cost, both in the existing product range and in future development. (9.2.2 (b)).

c) Restructuring the organisation of the company to clarify areas of responsibility and accountability, and so improve its ability to implement plans. (9.2.2 (c)).

d) Suggestions for improving the production operation to increase its efficiency and ability to manufacture to plan. (9.2.2 (d)).

The other part of the research in this phase contributed to marketing and sales plans for increasing volumes of sales. (Ch.10). Results from a market survey were used to recommend specific tactics for gaining market share in the sectors formed by smaller companies engaged in metal fabrication and engineering. (10.3.3). Historically, BOC AE had concentrated their marketing effort on the larger companies and the heavier type of welding application, but these were no longer the growth sectors of the industry. In order to sell to the smaller user, the company would have to change its routes to the market, and be far more competitive on price. (10.3.3). Although some of the current product range was suitable for these markets, long term plans for development should concentrate on simpler designs which would be less costly to produce, and so compete with the cheaper products of competitors. Assistance was given also in an exercise to evaluate the effects of planned increases in sales on projected revenue, costs and profit levels in the strategic plan. (10.4).

This summarises the interactive part of the project. This part was concerned with providing solutions to problems identified during the initial phase as being of crucial importance for the survival of the company. The effect of this work on planning in BOC AE is discussed in Chapter Twelve. (12.1 and 12.2).

Results from all of the research were then used as a basis for reviewing the approach to long term planning in BOC AE.

## 11.2 LONG TERM PLANNING IN BOC ARC EQUIPMENT

Over the period 1972-77, long term planning in the company had not been a success. There was no evidence of an increase in market share over this period, but rather of a continuation in the long term decline in share shown in the market survey. (10.3.2). A gradual decline in profit levels eventually turned into a trading loss in 1977/78. (8.3).

If the short term plans for turning the business around were successful there would clearly be a need for revising methods of long-term planning in the company.

In Chapter One, a review of planning methods led to a discussion of the most important issues which should be considered in such an appraisal (1.1.2). These now form the framework for a critical analysis of planning in BOC AE, with recommendations for the future.

Four main issues were raised in Chapter One (1.1.2). These are considered in turn, in 11.2.1 - 11.2.4.

### 11.2.1 The overall approach

The first issue is that of the overall approach to long term planning which would best help the business to cope with its internal organisation and external environment. (1.1.2(a)).

There are two crucial factors which affect the choice of approach in BOC Arc Equipment.

Firstly, the corporate role of the company within BOC Ltd. affects its planning in several ways. There is a requirement for formal plans so that the corporate body can co-ordinate its activities. The parent company also provides a level of financial support for growth and expansion. In the case of BOC AE this proved to be a disadvantage in the past, since financial support given to growth strategies in the early years (1972-75) put insufficient constraints on plans which turned out to be unrealistic and impractical. (11.2.2). The effects of failure were cushioned by the continued supply of resources from the parent company, and so reaction time was delayed.

In addition, the hierarchy of planning levels mitigated against the definition of clear objectives and criteria for monitoring plans. In the past, this was further confused by the hierarchy of portfolios. Each level of the company was supposed to consist of a balanced portfolio of businesses, with a growth business (star), a cash generator (cow), potential future star, and possibly one business in decline (dog). Thus, BOC AE was the 'star' in the portfolio of engineering division (ED), which in turn was the cash cow for BOC Ltd. In practice, ED, requested to supply a level of return on investment, merely passed this on as a blanket requirement to all of its businesses, irrespective of their theoretical position in the portfolio. (3.1.1.).

Meanwhile, managers within BOC AE had their own objectives for the business. Strongly influenced by the experience curve philosophy, they wanted the company to grow to a position of dominance in Western Europe. (3.1.1).

Consequently, plans for BOC AE were not based on a clear set of objectives. Planners in the operating company would submit a list of options for their 5 year strategic plan, with the preferred strategy based on growth of market share. The agreed option was always a compromise on this option, with unclear and potentially inconsistent objectives such as some growth with some profits. (3.1.2).

The second critical factor in appraising the general approach to planning in BOC AE is the changing environment of the arc welding equipment business. Rapidly changing technology provides a background in which the research and development required to produce the right product at the right time could be crucial. In addition, changes in economic conditions, which had already altered the balance of consumer industries making up the arc welding equipment market, could reasonably be expected to continue. (10.4.2).

Recommendations

In an environment of changing technology and market conditions, a company will need to formulate some sort of strategy for achieving its objectives, involving decisions on product/markets, resource requirements, methods of production, and so on. (1.1.1(c)). Since BOC AE is trading in this type of environment, it will require some planning process which will provide the means for making these decisions on a rational basis.

The role of the company in BOC Ltd. places an additional requirement for formal plans produced in a certain format.

These two factors define the need for some type of the formal strategic planning process described in Chapter One. (1.1.1(c)). The specific methods used in this process are reviewed and discussed in 11.2.2.

However, there is some doubt that the operating company level is the one at which strategic planning would be the most effective. All major decisions on objectives, choice of strategy, development and allocation of resources are made at divisional level. This may well be the level at which long-term planning for operating companies should be done.

### 11.2.2 Specific planning methods

Over the period 1972-77, strategic planning in BOC AE was based on the approach suggested by the Boston Consulting Group. (2.4.1). This was typical of the general strategic planning process described in Chapter One, which consisted of several distinct steps. (1.1.1(c)). Alternative strategies for achieving defined objectives were supposed to be developed by considering both environmental factors such as technology and market conditions, and also the strengths and weaknesses of the company (Steps (i)-(iv)). These were evaluated with respect to criteria such as profit, cash flow, market share etc., and the chosen option translated into tactical and operational plans (Steps (iv) and (v)).

These elements of the strategic planning process in BOC AE are critically examined in this section; monitoring and control (Step (vi)) and the implementation of plans will be discussed in 11.2.3.

Generally, the basis for generation of alternative strategies appeared to be weak. In appraising the environment, planners noted changes in market growth, but failed to appreciate the changing importance of market sectors. (10.3.2). There was also little recognition of evident weaknesses in operational management, typified by the continual failure to develop new products within a given time scale. (9.2.3 (c)).

In fact, strategic options were developed with little consideration of these factors. The preferred option put forward by planners in BOC AE was always that of growth in market share to some position of dominance. Alternative schemes were either compromises on the growth option, diluted in the hope of winning ED approval, or were obvious candidates for rejection, such as withdrawing from the market. (3.1.2).

This preference was based on theories put forward by BCG. (1.2). In the experience curve philosophy, they claimed that most companies could reasonably expect unit costs of production (in real terms) to decrease as they accumulated experience in running the business. If the various factors contributing to 'experience' could be represented by cumulative output of production, then the company with highest cumulative output could expect lowest unit costs and hence highest profits. In the long term, the company with highest market share would accrue the highest cumulative output. Hence they derived the strategic aim of dominance in the chosen market.

The argument put forward by BCG relies on three crucial assumptions:

i) The strategy will only be effective in a growth market, since gaining market share is both difficult and costly in slow growth or static market conditions.

ii) An experience curve model is valid for the business. I.e. As cumulative output increases, unit cost declines.

iii) That if (i) and (ii) are both satisfied, increased market share will result in higher profitability.

BOC AE applied this strategy in the MIG section of their business which was a high growth market, so the first assumption was fairly sound.

However, they failed to meet the requirements which underlay the second assumption, that of the validity of the model. As discussed in

Chapter Eight, the technical fit of the experience curve model to data for 1965-77 belied what was really happen ing. There was no reduction in the direct cost of the product, and in fact unit costs as a whole had risen from 1973-77, during the period over which this strategy had been applied. (8.1).

The reason for this failure is disclosed from investigation of the tactics used in pursuing this strategy.

Firstly, emphasis in tactical plans for 1972-75 was all placed on marketing plans to achieve increased volumes of sales, and on product development to satisfy the perceived needs of the growing MIG market. There were no plans for cost control or even monitoring of unit costs until much later. (3.1.3).

Secondly, BCG's advice to invest in capacity ahead of demand was based on the premise that this would give a huge advantage to the manufacturer concerned when an upturn in growth occurred. In following this advice, the management team at BOC AE pressed for a 2.5 increase in capacity plus a corresponding increase in the organisational structure to deal with commensurate volumes of sales. (3.1.4). When predicted market growth failed to materialise, and sales volumes fell below target, overhead costs were far too high for the level of sales. (7.3).

Thirdly, another tactic suggested by BCG was the acquisition of similar businesses, theoretically increasing the experience level of both and so resulting in lower unit costs and higher profits for both. The acquisition of SNS, the French manufacturer of manual arc welding sets, merely increased the problems within BOC AE by diluting the effective management of the business and further increasing the cost base. (8.3).

Consequently, by mismanaging the conversion of strategy into tactical plans, the company actually ensured that the experience curve was not a valid model for their business. Managers had in effect assumed that the relationship between increased cumulative output and decreasing costs was cause and effect, and had concentrated their efforts on increasing market share. Furthermore, resulting plans were based on inadequate perception of market conditions and little acknowledgement of weaknesses within the organisation.

As far as evaluation of alternative strategies was concerned, there was little evidence of any quantitative evaluations after 1972. A simulation exercise showed that in many cases, evaluation of different strategic options produced results which would not be expected from subjective considerations. For example, the apparently safe 'compromise' plans did not always produce the safest levels of profit and cash flow. (3.2.3). If carried out in subsequent years, such an evaluation would have produced a more informed basis for decision making and a means of quantifying and examining risks. This would probably have influenced some of the crucial decisions made over this period.

## Recommendations

a) Strategic planning should not be based on the use of any model for predicting the behaviour of important variables such as unit cost or average price.

Plans may include unit cost reduction as a strategic objective, but should specify exactly how this reduction is to be achieved. The best-fitting models described in Chapter Six (6.2) can then be used to evaluate the effect of these plans, as long as assumptions are specified and justified in practical terms.

It must be noted that although volume related models gave the best fit to historical data on unit cost and average price for BOC AE, the accuracy of prediction from these models will depend on the accuracy of prediction of volumes of sales. (6.2.1). BOC AE tend to project volumes of sales from targets for market share objectives. If these targets are not achieved, the model will overestimate the reduction in unit cost. For this reason, it is essential that planners provide realistic plans for achieving targeted volumes of sales, together with contingency plans in the event of failure.

If volumes of sales have been projected in this way, it is recommended that the models be used as follows:

i) Use the best-fitting model for average price of a rectifier in the UK to project average price and hence revenue to be expected from projected volumes of sales.

ii) Use the volume related model for BOC AE to project unit costs and hence total costs and profits.

iii) Use the time related model for BOC AE to provide alternative projections of unit costs, total costs and profits.

iv) Compare the results from (ii) and (iii), accounting for any major differences between the two with realistic plans showing how the greater reduction in unit cost will be achieved.

b) Future plans for BOC AE must be based on realistic assessments of the market and of the company's capabilities. In the past, strategic plans have been based on perceptions of the market which were unsubstantiated and inaccurate. This led to marketing strategies which failed to achieve targets for volumes of sales. (10.3.2). Failure to recognise organisational weakness in implementing action plans contributed to the lack of reduction in unit cost. (9.2.2(b)).

c) Any plans for increasing market share should be carefully evaluated, with estimates of possible costs and benefits. If possible, the evaluation should include factors such as the risk from competitive reaction and increase in imports of cheaper goods. Contingency plans should be provided for the situation in which target volumes are not achieved.

### 11.2.3 Implementation

Two important factors affecting implementation of strategic plans in BOC AE have already been mentioned.

Firstly, the concentration of management expertise on plans to increase market share and build up capacity had been made at the expense of operational management. For example, managers had failed to resolve problems in the production department which resulted in poor product supply over a number of years. (9.2.3(a)).

Secondly, organisational weakness in the company resulted in a failure to implement operational plans, particularly within a given time scale. Delay in the development of new products, and the failure to implement ideas for cost reduction are typical examples. (9.2.2(b) & 9.2.3(c)).

A further factor which contributed greatly to the effects of the first two was the lack of monitoring and control of the plan as a whole.

For its success, a strategy of market share maximisation requires that the costs incurred in gaining market share be offset by a reduction in unit costs of production. Monitoring of such a plan is therefore essential. Sales volumes should be compared with those of quantified market share objectives, and unit costs with the corresponding targets.

If BOC AE had monitored their unit cost in some way, however rough and ready, the adverse trends would have been noted much earlier, and remedial action could have been taken. Using the experience curve model to monitor the strategic plan was one of the objectives for the project; in view of the factors outlined above it was already too late.

It must be noted that much of the information produced for management control was in the wrong format, containing too much detail, or duplicated by computer and manual systems. (9.2.2(c)).

<u>Recommendations</u>

a) In the light of the many weaknesses in the company's planning process, monitoring and control of any plan is probably the most important factor for the future of the business.

Plans, whether long or short term, should be continually reviewed against performance, with respect to a clearly defined set of criteria.

This will probably require changes in the flow and content of information supplied to managers.

b) The performance and efficiency of the company should benefit considerably from changes in the organisation and organisational methods.

Appraisal of the current system should include the departmental structure, structure within departments, methods of reporting, project control, and accountability in general. Each job should have well-defined areas of responsibility, explicit targets, and accountability for action against these targets.

c) Lines of communication should be structured for formal needs, but with plenty of communication between all levels of personnel, so that the strategic plans and targets behind the operational goals are known to everyone.

### 11.2.4 The requirements of changing conditions

The final issue raised as a result of discussions in Chapter One concerned the adequacy of current planning methods for the requirements of a future. Ansoff predicted that the rate of change of technology may become too fast for strategic planning methods to be useful. (1.1.2).

The recommendations made in sections 11.2.1 - 11.2.3 apply to the current (1981) situation of changing market conditions and incorporation of new technology into arc welding products and production methods. If however, the rate of change of technology increased, the whole approach to planning in BOC AE may have to be reviewed. For example, if there was an increase in the rate of development of new welding methods, or of more general methods for fixing metals together, the company may well require the flexibility to respond to such changes in much shorter time scales than those used in the present planning horizon.

For this reason, it is recommended that planning methods are occasionally reviewed with respect to the changes in technology, so that planning will help and not hinder in a speedy response to the environment.

## 11.3 GENERAL COMMENT ON PLANNING IN BOC ARC EQUIPMENT

The author concludes that although failure of strategic planning in BOC AE was due to ineffective management and control, this in itself can be attributed partly to use of the experience curve model for strategic planning.

Derivation of strategic plans from this model puts planning onto a theoretical basis which planners in the company found to be intellectually stimulating and exciting. The resulting strategy of market share maximisation was ambitious and demanding, which suited the personality and style of management of the then General Manager. It was his enthusiasm and persuasive qualities which finally obtained consent for the plans to expand capacity, and for acquisition of SNS, both of which contributed to the scale of the problem when market share objectives were not achieved.

During the following period (Feb. 1980 - Jan. 1981) many changes were made in the company. Some of the recommendations made during the course of the project were implemented, and some were not. The author had the opportunity of visiting the company again in January 1981, assessing the extent and effect of these changes and the ways in which they related to the work of the project. This will be discussed in Chapter Twelve, which also includes recommendations for extensions to the research already carried out.

# CHAPTER TWELVE

## IMPLEMENTATION AND THE EFFECT OF THE PROJECT ON CHANGES IN BOC ARC EQUIPMENT

The project evolved and was carried out against a welter of change, both within and outside BOC Arc Equipment.

Effects of the economic recession were beginning to appear. Predicted market growth failed to materialise, and the company faced competition from cheaper imported products. The economic climate had also prompted a change in policy at the divisional level of BOC, whereby operational companies were required to fund their own growth and to generate cash.

Within the first year of the project, a new general manager was installed at BOC AE. As his brief was to bring the financial state of the business under control, his approach formed a complete change of style to the growth objectives of the previous GM, under whose auspices the project had been instigated.

Despite the efforts of the new G.M., the financial situation continued to deteriorate. A trading loss of £612K in 1978/79 followed the loss of £327K in 1977/78. By the summer of 1979 the parent company was forced to inject supporting cash into BOC AE on such a scale that the executives demanded immediate remedial action to turn the business around. The first such action took place in February 1980. (12.2.2).

During the period June 1979-February 1980, morale in the company declined rapidly. There was an atmosphere of distrust amongst the managers; in retrospect it was obvious that some of them had foreseen the impending action taken by BOC Ltd. Certain managers tended to bypass the general manager, and discuss strategy with engineering division executives, in an attempt to safeguard their own position.

Eventually autonomous management was withdrawn from the operating company. Executives in BOC Ltd. decided on a particular course of action for turning the business around, and put the plan into effect. These and subsequent changes affected most areas of the company and the way in which the business was run. (12.2).

This background makes it difficult to ascribe cause and effect to the relationship between the project and changes in BOC Arc Equipment. However, there is no doubt at all that the project did affect the company, and influenced many of the decisions made during this difficult period.

In general the response of BOC AE managers was not a formal reaction to a list of recommendations. Since most of the research was carried out on site, many of the results and their implications were discussed with managers at an informal level before formal reports had been compiled.

The effect of the project on planning in BOC AE during the period 1978-80 is reviewed in 12.1, subsequent changes in the company and links with the research are discussed in 12.2, and conclusions on the overall influence of the project in 12.3. Areas where further research would be beneficial are proposed in 12.4.

## 12.1 EFFECT OF THE PROJECT ON PLANNING IN BOC ARC EQUIPMENT DURING THE PERIOD 1978-80

One general way in which the project helped planners at BOC AE was in the formulation and discussion of the company's problems. This in itself prompted the management team to examine certain aspects of its organisation afresh, and to evaluate policies in a critical way.

Possibly the greatest impact from the research was made by the discovery of adverse trends between average price and unit cost, such that the profit margin per unit was being eroded. (11.1). This provided the management team with incontrovertible evidence of problems previously only suspected. Since it arose from a source with no status or political role in BOC, such evidence could not easily be ignored or 'swept under the carpet'. The further analyses of costs at the production site indicated those areas of the business where management attention and effort was most required.

Following discussion of these results with BOC AE managers, the first effect could be seen in action to improve management of the production operation. More resources were invested in production, a new manager was installed in the Thanet factory, and production systems were being computerised to improve control of stores management, processing of works orders, and purchase orders for materials.

In the strategic plan for 1979/84, formulated in late 1978, results from the research were used in several ways. (8.2). Evidence of the adverse trends in unit cost and price prompted a change of emphasis in strategic objectives, so that unit cost reduction had the highest priority. Objectives were quantified using the best models available at that time, so that plans could be geared to specific targets. These plans concentrated on the design of products with lower material costs, compatible components, and ease of assembly. The program for development of these products was brought forward, so that it was scheduled for completion by 1981.

It must be noted that the initial analyses of costs, average price, and explanation of adverse trends (Appendix G.1) was also of great use to the new General Manager, who received the report within a few months of starting this job. It provided him with an immediate insight into the business, pointing out those areas which should be his greatest concern.

The second report had emphasised that the survival of the company would depend on its ability to reduce costs and/or increase volumes of sales with control of associated costs. (Appendix G.4). The first part of the project's contribution to plans for achieving these short term objectives consisted of research into ideas for cost reduction. This was carried out in the early months of 1979, and the report presented to the general manager in June 1979. By this time, the financial situation in BOC AE had become acute, and it was evident that the type of major changes to the company's organisation and structure suggested in the report would have to be considered. The list of ideas was passed to BOC AE management for circulation to all concerned; at their insistence, evaluation and selection of ideas was left to the individual managers concerned. Major organisational and other changes did take place within 8 months of the publishing of this report. However, the specific link between the two is difficult to assess in the light of the changing role of BOC AE within BOC Ltd. (12.2.1).

Recommendations for marketing and sales plans for increasing volumes of sales were based on analysis of a market survey. (11.1 and Chapter 10).

This work was incorporated into the strategic plan for 1980/84, as described in Ch. Ten (10.5.2), but again implementation was affected by subsequent changes in the organisation. Particular changes in marketing policy and tactics, and comparison of these with the recommendations made in the project, are discussed in 12.2.3.

In February 1980 the first of the major organisational changes took place with the closure of the Milton Keynes site, and redundancy for most M.K.-based employees, including the author. In January 1981 the opportunity was taken to visit the company, assess the effect of these and subsequent changes, and evaluate the influence of the project on decisions, actions, and new plans being made.

## 12.2 CHANGES IN THE COMPANY DURING THE PERIOD FEBRUARY 1980 - JANUARY 1981

These are reviewed under four main headings, planning policy (12.2.1), organisation and structure of the company (12.2.2), tactical plans (12.2.3) and monitoring and control (12.2.4).

### 12.2.1 Overall approach to planning

As has already been mentioned, by February 1980 all major decisions concerning the future of the company were being made at the divisional level of BOC Ltd. At some time during the next few months, the divisional structure itself changed, and BOC AE became part of a new welding processes division. The welding businesses were no longer regarded as support for the core business of gases, but were required to be a profit centre. Although all planning during the crisis period was in the hands of the welding processes division, it was not yet known whether this was to be a permanent arrangement.

Long term objectives were still understood to be those of dominance in the U.K. and a 'significant' share of the Western European market. However, at that time, there were no formal long term plans for the business, since all efforts were concentrated on achieving the short term objectives required to turn the business around. As recommended in the second report to BOC AE management (Appendix G.2), the aims were to reduce overhead costs, and increase volumes of sales with control of associated costs.

In the plan for 1980/81, expressed in a budget, projected revenue was not increased over that for 1979/80. However, since revenue was by then exclusive of that from after sales service (taken over by gases division) and also since prices had been reduced (12.2.3), the plan represented a real increase in volumes of sales which had to be achieved in a depressed market. The planned turn around of the business was to come from a reduction in costs, with some savings in direct costs but mainly in indirect costs. In the budget, projected revenue and costs gave a trading loss of £0.5m for 1980/81, but with a positive cash flow.

Tactical plans for increasing volumes of sales are discussed in 12.2.3, and schemes for exercising the required control of costs, in 12.2.4. Before tackling these issues however, the divisional executives set about reducing the high level of overhead costs, through major reorganisation of the operating company.

### 12.2.2 Organisation and structure of the company

The geographical, departmental, and management structure of BOC AE have all been completely altered. These changes were recommended as a result of work undertaken during the project, both in the ideas for cost reduction (11.1(a) and (c)) and in suggestions for improving the company's ability to implement action plans. (11.2.3 (b) and (c)).

In February 1980, the M.K. site was closed, and all functions except for after sales service transferred to the Thanet factory. These functions were successfully integrated into the Thanet operation within six months, with the help of only seven members of staff transferred from M.K. It is interesting to note that the specimen evaluation of the two main alternative options (Thanet or M.K.) favoured the M.K. site, but this was probably influenced by estimated costs and benefits supplied by M.K.-based personnel. (Appendix I.1).

At the same time the departmental structure was greatly simplified by reducing it to four main departments, marketing services, engineering, production and accounts, all operating with significant reductions in personnel.

The remaining organisation took place in the management hierarchy. The management board was abolished and a new general manager appointed who was responsible for the operational management of the business. Communication became more open, and decisions were made at weekly or monthly meetings of all staff concerned.

Apart from obvious cost savings due to elimination of duplicated effort, transport and communication between sites, and reductions in personnel, the anticipated long term benefits from these changes are beginning to be evident.

Improved liaison between departments, and stronger management of the production operation had already affected the efficiency of product supply. Stock piles of finished goods reached unprecedented levels and became problems in themselves.

One effect of the immense reductions in personnel is that remaining staff are quite clear on their areas of responsibility. Monitoring of seven key criteria on a weekly basis provides immediate accountability for most actions. (12.2.4).

Overall benefits from the reorganisation as a whole could be seen in the performance of the company, since they had met their budget for the first three months of 1980/81. In addition, it was obvious that the morale had improved enormously.

### 12.2.3 Tactical plans for increasing volumes of sales

Having reduced a large proportion of the overhead costs by reorganising the company in this way, the divisional executives turned their attention to marketing plans for increasing volumes of sales with control of associated costs.

Here tactics differed from those recommended in Chapter Ten and reviewed in 11.1, in that they were product rather than market oriented. With the aim of selling high volumes of low cost products, both long and short term plans concerned the direct costs of welding sets in the popular ranges.

Within the first few months after reorganisation, a sweeping price reduction of 20-30% on existing products helped to clear the growing stockpiles, which had accumulated as production efficiency improved. (12.2.2). Sales to other equipment manufacturers were discontinued, and the costs of remaining products were critically examined and compared with similar models manufactured by other BOC companies, AIRCO in the USA and CIG in Australia. BOC AE models found to be relatively costly were replaced with bought-in versions. If the new model proved to be satisfactory for the U.K. market, it would be adapted for in-house manufacture. In this way, direct costs of the current product range were reduced in the quickest possible way.

Long term plans for product development centred on the modular range with commonality between BOC AE, AIRCO and CIG. However, resources were limited and research into new technology would be delayed as a result.

These tactics appeared to have been successful, since revenue and costs compared favourably with the budgeted figures for the first 3 months of 1980/81. The key to this success was probably in the speed with which the plans were implemented, due partly to the higher level of power of personnel at divisional level, and partly to the increased flexibility and response time of the organisation.

### 12.2.4 Monitoring and control

As discussed in 11.2.3, and recommended in 11.2.3(a), monitoring and control of any plan was possibly the most crucial factor in planning the company's immediate future. This would require continual reviewing of performance against plan, with a clear set of criteria defined for this purpose.

In the period since February 1980, monitoring of performance against plan has been carried out in a systematic way, against the following clearly defined set of criteria referred to as the key factors:

i) Cash flow, including value of all goods received, finished goods stock, and invoiced sales.

ii) Value of orders received.

iii) Breakdown of orders/supply/shortages.

iv) Analysis of sales and contribution levels.

v) Forward planning program.

vi) Key overhead costs (versus monthly targets).

vii) GD sales.

In addition, a monthly report prepared for BOC Ltd. includes cash flow, further breakdowns of sales and contribution, monthly departmental costs, and any highlights in the month.

In order to facilitate the monitoring of key factors, management computer reports have become more user oriented. There are fewer daily reports, and weekly reports have been shortened or summarised. Two very short reports on the financial state of the business and core business items have been produced specifically for monitoring and control.

## 12.3 CONCLUSIONS

Although the closure of the M.K. site and accompanying reorganisation of the company helped to reduce overhead costs, BOC AE still had to pay the costs of the M.K. site for a further 6 months. The net result for the financial year 1979/80 was a loss of £2m. However, since the budget for 1980/81 had been met for the first 3 months of the financial year, the company had every hope that they were well on the way to achieving the planned turn around of the business.

Most of the recommendations concerning the short term plans for BOC AE have been carried out. The short term objectives for future survival of the business were beginning to be met, although the means for achieving increased volumes of sales were different to those recommended in Chapter Ten. (12.2.3).

As far as long term planning for BOC AE is concerned, many of the recommendations made in Chapter Eleven still hold. BOC AE will need some type of formal planning process, with strategic planning for coping with changing technology and market conditions, but this may be more effective if done at divisional level. (11.2.1).

Strategic plans should be based on a realistic assessment of the market and of the company's abilities. Schemes for increasing market share should be carefully evaluated, with consideration of the risks involved, as well as anticipated costs and benefits. A planning model should only be used to project and evaluate the effect of plans, not to make plans based on manipulation of the variables involved. (11.2.2).

The reorganisation of the company, carried out along the lines suggested in 11.2.3, will enable it to implement plans, respond quickly to the environment, and monitor and control its performance against plan. This should help the company to be more flexible, particular with reference to the possible requirement of planning in the future. (11.2.4).

## 12.4 FURTHER RESEARCH REQUIRED IN THE COMPANY

Once the turn around of the business has been achieved, further consideration should be given to some of the issues concerning long term planning which have not yet been resolved.

Possible areas for further research are as follows.

a) Methods and procedures by which market conditions and changes in market requirement can be monitored and reported.

b) Further work on the forecasting accuracy of the model including investigation of the inaccuracy of BOC AE volume forecasts in the past.

c) Outlining procedures for incorporating the best forecasts of industry price and BOC unit cost into the strategic planning process, for evaluation of planned changes.

d) Setting up a model for evaluating plans to increase market share. This should include consideration of factors such as competitive reaction, changes in exchange rates and so on, as well as the effect on profit and cash flow if planned volumes of sales are not achieved.

e) At a higher level in BOC Ltd. there should possibly be some investigation of the way in which the strategic planning process operates with the hierarchy of planning levels. This could be incorporated with an evaluation of the level at which the strategic planning of an operating company is most effective.

These ideas for future research form the concluding section of that part of the thesis which deals with the problems of BOC Arc Equipment and the ways in which the project contributed to their solution.

The scope for comment is now widened to include all companies, and to discuss any implications arising from the results of this research for the planning of companies in general. (Chapter 13).

# CHAPTER THIRTEEN

## CONCLUSIONS ON PLANNING IN GENERAL AND THE SUCCESS OF THE PROJECT

Conclusions and recommendations arising from the work of the project specifically concerning the planning activities of BOC Arc Equipment have been discussed in Chapter Eleven.

Results from the project can also be used to make comments and suggestions on the approach to planning by companies in general, particularly for those who wish to reappraise their own methods. These are discussed in 13.1.

These comments lead to the development of some ideas for areas where further research may benefit the planning of companies in the future. (13.2).

The opportunity is then taken to assess the success of the project from the point of view of the company and its problems, and the suitability of using an IHD approach in this situation. (13.3).

### 13.1 IMPLICATIONS FOR PLANNING IN GENERAL

Since the project was concerned mainly with the approach to planning used by one particular company, the results can be used to comment on only certain of the issues raised at the end of the discussion of planning methods, in Chapter One. (1.1.2).

Each of these issues is considered in turn and comments made where appropriate.

### 13.1.1 The choice of approach (Issue (a), 1.1.2)

The discussion of planning in Chapter One began by pointing out that any business enterprise needs some form of planning in order to utilise available or potentially available resources in the best possible way for achieving its objectives. (1.1.1).

In reviewing the differing approaches in current use, it became apparent that selection of the most suitable approach for any particular company should depend on several factors. The size and complexity of the organisation may determine the need for a formal approach and, possibly, a corporate planning system to integrate the planning of several businesses with differing characteristics. (1.1.1(d)). The second critical factor is the potential ability of the company to meet its long term objectives with the existing product/market mix. If some sort of change is required, then strategic planning methods may help in evaluating alternative options on a rational basis. (1.1.1(c)). On the other hand, budgetary methods may be perfectly adequate for planning the development of current products and markets. (1.1.1(b)). A further factor not always considered is the style and strength of management in the organisation. This will contribute to the ability of the company to effect change. (1.1.2).

Results from the project can be used to supplement this discussion, and to make recommendations for any company using, or thinking of using, some type of formal planning process. These concern an additional factor which may affect the choice of approach, the actual basis upon which the choice is made, and possible dangers inherent in using the type of strategic planning described in Chapter One. (1.1.1(c)).

An additional factor - the corporate role of the company

If the company in question is operating within a larger organisation, then this becomes an additional factor to be taken into account when choosing or appraising the approach. The presence of a parent company not only imposes constraints, but may influence the effectiveness of certain types of planning within the individual business unit.

Problems may arise in strategic planning for operating companies, involving the level at which this type of planning should take place, and the way in which resulting plans are integrated into corporate plans of the parent company.

The dilemma is typically that of the top down or bottom up approach. In order to shape its own future, the corporation must plan and control the overall direction and policies for its operating companies. However, if strategic plans for each business were made at this level, planners would have the disadvantage of being distant from the products and the market. In addition, it may be difficult to motivate managers of the operating company to implement a dictated strategic plan. On the other hand, if operating companies are allowed to make their own plans, the parent company may lose control of the overall direction, and there may be conflicting sets of objectives for the future of each business. (11.2.1).

This also throws doubt on the efficacy of a hierarchy of planning levels, since the above comments may apply at each level in the organisation.

The conflict between overall control provided by a top down approach and the practical advantages of a bottom up approach possibly requires further research before it can be resolved. (13.3).

Basis for choice

The main conclusion arising from the above discussion would be that choice of a particular approach to planning should be based on an objective evaluation of the alternative options, with respect to the critical factors involved.

However, observations made during the project suggest that the choice of approach is unlikely to have been made on this basis. A specific type of planning may have been selected by the owner or manager of the business simply because it appealed to him and suited his style of management. Thus the approach may be intellectual, idealistic, ambitious or pragmatic, according to the personality, motivation and ambitions of the manager concerned. (11.2.5).

The strategic planning approach

The systematic approach to strategic planning is recommended both to cope with increasing complexity of a business, and in situations of changing markets and technology. (1.1.1). Whilst agreeing that these conditions require some type of long term planning, the author feels that there are dangers in the use of typical strategic planning methods as described in Chapter One. (1.1.1(c)). There is a risk that planning becomes a theoretical exercise divorced from the practical running of the business. Perception of the market environment and capabilities of the company together with the ensuing generation and evaluation of alternative strategies, may all be completely out of touch with the realities of the situation. (11.2.2). Even if plans are based on an accurate viewpoint of these factors, management effort is required to ensure that these plans are implemented. Top managers may become so involved with strategic planning that implementation suffers. (11.2.3).

Recommendations

The most important recommendation arising from the work of the project is that a critical appraisal of their current approach to planning can be of great value to the managers of any company. Results from the research demonstrated that an analytical investigation of the planning process can provide insight not only into the success of current methods, but also into key factors governing the profitability and competitive position of the business. (8.1).

Since current methods may well have been a rather subjective choice made by top management personnel, such an appraisal is best done by an external agent with no political role in the company. In this way, even the implicit assumptions made by the management team or planners can be challenged. These may include their definitions of objectives, business areas, the product market/mix, the position of the company in the market place, and the company's strengths and weaknesses.

An evaluation of current versus alternative methods should be based on the size and complexity of the business, the need for strategic change, for example in the product/market mix, the style of management, and the corporate role of the business unit, if any. In particular, if a strategic planning approach is thought to be required, the investigation should consider the means by which plans will be implemented, and the potential ability of the management to effect changes within the business and the organisation.

The second recommendation is that, whatever the approach used, it is essential that plans are based on a realistic assessment of the company's capabilities, trends in the market, and future developments both in the market and in the relevant technology. Overoptimistic plans which are almost impossible to achieve will only result in low morale and a tendency to ignore the planning process.

### 13.1.2 Use of specific techniques, in particular the experience curve model for strategic planning (Issue b, 1.1.2)

The experience curve expresses the hypothesis that in the long term, a decline may be expected in the real unit cost of a product resulting from increased efficiency gained through accruing experience in all aspects of the manufacturing process. As the rate of decline is not expected to be constant, but to decrease gradually, the model relates the log of unit cost (or its proxy variable, average price), to the log of cumulative output, the variable generally chosen to represent production experience.

From this model the Boston Consulting Group (BCG) derive a strategy of market share maximisation, by which a company engaged in a particular business should achieve higher levels of profitability than its competitors. (1.2). The argument supporting this derivation depends on three assumptions, not all explicitly expressed in BCG literature. Firstly, as BCG point out, the strategy should only be applied to a growth market, so that costs of gaining market share will not outweigh the benefits. (Hedley, 1976). Secondly, the model must be valid for the business to which the strategy is to be applied. Thirdly, an increase in market share will actually result in increased profitability, even in a growth market. Results from the project demonstrate that the second assumption is not as straightforward as it may appear.

In their literature, BCG cite many examples of instances in which a gradual decline in real unit cost or average price of a product is well fitted by an experience curve model. Although BCG themselves supply little or no statistical evidence supporting this claim, it is backed up both in the thesis of K. Woolley (Woolley, K., 1972), and by the work of other researchers in this field. (4.2). In addition, results from the project supported the hypothesis that this model fitted data for the company involved. (5.2.3). However, the fit of the model to historical data is not the only point at issue.

The argument that market share maximisation will result in higher profitability requires not only that the model be valid over a historical period, but that this relationship can be extrapolated into a future period in which volume of output is planned to change drastically. Three pieces of evidence from research undertaken during the project mitigate against this assumption.

Firstly, results from testing sets of data which span long periods of time suggest that a significant change in volume growth is not necessarily accompanied by the change in unit cost or average price which would be expected by extrapolating from the experience curve model. (6.3.3). Secondly, in most cases where alternative models have been tested on the same data, any decline in unit cost or average price was found to be equally significantly related to each of cumulative output and elapsed time. (6.3). This implies that manipulation of cumulative output by increasing volumes of output in the strategy of market share maximisation is unlikely to result in an increased rate of reduction in real unit cost unless justified by specific plans for cutting these costs. The third piece of evidence comes directly from investigation of the success of this strategy in the company involved in the project. Although historical data would have supported the validity of the experience curve model in the past, by mismanaging the strategy the management team ensured that the model was not in fact valid over the period during which they were trying to increase market share. (11.2.2). This illustrates the inherent danger in using this strategy, that management effort and attention is concentrated on tactics to increase market share, whilst expecting unit costs to fall automatically.

Recommendation

Use of the experience curve model for derivation of a strategy of market share maximisation is not recommended, unless it can be shown from some other source that an increase in market share will result in lower unit costs of production.

However derived, a strategy of market share maximisation must be carefully evaluated with respect to the costs and benefits of gaining share. The evaluation should consider factors such as competitive reaction, economic conditions, exchange rates, and imports of cheaper foreign goods, all of which may threaten and affect the success of the plan.

### 13.1.3 Implementation (Issue c, 1.1.2)

Successful implementation requires effective organisation of the planning process, particularly in the translation from strategic to operational levels. This can be adversely affected by the following factors.

Complex management hierarchies with poor communication between levels can result in inadequate perception of the overall objectives at lower levels of the organisation, with resulting lack of committment to strategic plans. (9.2.3(b)).

Implementation of operational plans requires well-defined targets, allocation of responsibility for meeting these targets, a monitoring system and accountability for performance. Inadequate organisation of this part of the process will result in delays and failure to achieve objectives. (9.2.3(c)).

In addition, the strategic plan should be monitored against a set of clearly defined criteria such as market share targets, unit cost targets, profit levels etc. The absence of a monitoring system means that control cannot be exercised over progress towards these targets; the fact that a strategic plan is not succeeding in any of its major objectives may not even be known. (11.2.3).

Recommendations

a) Strategic or other long term plans should be developed into short-term operational plans with a series of explicit targets, action plans, and accountability for performance against these targets. All personnel should be acquainted with the overall strategic objectives, and how their areas of responsibility fit into the strategic plan.

b) It is essential that progress be monitored against long term as well as short term objectives. The long term objectives should be clearly defined and there must be a system capable of either measuring or giving a realistic estimate of the current state of any variables defined as key criteria. For example, if a strategic plan is expressed in terms of market share objectives, there must be a part of the plan which provides a method of estimating the company's market share, hopefully with some sort of check of its validity.

### 13.1.4 The requirements of changing conditions (Issue d, 1.1.2)

The last issue raised as a result of the discussion in Chapter One (1.1), concerns the adequacy of current methods of planning to meet the demands of the future.

Various authors have suggested that an increase in the rate of change of technology and consequent changes in the market place will make current methods of long term planning ineffective, since the planning process will lag behind the need to cope with the changes. Ansoff in particular proposes that companies will need to revert to informal planning and entrepreneurial behaviour in order to give them the requisite flexibility and speed of reaction to their environment. (1.1.2).

The work of the project cannot really contribute to speculation on this issue, except to endorse its importance. In the future, flexibility will probably distinguish the survivors from the non-survivors. Since the large complex organisations clearly require formal plans merely to control and co-ordinate their activities, the answer may be found in the size of business unit, rather than in the type of planning used. A small unit which can cope with the management and successful implementation of change could be flexible whilst still retaining the advantages of a planning system.

The comments discussed in this section were used to develop ideas for further areas of research which would benefit the planning of companies in general.

## 13.2 AREAS FOR FURTHER RESEARCH ON GENERAL PROBLEMS OF PLANNING

From the discussion of 13.1, it would appear that some of the major problems in planning occur in the use of strategic planning methods, (13.1.1), in use of planning models to derive and evaluate growth strategies (13.1.2), and in implementation of strategic plans. (13.1.3). Additional problems may be created if the planning unit is part of a larger organisation (13.1.1). These suggest four areas where further research could be used to help companies improve the effectiveness of their planning.

### a) Assessing the suitability and benefits of strategic planning methods for a small business

Investigation of strategic planning as practised by the company involved in the project showed that one reason for its failure lay in the way in which the specific techniques were applied. (11.2.2).

A general study of the use of these methods in small companies could be used to compile a list of guidelines for their application.

The study should aim to give some indication of the following:

i) Methods for gathering market information and feeding it back into the planning system. Typically this information would consist of some estimate of market growth rates, market share of the company and its competitors, and monitoring trends in these variables. The source for making the estimates may be government trade figures, trade organisations, census figures; the study could also investigate methods used in the absence of such information.

Market information gathered from the sales force may include trends in sales in geographical areas, or market sectors, comparison of products and prices with those of competitors, changing patterns in consumers and their routes to the markets, and so on.

ii) Methods for assessing a company's capabilities, strengths and weaknesses.

One way of doing this could be for planners or managers to investigate reasons why targets and objectives have not been met in the past. Over a period of time, these could be compiled into a picture of company weaknesses, with accompanying estimates of penalties incurred in terms of loss of business, increased costs, decline in sales etc. For the company concerned, the results could be used in two ways, both to focus management attention on problems where penalties for failure are high, and to incorporate known weak points into evaluation of plans. Comparison of such analyses over a variety of companies could reveal many common problems, with information on which are the most important. This could provide invaluable guidance to others who are just setting up their organisation, introducing more formal planning procedures, or who do not have the resources to do such an exercise for themselves.

iii) Use of models for generation and/or evaluation of strategic plans.

Use of a model carries the advantage that plans can be evaluated on an objective basis, with quantification of key variables. This also implies that objectives can be quantified, and so provide the criteria for a monitoring system.

Disadvantages of a model may be that it is too complex for ease of use, requiring an 'expert' to do the calculations, or that it is too simple, omits important factors, and so prejudices decision making. One danger demonstrated by the company involved in the project was that assumptions underlying the validity and use of the model were not clearly understood. (11.2.2).

A survey of models used by small businesses could be useful in pointing out common models, their advantages and pitfalls, and possibly which models are more applicable and useful for different situations.

The particular need for a model to evaluate growth strategies is discussed in (b) below.

b) <u>Creating a simple model for evaluating plans to change market share</u>

Particularly in the case of a small company, it is important that evaluation of such a plan includes not only the costs and benefits of gaining market share, but also penalties which will be incurred if the planned growth does not happen.

Essential variables would consist of the unit cost and average price of the product, cost of additional resources and capacity required, cost of marketing effort, and forecasts of market growth. Further variables could include number of competitors, influence of technological change, economic climate, and so on.

In investigating and comparing the benefits of such models, analyses should be done not only of the fit of models to data for companies where growth in share has occurred as a result of deliberate strategy, but also how useful such a model would have been to the planners before they embarked on the strategy.

The ideal model would be simple enough to be generalised for use in different companies, but include sufficient critical factors to represent the real cost, benefits and risks attached to such a venture.

c) Implementation of strategic plans

Again a study of companies who use a formal planning process could be used to generate ideas and guidelines on the most effective systems for implementation of these plans. Arising from the work of the project, it is suggested that factors for investigation would include organisational structure, operational plans, the use of budgets, target setting and accountability, together with monitoring and control systems. (See also the methods for assessing company's weaknesses, described in (a)(ii) above.

d) Planning in a large organisation

A study of the planning process in several large organisations could provide information on the best ways in which this could be done, with respect to the effectiveness of planning for the corporation as a whole.

The aim of the study would be to determine the optimal solution to the dilemma discussed in 13.1, that is, whether strategic planning in a large corporate body should be top down, bottom up, or a combination of the two. The investigation should be based on the following factors:

i) The number of levels of planning and optimal size and type of planning unit.

ii) Integration of objectives and plans between levels so that motivation, monitoring, and control are effective at each level.

iii) Translation of strategic into operation plans and goals, particularly if strategic planning is done at a different level.

iv) The most effective way of monitoring strategic plans for each level and for the business as a whole.

## 13.3 THE SUCCESS OF THE PROJECT

This is assessed both from the point of view of BOC Arc Equipment, who raised the original problem, and as an example of the application of an IHD project in this type of situation.

### 13.3.1 In coping with the problems of the company

The initial objective for the project was to investigate the validity of the planning model being used by BOC Arc Equipment, and the progress of their strategic plans based on this model.

During the course of this investigation, further problems were revealed that were of more immediate importance for the company. The lack of reduction in direct costs of the product, rising factory costs and high overhead costs had resulted in adverse trends between unit cost of production and average price, causing an erosion of profit margins.

Action was required to avert these trends, and the work of the project contributed to tactics for increasing volumes of sales and reducing costs.

Thus, each stage of the project arose from results of the previous stage, or from the original problem. Investigation of the planning model produced evidence of adverse trends which indicate the failure of the current strategy. The project then contributed to short term plans for restoring the business to a profitable position.

There is no doubt that the research, particularly the early work on analysis of costs, was instrumental both in initiating action and providing information and guidance for decision-making for the changes needed to turn the business around. The contribution of the project in different areas is discussed in Chapter Twelve.

However, there are two ways in which the work of the project could possibly have been made more effective:

a) One of the main problems of the company at that time (1977) was in production. The organisation and control of the operation was inefficient, causing poor product supply and contributing to high unit costs. (9.2.3). However, the project was prevented from working in this area by BOC AE management, who feared further disruption of industrial relations.

b) During the course of the project many changes were taking place in the company. (Chapter Twelve). Towards the end of this period the worsening financial situation and increasing pressure and involvement from BOC Limited meant that these changes were taking place against a background of individual insecurity of jobs, political manoeuvering, lack of communication and outright secrecy. In fact the major decisions were being made away from the normal BOC AE management process. Ultimately, after the closure of the Milton Keynes site, all strategic decisions were made at divisional level, by the chief executive of the new welding processes division. (12.2.1).

As a result, although much of the work of the project was still being used, the control and decision-making function of BOC Arc Equipment was at a level remote from that at which the project was operating.

It may well be that, in an operating company such as BOC AE, part of a much larger concern, long term planning should always have been at divisional level.

Siting the project at divisional level would have provided two major benefits. Firstly, work concerning strategic plans could have taken all relevant factors into account, including the plans and requirements of BOC Limited. Secondly, it would have been in a better position for affecting and influencing decisions.

### 13.3.2 As an IHD project

In general this was a good application for an interdisciplinary approach, since the problems of the company spanned many areas of the business, from quantitative business analysis and planning to company organisation and methods of production.

The problems involved in using an academic approach in a dynamic business environment were usually those of timescale. The company wanted immediate answers instead of waiting for academically sound reports. This was solved by discussing results, as they arose, informally with the managers concerned. These would either be confirmed or adjusted with the issue of a report.

Just occasionally real conflict arose between the requirements of the company, and the need to provide rigorous justification for some of the conclusions reached from the research. However, successful management of these conflicts must be part of an IHD project, and adds to the experience of the student.

Later on, when the worsening financial situation in the company threw doubt on the future of the project, the flexibility of the IHD approach enabled it to continue. It appeared to the General Manager that the initial scope of the project did not include the real problems of the company. However, by changing its course slightly, the work of the project could concentrate on the tactical side of planning, and provide help for short term plans to improve the situation.

The author feels that an IHD project provided a good approach to the problems of BOC Arc Equipment. Careful definition of the problem was followed by solutions drawing both on existing knowledge and on new sources of information and skills. These solutions, tailored to the needs and resources of the company, had to be applied in a dynamic business situation. This approach gives a good general basis for problem solving which can then be carried into any other situation.

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