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PRICING POLICIES IN AN OLIGOPOLISTIC MARKET:

A SYSTEM DYNAMICS STUDY

A study of the design of pricing policies in a manufacturing firm, with specific reference to the synthetic fibre industry

by

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TO

MY FATHER AND WIFE AND SON

ABSTRACT

The objective of this thesis is to investigate and describe components of pricing system which influence the dynamic performance of a price leader manufacturing firm in an oligopoly capital intensive industry producing an identical intermediate product (s). The synthetic fibre industry is chosen as an illustrative case upon which the discussion is built. However, this work could generally be applied to a wide variety of organizations and situations.

After discussing the suitability of system dynamics to the formulation of long-run pricing strategy, a model of the pricing system is constructed by using this technique. The behaviour of this system is examined in terms of feedback loops. That is to illustrate how the characteristics of these loops and the interaction among them affect the dynamic behaviour of the system, and how this behaviour can be improved via changing the components of these loops and/or their structures.

The improved system is simulated under different external disturbances, certain parameter changes, and different pricing control policies. The simulation shows that the design of a set of robust pricing policies makes the system insensitive to external disturbance and error in parameters. It also shows that the ability of the firm to attain its growth and profitability objectives is affected by the chosen control pricing policies.

Some potential applications of the model, particularly, as planning and training tools are highlighted.

It is concluded that System Dynamics is an appropriate approach to the formulation of the long-run pricing strategies.

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CHAPTER I

INTRODUCTION

CHAPTER IINTRODUCTION1.1 The Nature of the Problem

One of the most perplexing of all market structures is the undifferential oligopoly where there is a handful of large producers of homogeneous products ^{which} can set prices. Under these oligopoly conditions price-setting is so terribly difficult because of the vast array of factors which must be considered and evaluated by the firm's top management. X

On the one hand, the firm which particularly acts as price leader, faces a complex environment for its products. Typically, it serves more than one market for which the demand characteristics of each vary dynamically over time. Secondly, it must consider the counterstrategy of producers of substitute products whose actions are uncertain. Thirdly, since the firm dominates its own industry, it must consider the possibility to alter certain industrial practices such as, discount structure, and price movements. Finally, government regulations, such as price codes, restrict the actions of the firm.

On the other hand, such a complex environment usually intersects with the highly capital intensive nature of the oligopolist's production system. Production requires a high capital investment per unit of output. Likewise, there is a tendency towards very large plant because of the economies of large scale production. The firm, therefore, occasionally carries out substantial expansion programmes. These programmes should be justified by the realistically computed profitability from the pricing policy. In fact, the pricing and investment policies are intimately connected.

Many other policies should be considered, in addition to those mentioned previously, such as costing, production, marketing and financing.

To clarify the interaction between the pricing and the other factors, and to highlight the important role of price in oligopolistic industries the following brief description of some policies in the synthetic fibre industry, which represents a classic example of this oligopoly (The Economist, November 20th, 1970), will be appropriate

The synthetic fibre industry is one of the leading growth industries in recent years. This industry has experienced almost continuous growth as it can be seen from Table 1.1. Producers, as a result, have rushed to build new plants. Moreover, high costs and the attempts of each producer to achieve maximum economies of scale, have contributed to the tendency for a high rate of expansion. Inevitably, this has meant overcapacity and price cutting. These developments have been worldwide (The Economist, September 3rd, 1966).

Actually, prices play a significant role in this industry, but so does non-price competition. The downward trend in prices, which is the result of the decline in unit costs as production volume increase, may have a very favourable impact on effective demand. Thus, Du Pont has reported, "The substantial rate of growth in the market for synthetic fibres, was stimulated by a long-term downward price trend, which broadens market penetration (Backman, 1970)." In the U.K., since the early 1960's, the price of synthetics has been falling (Shirly Institute, 1972).

Year	1967	1968	1969	1970	1971	1972	1973	1974	1975	Average annual growth rate in last 9 years
Production (Million Kgs)	194.7	268.4	291.4	336.9	357.3	373.9	453.9	396.1	361.1	9.3%
Annual Growth Rate (%)	11	38	9	16	6	5	21	-13	-9	

Table 1.1

Growth in Production & Delivery of Staple and Continuous Filament Synthetic Fibre

Source : N.E.D.O., Textile Trends 1966-1975: An Economic Profile of the U.K. Textile & Clothing Industries

In periods of economic stagnation, all companies have experienced slow growth which has been quite pronounced in terms of excess capacity. Excess capacity has created a pressure to cut prices to stimulate customer's demand. Actually, most companies experience price cutting. Some illustrations may be cited to show the widespread price cutting:

- (a) The big recession, which the textile industry had gone through in 1967, led to reduced list prices of polyester fibre to end "prevalent off-list pricing" (Backman, 1970).
- (b) The slump that hit the synthetic fibre market in 1970-1972 led to a loss in the operation of fibre division in I.C.I. (Gower Economics, publication, 1974).

In an attempt to decrease the significant impact of price cutting on sales and earnings to maintain profitability, some companies may try to cut costs. Cost cutting offsets price cuts to some extent. The following illustration shows cost cutting:

- (c) I.C.I. cut costs to improve the profit of the fibre division in 1973 (Gower Economics publication, 1974) by:
 - (i) concentrating production capacity at fewer factories
 - (ii) introducing improved technology.
- (d) Charles H. Sommer, Chairman of Monsanto Company, has pointed out that the pressure of lower price "has speeded up plant modernization and improvement, and has put pressure on production costs with rather remarkable results" (Backman, 1970).

The following quotation may shed more light on the dynamic aspects of pricing problems in this industry. W.J. Marshall (1967) has pointed out that "each decrease in price and each new fibre has increased the manmade fibre group's competitive strength with respect to the natural fibres (cotton, wool, silk), and allowed the new industry (refers to synthetic industry) to capture a large share of the total fibre market. As this share has grown, production (and capacity) has been expanded. Product refinement and innovation have been encouraged as sales and income increased, and while the costs of these developed activities were more rapidly absorbed. The increase in exposure, quality and variety of products has led to increased end uses and wider acceptance, assuring market growth. As the industries grew, they further developed the mechanics of production and techniques of management, thus, raising prior optimums of scale and other limiting factors to new and at least, potentially more profitable levels. With a greater variety of products being sold at lower cost, prices have continued to decline."

The foregoing paragraphs give an insight into the pricing problem and the dynamic aspects of it. Fig. 1.1. represents these aspects diagrammatically.

Up to now, two facts have become apparent: the complexity of pricing problems and the important role of price as a part of business strategy. Adding to these facts the observation that a considerable amount of pricing decisions are based on inadequate

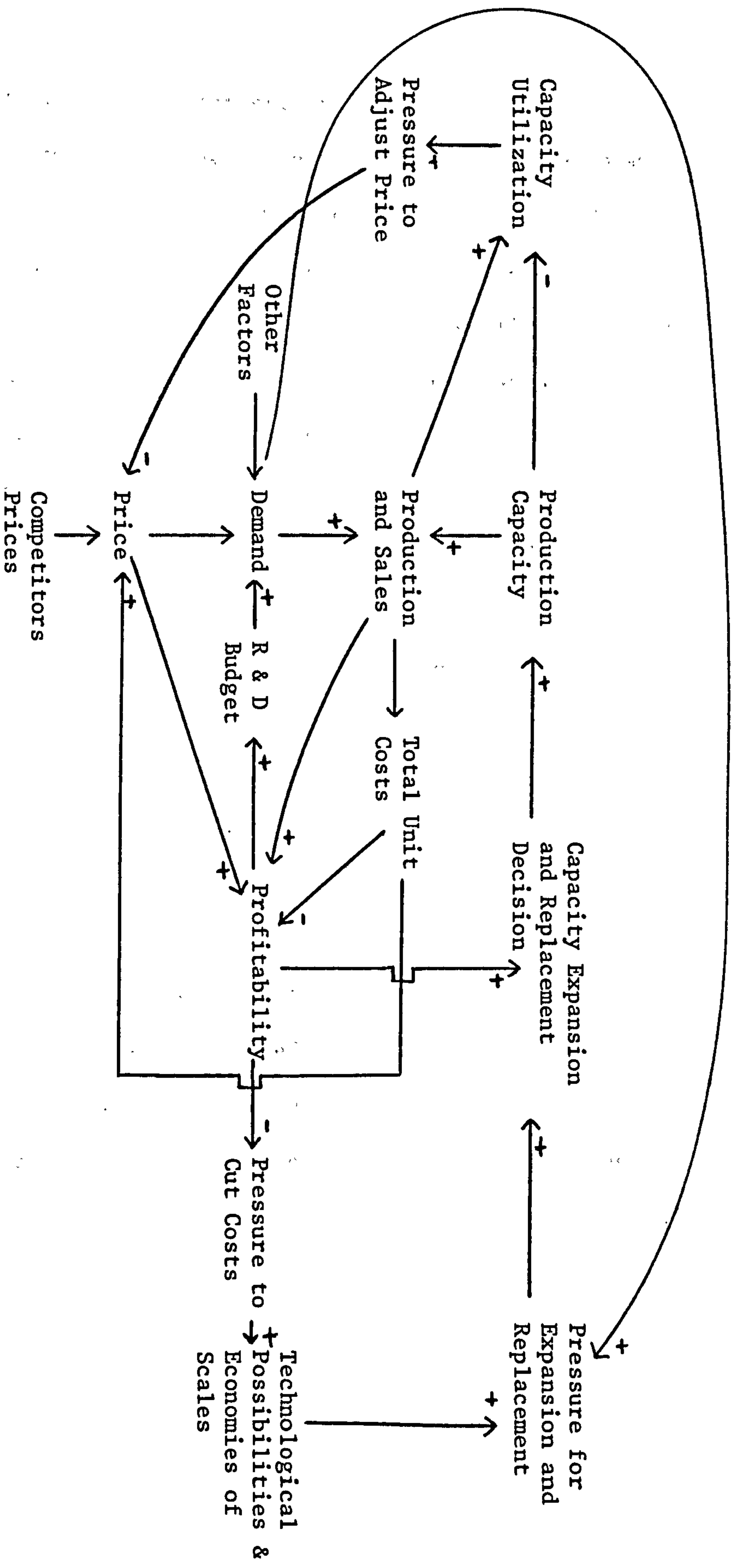


Fig. 1.1 Basic Causal Relationships in the Pricing System

information, a "feel" of the market, or just plain hunch (Backman, 1970). Moreover, the present highly unstable economic conditions have forced firms' top management to pay more attention to pricing problems and become increasingly interested to have effective pricing policies. In this context, Fuss (1975) pointed out that "Managers are, of necessity devoting much greater percentage of their time and efforts to pricing decisions than they did before". All of these factors have generated an increased interest to study the process whereby pricing policies are formulated. This is far from easy.

There is, as has been seen, a wide range of variables involved which must be considered. The interdependence of them in a dynamic environment is essential that they be taken into account and the causal relationship among some of them, that are of major importance in a policy formulation process, is very difficult to quantify. Such features are sufficient to create problems which are difficult to appreciate and solve. The need, therefore, is for an approach which can cope with these problems effectively, i.e. this approach should enable management to understand the dynamic behaviour of price systems, as a prerequisite step towards the formulation of pricing policies.

1.2 Short Review of the Literature

The pricing strategy field is one of the most explored. The literature abounds with models for pricing decisions. A short review of some of those works will give some specific indications of the applicability of the existing pricing models.

Some backgrounds are provided by Silbertson (1970) in his survey of price behaviour, which, supported by one hundred and fifty three references, he concluded that further work needed to be done on pricing of both an empirical and theoretical nature.

More recently, Oxenfeldt(1973) gave a critical look at literature trends. He pointed out "The current pricing literature has produced few new insights or exciting new approaches that would interest most businessmen enough to change their present methods. Although the current literature on pricing draws heavily on the behavioural science, quantitative tools and detailed empirical research, large gaps still remain".

In the following paragraphs we will throw light upon some existing techniques to tackle pricing problems. In addition, we shall attempt to evaluate them from the direct practical application point of view.

1.2.1. Economic Approach

There is no point in giving a detailed description of the models developed by economic theorists. For this study it is fair enough to evaluate them in terms of their comprehensiveness in dealing with the factors which affect pricing decisions, namely: demand, competition, costs and pricing objectives. (Br nner, 1971).

a) Demand

Firstly, demand from the economists' point of view represents a condition to which the firm must adapt, but businessmen are mainly concerned with methods of altering the level of demand schedule.

Secondly, the demand curve is static. Price theorists have tended to speak about price elasticity for individual products, as if it was uniform over the relevant stretch of the demand curve over time, but this is a misleading concept in terms of realistic price making. Price elasticity of demand probably varies considerably from one part of the demand curve to another and overtime.

Thirdly, demand law states that a reduction in price will increase the sales units because of income and substitution effects but this law does not take into account the effect of the price on buyer's evaluations and perceptions of the product itself (quality), and that customer reaction to price changes are affected by the passage of time.

b) Competition

With regard to competition, economic theory treats the interdependence among the competitors in an industry, and how everyone reacts to the price or output changes of others under two headings, (i) number of firms, (ii) cross-elasticity of demand.

- (i) Economics recognises three types of market situations: purely competitive, oligopoly and monopoly. From the businessman's standpoint the oligopoly market is of a paramount interest. Indeed, this is the area businessmen find help from economic theory. It is helpful in illuminating the nature of the environment in which pricing decisions must be made.
- (ii) The cross-elasticity concept does help to make precise and at least theoretically measurable, the degree of interdependence between any two firms. Businessmen's methods of measuring interdependence is different from that used with the concept of cross-elasticity; they frequently make "lost-order analysis" and "lost-customer studies" which indicate the circumstances under which business was lost and to which company and for what apparent reason(s). Moreover, economic theory considers only one reaction of competitor(s); it does not consider all possible reactions and the time lags of these reactions.

c) Costs

As far as costs are concerned, the economic theory does make full consideration of costs by using both average (full) and marginal costs in its decisions.

d) Pricing Objective (Firm's Objective)

From the economists' standpoint it is to maximize profit. In real life this is one of the multiple pricing objectives.

Each firm has often more than one pricing objective, although profit maximization may be the ultimate goal in the long run.

The conclusion which can be drawn from the preceding paragraphs is that the economic approach represents a severe simplification of the pricing problem as it is confronted in practice. The practical application of the models developed by economic theorists, therefore, is rare. (Kollat, et al., 1972).

1.2.2. Accounting Approach

In the accounting approach, which is called Cost - plus or markup, prices are arrived at by finding out what it costs to produce a product and then adding to it a certain amount for profit. This is a commonly observed method of arriving at prices in manufacturing industries as Wiles (1973) stated. The amount for profit is often fixed but it may vary to reflect consideration of demand and competition.

This approach, however, ignores demand and competition (Brenner, 1971), or it does not consider them to an adequate extent in the case of using a varying markup. Also it fails to take into consideration the impact of price on the attainment of a firm's long run objectives.

1.2.3. Bayesian Approach

The Bayesian approach to decision making under uncertainty provides a framework for explicitly working with the economic costs of alternative courses of action and the prior knowledge or the judgements of the decision maker. Green (1963) illustrated the applicability of this approach in his study of the Everclear Plastic Co. case. The objective was the determination of a best pricing policy for an industrial product where such factors as demand elasticity, competitive retaliation, threat of future price weaknesses, and potential entry of new competitor influence effectiveness of the company's courses of action. His search for possible courses of action indicated that four pricing alternatives covered the range of strategy under consideration. The problem has been described by a decision tree diagram for each pricing alternative. Each branch of the tree represents an event, the probability of which will be assessed by management.

The applicability of Bayesian approach therefore relies on management's ability to generate short-term forecasts. One may conclude that this approach is applicable only when decision periods are sufficiently short to render management forecasts meaningful. Beyond this time horizon, management can not make meaningful decisions between the alternatives.

1.2.4. Optimization Techniques

Optimization techniques such as linear programming, frequently employ unrealistic simplifications as with linear objective functions which, in fact, only linear approximation of the non-linear functions which govern the marketing environment of most businesses outside the short run and with constraints which are only introduced to reduce the number of admissible solutions. Thus, "the mathematical analysis almost never analyses a real problem but a simplified, somewhat unrealistic version of it", (Lewis, 1974). The following quotation may shed more light on the applicability of mathematical programming in general. Kotler (1963) has pointed out that, "The great majority of marketing problems would remain intractable to ordinary mathematical solution. For example, the correct price to charge depends upon elements such as the future sales outlook, the possible reactions of competitors, the time lags of these reactions, the intended level of advertising support, an infinitum. A complex phenomenon is characterized by feedbacks, distribute lags, uncommon probability distributions and other features which render exact mathematical solutions difficult or impossible."

1.2.5. Econometric Models

Based on historical data, this technique (the multiple regression) determines a linear functional relationship between a dependent variable such as price and independent variables such as unit labour cost, unit material cost, inventory change, and backlog change.

The function(s) may show a statistical fit to the historical data and be useful in prediction if the real system remains unchanged in the future. Consequently, the applicability of this technique depends upon the nature of the real system. Whereas the market environment of most businesses changes over time and this technique fails to get at the dynamic characteristics underlying observed market behaviour, the application of it will remain limited to few cases.

1.2.6. Simulation

Simulation has been increasingly applied to a wide range of marketing problems including pricing problem. A number of models have been developed to treat various aspects of the pricing problem. Indeed, simulation technique has the potential to contribute substantially to policy and strategy formulation by answering the question: "What if" (IBM, 1966).

1.2.7. System Dynamics

According to my knowledge, there is only one study which deals with the pricing problem. In investigating the determinants of price of a new industrial product and to explore the impact of different policies, Miller (1961) constructed a system dynamics model describing the behaviour of the producers of this product.

The model has been divided into three sectors:

- (i) the market
- (ii) the innovator - which includes: market development, pricing, and production and capacity acquisition sub-sectors
- (iii) the competitors sector which are represented as an aggregate competitor in the model.

In very brief terms, the variables considered in changing the price are capacity utilization, competitor's price and markup over cost. Unit cost is considered a function of unit labour cost, market development and unit overhead cost (include everything else).

This work, however, has oversimplified the treatment of these costing variables. Also it has treated price as a continuous variable. This means that price includes implicitly discount (price shading) policy. There is a great need today, from the management's standpoint, to deal explicitly with discount, in order to design a flexible discount policy to meet short term fluctuation in demand. Lastly, in this work no attempt has been done to investigate the interdependence between price and the market efforts, although a change in any one may lead to alter the other.

1.3. Purpose of The Present Work

The objective of this work is to develop a system dynamics model of the long - run pricing strategy, for a leading manufacturing firm in an oligopoly industry producing an established intermediate product, i.e. synthetic fibre type. The model can then be used to assist corporate management to explore the implications of various long - run objectives, in particular, long-run profitability, stabilize price, maintaining the firm's market share and increasing total industrial demand and how these specified objectives may be achieved. In doing this the main causes of price movement will be determined and the impact of different current pricing decision rules on the behaviour of the overall system will be assessed to determine those most likely to be satisfactory in use or indeed, to devise new ones, if necessary.

In short, the model is intended to provide satisfactory answers to the following questions:

- a) How do the pricing policies affect the overall performance of a firm?
- b) Do the managerial pricing control policies have significant effects on the dynamic behaviour of the system?

In this study we are not going to overcome the enormous problems associated with the developing of a price strategy, but only some of them. Particular attention, therefore, is given to the following policies:-

- (i) promotion policies (quality, advertising)
- (ii) discount (price shading) policies
- (iii) costing policies

Other pricing control policies such as cost reduction and credit policies are omitted from consideration.

With regard to the level of aggregation, my model will be, in some aspects, more aggregate in nature and less complex than the model intended to study the dynamics of day to day marketplace:- pricing to maintain from day to day.

1.4. Organization of the Thesis

The thesis is divided into three parts:

Part One: is devoted to discuss the applicability of system dynamics technique to tackle pricing problems. After the discussion of the nature of pricing problems the relevance of this technique to these problems is examined in comparison with the other simulation techniques.

Part Two: deals with model construction and test. After formulation^{of} the problem and determination of the objectives which the model aims to achieve, the process of pricing policies design and quantification is discussed. Following this, the feedback loops included in the system are analysed to indicate how the characteristics of these loops and the interaction among them affect the dynamic behaviour of the system. This is followed by an examination of simulation results of the developed model to find out the possibilities to improve the performance of that system. The improved system is then tested to define the sensitivity of the variables as well as the behaviour of the whole system to changes in the values of certain parameters.

The last chapter in this part deals with the experimentation of the model under different pricing control policies to discover which policies are more effective in attaining overall the firm's objectives.

Part Three : is concerned with some aspects of model applications.

It begins with specifying the required input data and their sources.

The nature of the model output is then discussed. Following this the features of the model are defined and its potential applications are discussed. It is ended with a chapter on the main conclusions and the desired further studies.

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P A R T O N E

THE APPLICABILITY OF SYSTEM DYNAMICS

TECHNIQUE TO TACKLE PRICING PROBLEMS

CHAPTER II

PRICING SYSTEM AND METHODOLOGY OF THE RESEARCH

CHAPTER IIPRICING SYSTEM AND METHODOLOGY OF THE RESEARCH

This chapter is divided into two sections. They are:

1. Characteristics of Pricing System

In this section we try to explore the most important characteristics of pricing system in industrial markets. Briefly, we try to answer the two following questions:-

- a) What are the characteristics of a pricing system?
- b) How do these characteristics make this system intractable to formal mathematical solution?

2. Methodology of the Research

In this section we try to determine the appropriate approach to the formulation of pricing strategy. To do so a brief account of the advantages and disadvantages of one of the most important techniques, namely simulation in respect to this application is given. We then discuss why system dynamics is considered an appropriate approach to formulating pricing strategy.

2.1. Characteristics of Pricing System

2.1.1. Marketing - Concept and Function:

It would be appropriate, before discussing the characteristics of pricing/marketing system^{*}, to throw a light on marketing as a concept and a function.

The key idea of marketing is that business thinking and planning start by considering consumer needs. This seems a matter of course. However, it has only been recognized by business organizations in the last decade. In this context Giles (1974) has pointed out, "The practical implications of consumption being the purpose of production have only in the last decade or so been recognized by business organizations". This shift in business philosophy from a production orientation towards a marketing orientation is caused by the present economic, social, political and technological conditions.

The adoption of marketing orientation implies that customer satisfaction becomes the focus of business operation. Customer satisfaction, of course, should be related to the need for the business to satisfy its objectives. This is the marketing concept. In Kotler (1972) words " The marketing concept is a customer orientation backed by integrated marketing, aimed at generated customer satisfaction as a key to satisfying organization goals."

* In this research we are concerned with pricing/marketing strategy rather than pricing strategy. Therefore, the terms pricing system and marketing system will be used interchangeably throughout the thesis.

This concept, in the marketing operation, involves all those concerned with meeting the firm's customer requirements not only those which would functionally be called 'marketing'. In other words, marketing is concerned with every aspect of a firm, which in any way affects the attitude of customers to the output of that firm: such as research and development, production planning, stockholding, credit, pricing and advertising policies.

On the other hand, marketing may be viewed as major marketing activities such as pricing, selling, advertising, and distribution put together as a functional activity, and considered separately from the production and finance functions.

In short, marketing can be viewed as an isolated function or it can be viewed as an interdependent sub-system in the whole system of a firm as the marketing concept refers to.

For the purpose of this research marketing will be viewed as an interdependent sub-system of the system of the firm. This is because the interaction between that sub-system and the other sub-systems, namely production and finance, affects considerably the performance of marketing sub-system as well as the overall system.

What is important to mention is that an understanding of the marketing concept, and its implication for marketing decision-making is essential from a strategy formulation standpoint. The formulation of pricing strategy must be done in a system context. Developing appropriate pricing policies must be based upon a thorough understanding of the dynamic behaviour of the overall system. In Forrester (1968) words, "Market dynamics can only be understood in the context created by other company functions because these functions produce the variables with which marketing must deal".

2.1.2. Characteristics of Pricing System

Despite the fact that the nature of pricing policies in industrial marketing differs from one firm to another, there are certain general characteristics which should be recognized before selecting the approach to be used in the formulation process. The most important of those characteristics are:

a) Interdependency:

There is a high degree of interdependence between the marketing system and other firm's system, namely production and financial systems. In this context Forrester (1965) pointed out that "Marketing could not be successfully isolated from its dynamic interactions with other company function".

This interdependence is more important in industrial marketing than consumer marketing. In this context Mattsson (1975) emphasized that, "The interdependencies in the seller firms total organization are more serious in industrial marketing analysis than in consumer marketing". This is due to the presence of limited numbers of potential buying firms in the industrial marketing. The interdependency between them and selling firms is usually high, so that, the seller's goal - fulfillment is noticeably affected in several individual relations to buying firms. Therefore, the direct and often long-term relations are of great interest to the total firm.

These direct and often long-run relationships between seller and buyer may well be progressively strengthened by the mutual trust between them. The first important factor which contributes considerably to this trust is the ability of the seller to serve as a supplier that suits the needs of the buyers. This is dependent on the activities of the whole firm rather than marketing alone. The importance of the factors which affect the long-run seller/buyer relationships make Fisher (1976) suggest that, "marketing and corporate strategies may be difficult to separate in industrial marketing, and long-run customer/supplier linkages are one factor fusing the two together".

This phenomenon creates difficulties for the manager in following and recognising the consequences of a change in a marketing policy on the whole system without special assistance. Model-building techniques are very useful to a different degree in this respect.

b) Complexity

The marketing system is extremely complex. It is made up of a series of interdependent sub-systems each involved with complex relationships with the other as well as the firm.

The complexity of marketing systems means it is difficult for the manager to foresee the consequences of a change in the parts of the system and he can not intuitively appreciate the dynamic behaviour of the overall system.

c) Nonlinearity

Most of the relationships between the variables of marketing systems are nonlinear, e.g. decreased price may lead to increased sales but not proportionately and the percentage improvement in product quality is not the same percentage increase in R & D Budget. Such nonlinearities coupled with system time delays and feedback loops create the behaviour mode of that system. In this context Forrester has pointed out, "Some of the most important behaviour mechanisms in marketing depend for their very existence

on nonlinear relationships." This nonlinearity makes formal mathematical solutions to marketing problems very involved.

d) Intangibility

Pricing system involves many important intangible variables which may be difficult to express precisely in quantitative terms. Examples of these variables are responses of customers and competitors to a price change. Meanwhile, our understanding of the dynamic behaviour of the marketing system and the main causes of that behaviour required the measurement of these intangible variables.

Consequently, the formulation of pricing and marketing policies requires a technique which encourages the approximate quantification of such variables. This is better than ignoring their impact on the system altogether or attempting precisely to define relationships between these variables through massive data analysis (Rivett, 1972).

Moreover, this data analysis may not give accurate estimations of these variables. In this context Oxenfeldt (1975) has pointed out, "Few, if any, manufacturers could accurately estimate the effects of a general price reduction on the basis of a statistical analysis of the firm's market history".

He attributed this to the following reasons:-

- i) markets for many products change substantially over fairly short periods of time so that the effect of price on sales would differ between the beginning and the end of, say, a ten year period. Statistical generalizations about this relation would be based on the presumption of unchanged relation.
- ii) Firms themselves sometimes change the emphasis that they themselves place on price appeal. In that case, the relation usually changes over time.
- iii) Market development such as the entry and departure of rivals would ordinarily affect the responsiveness of customer to change in price.

e) Uncertainty

Pricing and marketing policies are, mostly, concerned with generating income through processes, the effects of which are usually unpredictable. It is subjected to uncertainty which results mainly from unpredictable environment changes.

In this context, the Committee on Cost and Profitability Analysis for Marketing (1970) has pointed out that the promotional system (marketing sub-system) involved all the complexity of the other two systems (the production and physical distribution system) plus the complexities introduced

by the uncertain demand for the product and the virtually innumerable ways of meeting (or changing) that demand and uncertain outcomes from pursuing various input alternatives.

f) Dynamic behaviour

Because of the dynamic state of different forces including economic condition, technology, social changes and product life cycle, a marketing system can never be static but is dynamic. The dynamic phenomena have been observed over the previous periods and will continue but the behaviour mode may be different in the future. (As an example, the recent history of fibre prices is shown in Appendix C). This dynamic behaviour could (or could not) cause undesirable implication in some of the firm's other flows because of system time delays coupled with feedback loops.

g) Goals conflict

All firms have multiple objectives of which price and marketing policies are used to reach them. For example, the relation of price to firm's objectives is seen in Fig. 2.1. These objectives are often in conflict and their relative importance are changing over time. Moreover, sub-goals, for different sub-systems might be in conflict. A good policy for a particular sub-system may be a bad one for another. For instance, there is a possible conflict between the marketing, production and financial sub-systems regarding the price of a product.

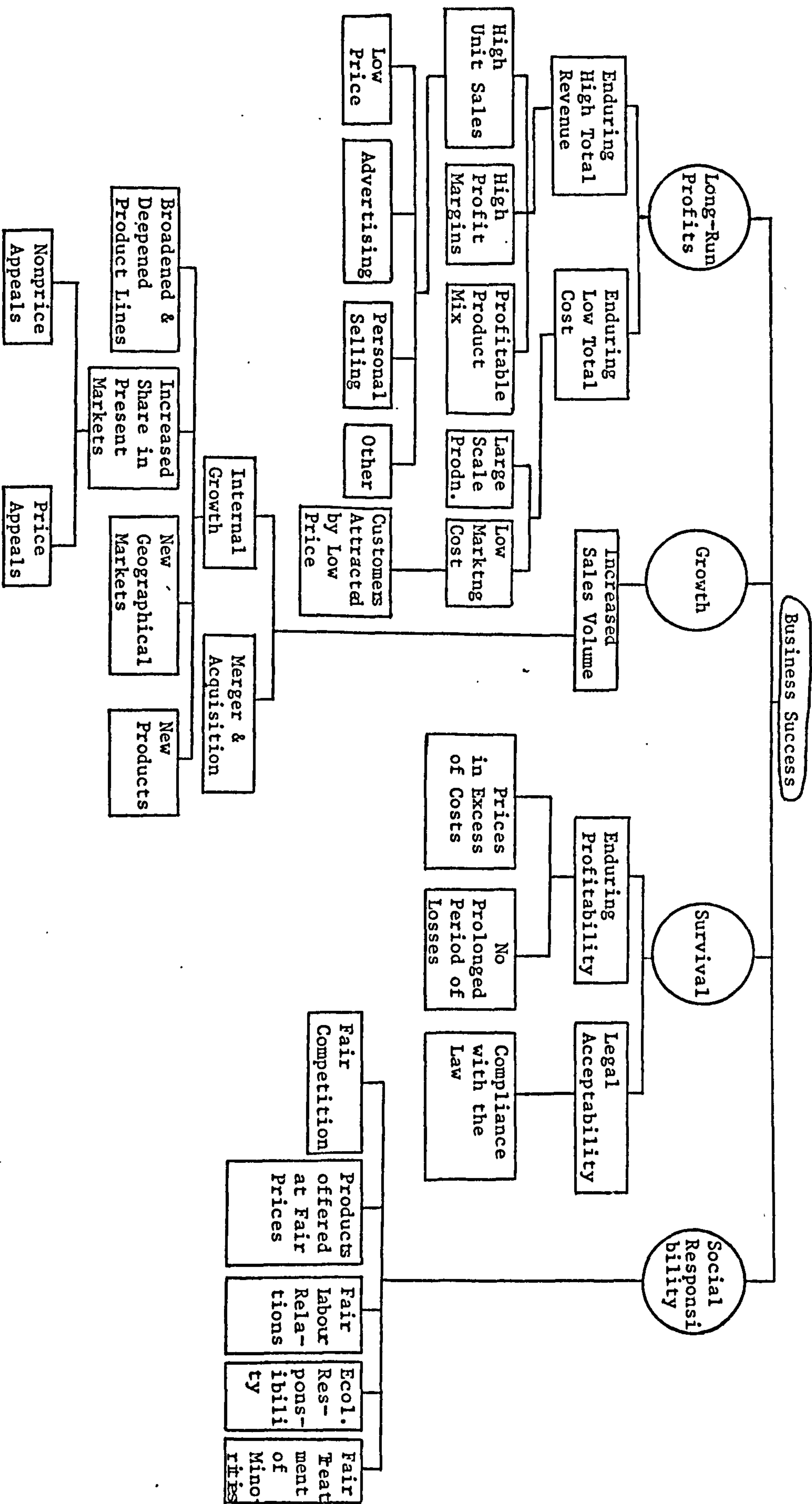


Fig. 2.1. Relation of Price to Ultimate Business Objectives
 Source : Oxenfeldt, Alfred R., "Pricing Strategies", Amacom, New York, 1975. p.p. 43-47

In sum, marketing systems are extremely complex, dynamic, non-linear and interdependent. Many components are not easily measured and controlled. There is a high degree of uncertainty. They interact with external forces including the environment and competitors.

The primary question that must be addressed here is:

which approach would enable the researcher to cope best with the complex nature of pricing strategy formulation. In other words, the selected approach should enable the researcher to understand the main causes of the behaviour of the marketing system over time, and to assess the impact of different current marketing decision rules on the behaviour of the overall system to determine those most likely to be satisfactory in use, or indeed, to devise realistic and workable ones, if necessary.

The last point leads us to the next section, which is concerned with the approach being used to achieve this need.

2.2. Methodology of the Research

Now it should be obvious that the relevant approach for the solution of pricing problems must be one of the approaches which are drawn from many disciplines such as business administration, accounting, economics, engineering, statistics and behavioural science. In short, it must be interdisciplinary approach.

Basically, there are two methods which are of value in different ways in this respect. They are: simulation and System Dynamics. Each method will be discussed briefly.

2.2.1. Simulation:

System simulation is defined by Gordon (1975) as "the technique of solving problems numerically by following the changes over time of a dynamic model of a system". The definition is broad enough to include simulation involving the stochastic selection of variables (e.g. Monte Carlo techniques), Man-Machine simulations (e.g. financial modelling) and system dynamics. However, in this research simulation means all of these methods except system dynamics which has its distinct features.

Simulation is a powerful tool to solve complex, interdependent, nonlinear and dynamic problems. Examples of the application of simulation in marketing areas can be found in IBM (1966).

System simulation has the following advantages. Firstly, it enables decision makers to study the complex interactions between, as well as, within sub-systems which play an important role in finding the best overall solution, and the multiple effective upon results.

Secondly, "it provides a framework within which experiments can be conducted. The sensitivity of the system to changes in the magnitudes of its variables and to changes in relationships among the variables can be observed. Critical variables and significant relationships can be confirmed or rejected. Factors having negligible influence on final outputs can be identified. The impact of current policies on future system behaviour as well as the influence of potential policies can be tested" (Kornbluh, et. al, 1976).

Thirdly, simulation does not require high mathematical sophistication with which the average manager is not familiar. It requires from him the ability to recognize the structure of a situation which he possesses (Piddel, 1977). This enables non-technical managers to understand the system analysis efforts. This understandability is essential to get the full support and involvement of management in model construction and for successful implementation of the changes recommended.

In spite of these obvious virtues of simulation, in complex large problems the task of exploring all the possibilities of parameter changes by the use of trial and error, creates a volume of calculations that may swamp the analyst. Moreover, there is no guarantee that the achieved results will be the most satisfactory ones. In this context Coyle (System Dynamics Research Group) points out that "The drawbacks of simulation are that the study may become lost in an interminable round of computer runs and there is little guarantee that the most satisfactory result has been achieved". Unfortunately, this is not at all uncommon.

This fact has led some writers to suggest a new technique which has the advantages and eliminates most of the disadvantages of simulation. It is the system dynamics methodology which is developed by Forrester (1961) and his co-workers at M.I.T.

System Dynamics techniques combine the advantages of mathematical analysis and simulation "in that it uses a simulation technique to test predictions about the system behaviour as a result of an analysis of the properties of its feedback loops" (Coyle, S.D.R.G.).

In the rest of this chapter we are going to define why the system dynamics methodology is the appropriate technique to formulate long-run pricing and marketing strategy. But we are not going to discuss the technique itself. It is assumed that the reader of this thesis is familiar with it. The interested reader can find in "Management System Dynamics" (Coyle, 1977) extensive bibliography of over 60 references on the theory and application of system dynamics.

2.2.2. Methodology of the Research: System Dynamics Methods

We can state that system dynamics would be the appropriate approach to formulating pricing/marketing strategy for several reasons:

- (i) As shall be indicated the interaction between the company and its market forms a closed feedback loop type system of relationships. System Dynamics is of great value for this feedback loop system.
- (ii) Marketing strategic problems are ill-defined. In this situation the understandability of complex interaction of factors and its effect on the behaviour of the system are the major concern of management. System Dynamics, which focus attention to feedback loops form the system, provide great aids to the management to understand how the system operates and why it behaves in that way.

- (iii) Marketing systems are dynamic, their future behaviour is affected by the results of both past and present policies as well as by changes in environment. Consequently, the formulation of long-run pricing strategy can be carried out by using system dynamics which is applicable to dynamic systems whose conditions change over time, and where the past influences the future.

Before ending this chapter it is worth emphasising that the System Dynamics model is a tool to assist the decision maker in making pricing decisions, but it is not subordinated to his judgement and experience.

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PART TWO . . .

MODEL CONSTRUCTING AND TEST

CHAPTER III

MODEL FORMULATION

CHAPTER IIIMODEL FORMULATION

In this chapter the model formulation process will be presented in two sections.

Section One focuses on the initial and essential step in developing a system dynamics model. This step includes the definition of the problem, the specification of the objectives of the model to be achieved, and the determination of the appropriate performance criteria for system evaluation.

In Section Two the model formulation process itself will be examined. The boundary of the model will be drawn and the included relevant variables will be decided. The acceptable level of aggregation will be determined. On the basis of the boundary and level of aggregation an influence diagram of the model to show the causal relationship will be constructed.

3.1. Problem Definition, Model Objectives and Performance Criteria

This section deals briefly with three inter-related points, namely: diagnosis of the problem, objectives of the model to be achieved and performance criteria.

We have stated in chapter one that the determination of the pricing policy is one of the most crucial problems facing top management in price leader manufacturing firms today because the price policy will affect the success of these firms in the market. On the other hand, these firms commit a great deal of resources to technological and productive efforts which should be justified by the realistically computed profitability from the pricing policy. Furthermore, the chosen policy can slow or hasten the firm's growth and either cause or prevent fluctuations in sales. It can also increase or reduce the probability of labour and government intervention; instill the trust or suspicion of competitors in the integrity of one's business practices. The main symptoms of this problem can be summarised as follows:

- (i) Pricing policy is a very complex process. Many variables must be considered and many alternative course of action should be evaluated. Meanwhile, price policy is inter-related with all other marketing policies and all of them must be brought into a consistent body of policy and action. Obviously, this is beyond ordinary skill and experience. It is, therefore, necessary to resort to a model which guides the process of formulating these policies.
- (ii) There are many alternatives available to price setter, selecting any affects the dynamic behaviour of the firm, what is the number of price changes during a given period? what should be magnitude of these changes? what are the directions of the price changes? what is the time interval to which price change applies? what are the customers responses to these changes? what does the other marketing action combine price changes? These are some of the crucial questions which require extensive and deep investigation.
- (iii) Price administration is subjected to external shocks such as change in industrial total demand, price code, tax policies, price of competitive products and inflation rate. It is, therefore, required to construct a set of ROBUST sensible price policies which make the system relatively insensitive to such shocks. The term Robustness in this research means that the system responds satisfactorily to the external shocks, and insensitivities to errors in estimating parameter values and functional relationships (Coyle, 1977).

These symptoms frame the main objectives of the proposed model to be achieved which are:-

- I. The model should provide satisfactory answers to the following questions:
 - a) how do the pricing policies affect the performance of the system?
 - b) do the managerial control policies have significant effects on the behaviour of the system?

- II Moreover, the model should provide the critical information in easy-to-use form for redesigning a set of pricing control policies which enable achievement of various desirable long-run objectives such as maintaining the company market share, increasing industry market share, long-run profitability, and stabilizing price. These policies should be ROBUST (Coyle, 1977), i.e. they should produce a satisfactory mode of behaviour under different external shocks such as any movement in the prices of the competitive product (s).

Clearly, the achievement of the model to its objectives, which have been stated in the previous paragraphs under a wide range of market conditions, represent the appropriate criterion to evaluate the performance of this system as a whole, and its sectors such as pricing, costing, and promotion and quality. The model must also be compatible, defensible, flexible, simple, understandable and acceptable. These requirements will be discussed in Chapter 10. (The problem of evaluating the performance of this multiple-objective model in quantitative terms will be discussed in Chapter 8.)

3.2. The Structure of the Model

This section deals with three points: the boundary of the system, the level of aggregation, and the influence diagram construction. The first two points are the pre-requisites of modelling a system and the basis of constructing its influence diagram.

3.2.1. Boundary of the System

The important step in developing a system dynamic model is to decide upon the boundary between the controller and its environment and complement. Moreover, it should determine the relevant variables to the problem to be included in the system. Before doing so, we feel it is necessary to decide what is the system to be modelled?

a) The system to be modelled

The purpose of this research as it is stated in chapter one, is to tackle some pricing problems of a hypothetical leading firm in a capital intensive industry producing an intermediate product(s), and its market is oligopolistic with identical product(s). For the sake of guiding, the development of the model and selecting some of its parameters, it becomes necessary to choose a specific industry.

The industry chosen is the synthetic fibre industry. It is a growing industry. The basic products of this industry are polyester, nylon and acrylic. Prices among all suppliers are identical and products are comparable. The synthetic fibre industry relative share of U.K. consumption of fibres amounted to 40 per cent in 1972 (NEDO, 1972).

Four industrial end uses comprised the marketing for synthetic fibres. These fibre users are: clothing and piece goods, household textile and similar goods, carpets as well as industrial uses. (Programmes Analysis Unit, 1973).

The synthetic fibre industry's competition in those four sectors of the fibre market consists of two other types of fibres: natural and cellulosic fibres. The entire fibre competitive system has been shown in Figure 3.1.

It can be noticed, that there is no information flow in this figure about qualities and prices of man made fibres to natural fibre sector. This does not imply that natural fibre producers have stood by idle in the face of the competition of man made fibres, but it implies that their efforts to improve fibre qualities (properties), which are limited by the physical properties of those fibres, have no significant effect on the competitive position of man made fibres. In

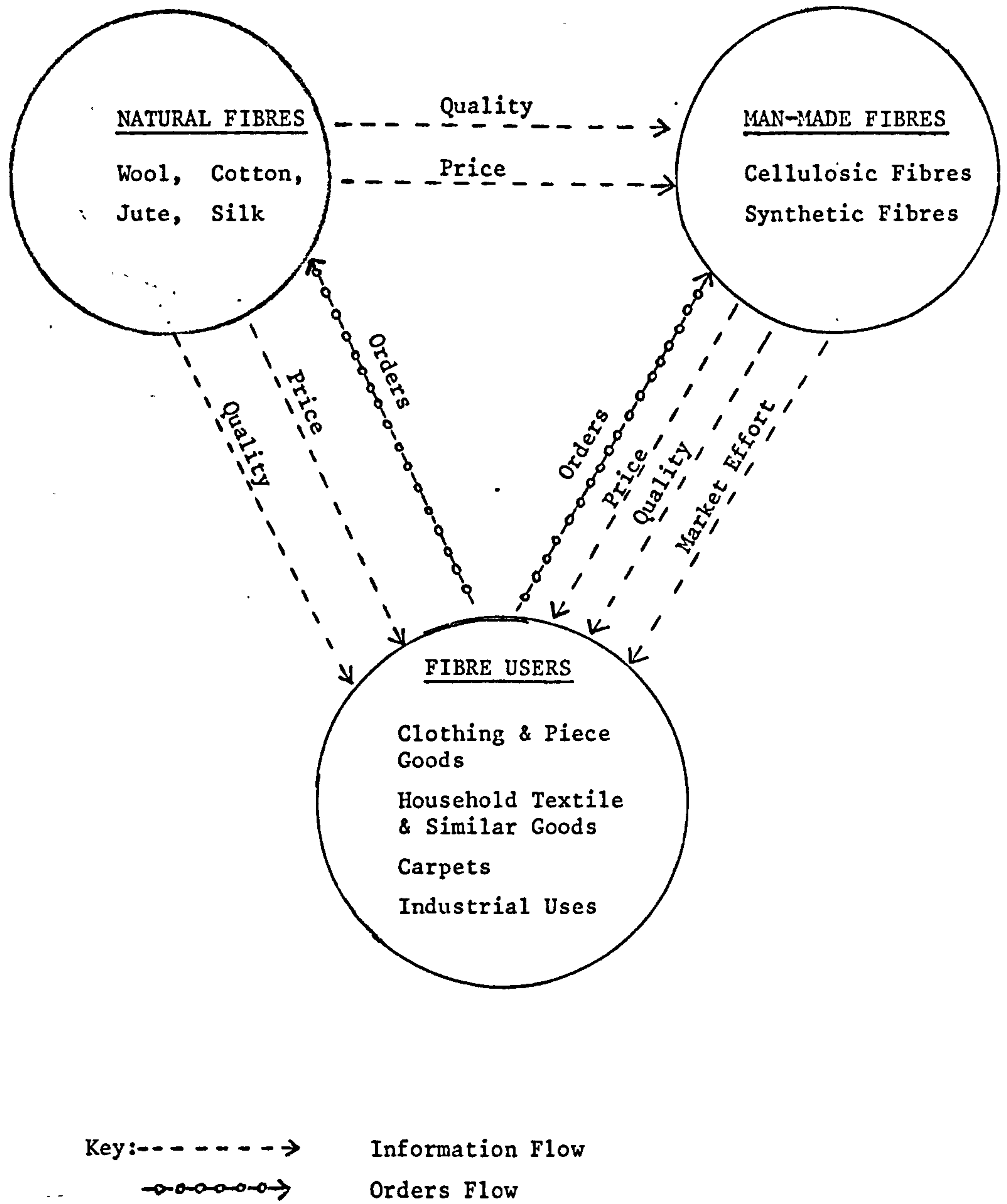


Fig. 3.1. Entire Fibre Competitive System

Source (with Modification): McPherson, L.F. et al.,
Advanced Systems Analysis of Textile Problems,
Pugh-Roberts Associates Inc., March, 1966.

this context, the Shirley Institute's report dismisses the challenge from natural fibres as follows: while intensive work on natural fibres has certainly endowed them with some degree of easy care property there is no reason to believe that synthetic fibre with greater hydrophilic properties could not be produced if the economic rewards were greater enough (NEDO, 1977). With regard to man made fibre prices, they do not affect in any way natural fibre prices. The latter is determined by the world supply/demand conditions.

The extreme complexity of entire-fibre competitive system makes it necessary to exclude some sectors of this system and integrate the others, because, the extensive investigation required to incorporate all these sectors with required details could not be accomplished in this thesis, and beyond the scope of this research.

Firstly, the criterion for inclusion has been the effect of the sector on the competitive position of synthetic fibres. Any sector whose behaviour could be expected to influence synthetic fibres has been included under this criterion. For example, synthetic fibres compete quite widely with natural fibres. It is therefore necessary to consider the implication of this competition in view of the relative ease with which a fibre user can change over from one fibre to another. On the other hand, cellulosic fibre industry may

compete with synthetic fibres, but since that industry had become mature (it may enter the declining phase), as can be inferred from the statistical information presented in Fig. 3.2, it is not included in belief that this competition is not very important and natural fibres represent the primary competition for synthetic fibres.

Secondly, the criterion for the integration has been the aim of the research. Here, two points have been examined carefully: interfirm competition and market segmentation.

Interfirm competition is dependent upon the characteristics of the particular market. The market for synthetic fibres is oligopolistic with identical product(s). Essentially, there are few large firms dominating the synthetic fibre industry and a host of smaller firms play a passive role. "Prices charged for a particular fibre by one producing firm tend to be identical with those of all other firms over any particular period of time. Price changes do occur and they occur in response to events in the market place. Most changes in the synthetic fibre industry are initiated by a barometric price leader. This term has been defined by Stigler as a firm that commands adherence by rivals to its price only because its price reflects market conditions with tolerable promptness (Marshall, 1968)". Under this condition of relatively

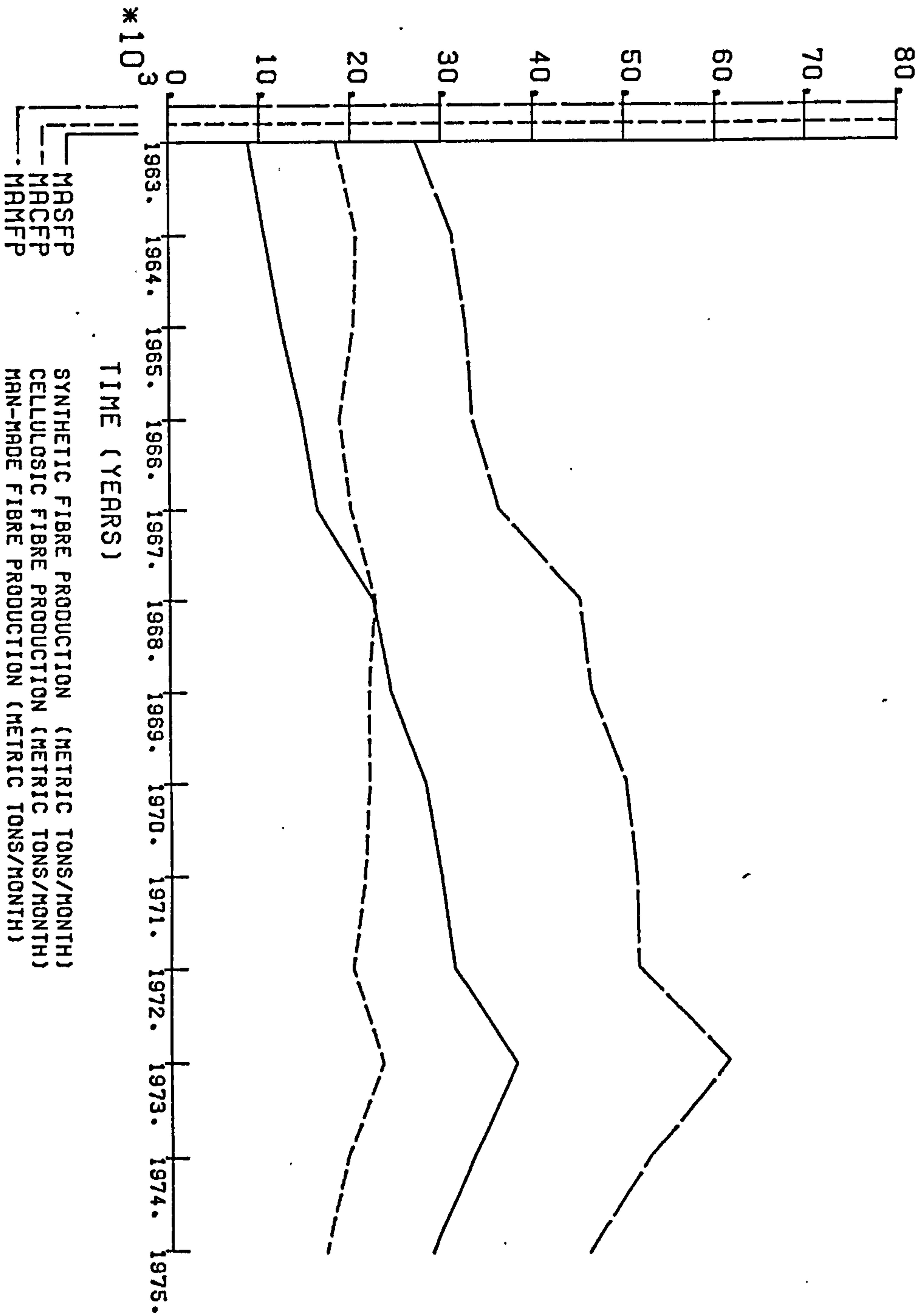


Fig. 3.2: UK MAN-MADE FIBRE PRODUCTION (MONTHLY AVERAGE)
 SOURCE: UNITED NATION MONTHLY BULLETIN OF STATISTICS

uniform price level, it is reasonable to assume that the distribution of market share across all competitors within the synthetic fibre market should remain fixed, even in the growth market. This assumption is valid as long as each competitor can meet the capacity requirement for his pro rata share of the growth market. This will be held in this research.

In this case, the differentiation between the industry and the leader serves nothing and the undifferentiation does not weaken the model on the grounds that the leader firm determines its price and output policies and its competitors, which have the same structure, following the same policies. The following quotation supports this argument, "ICI fibres, Britain's biggest fibre producer, is to put up the prices of all its nylon and polyester. ICI's move is likely to be followed by other U.K. producers" (The Financial Times, 1976). They can, therefore, be combined so that the industry has been considered as a representative of the price leader.

In regard to market segmentation, since it is not intended to develop a model to study the dynamics of day-to-day marketplace-pricing to be maintained from day-to-day, it is reasonable to integrate the four sectors of fibre market into one sector.

Figure 3.3 shows the system to be modelled.

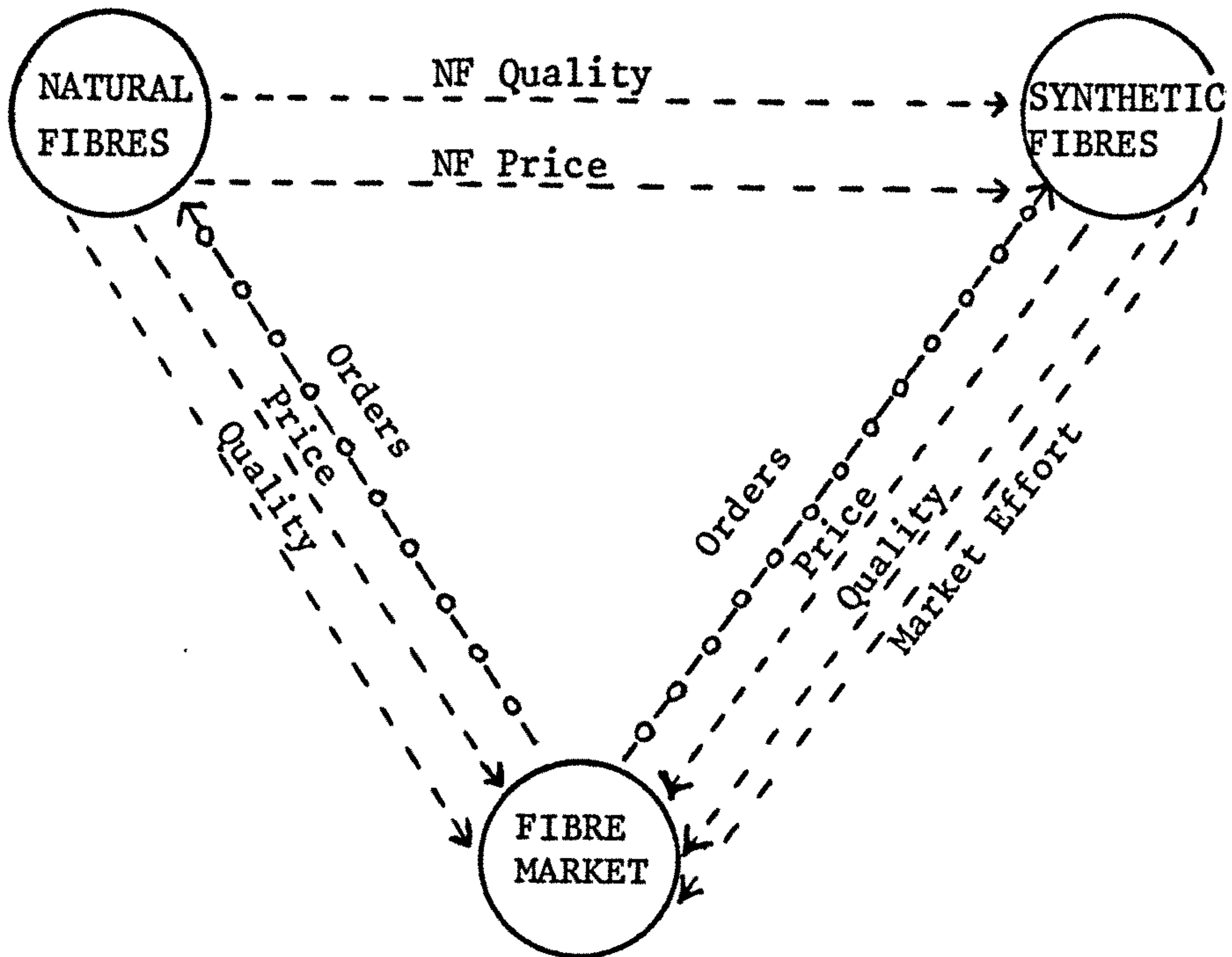


Fig. 3.3. The System to be Modelled

b) Boundary of the system

A close boundary should be drawn for the system to be modelled.

It is therefore necessary to determine what the relevant variables to the problem should be included in the model, and the variables to be safely left out. To do so, the variables that are obviously relevant to the problem under study, as acknowledged by any theory which surrounds this area of investigation, should be defined. Then they should be discussed with the people involved to choose those factors to be included in the model (Carter, 1973). Because we are unable to contact the people involved as regards this particular study, it becomes necessary to depend on the theories which surround the pricing system for choosing these relevant variables.

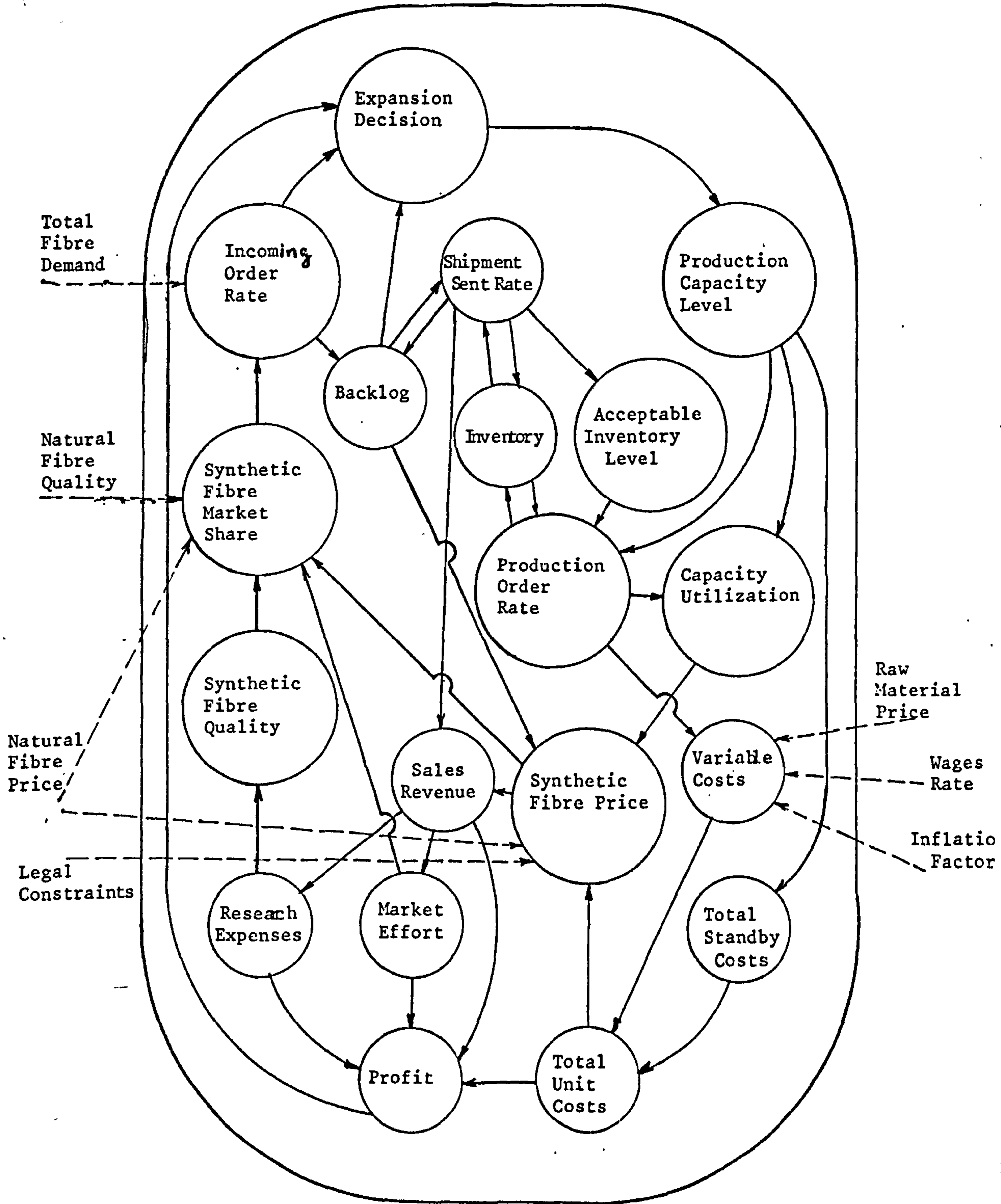
Therefore, our understanding of accounting, financing, pricing, marketing and economic theories coupled with general knowledge of the fibre industry are the major sources used in drawing the boundary of the model and choosing its variables. Figure 3.4 shows the endogenous and exogenous variables which are assumed to affect the problem concerned.

3.2.2. Aggregation Level:

After the determination of those aspects of the system, which are relevant to the objectives of the study and should be included in the model, it becomes necessary to consider the level of aggregation; the extent to which a number of individual factors can be grouped together into a single aggregated one. Two criteria control the process of aggregation:

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Figure 3.4 The Boundary of the Model



- I - The adequacy of the model to provide answers to the questions for which it is designed; and
- II - The accuracy of the model as a representative of the real system. In this context a trade-off has been made between simplicity and realism. However, the former has been weighted over the latter.

To carry out this process, there are two techniques that can be used: the LIST EXTENSION METHOD (Coyle, 1977) and mathematical techniques (Sharp, 1974). We have, in this research, applied LIST EXTENSION METHOD. This method has the following advantages:

- 1) It is so simple to apply, in particular by non-mathematicians.
- 2) It is very effective in highlighting the significance of each factor (or group of factors) on the behaviour of the system.

After experimenting with different levels of aggregation an acceptable level of aggregation in the model has been achieved.

3.2.3 The Influence Diagram Construction:

Based on the available information about pricing policy and the related activities, pricing and marketing theories, economic concepts, conventional accounting principles and discussion carried out with system dynamicists a system dynamics pricing model has been constructed. A simplified influence diagram of this model has been shown in Figure 3.5. The following points should be noted in connection with the diagram:

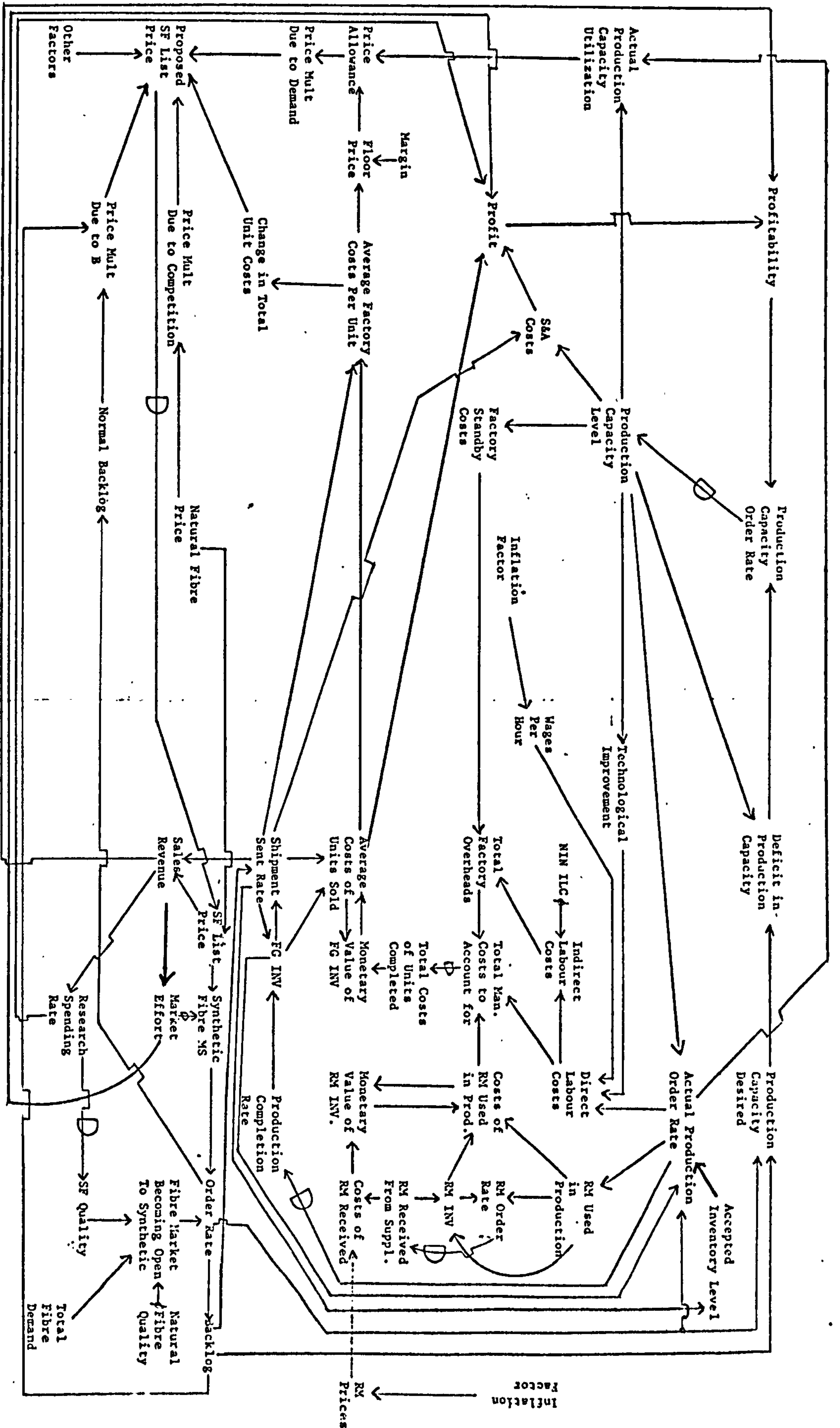


Figure 3.5 Simplified Influence Diagram of The System Under Investigation

1. It is assumed that:-

(i) The firm produces an intermediate product (s).

In reality all leading firms are multiproduct. For instance, ICI produces all main synthetic fibres such as polyester and nylon. Among those fibres there is vigorous competition for the market such as the competition between polyester and nylon in tire cord.

This competition which only results in shifts of emphasis from one fibre type to another, is here not relevant and has no effect on the behaviour of the whole system.

So that, from the standpoint of pricing strategy formulation, no matter how many products the firm produces, what matters is the nature of the product: rapid turnover of consumer product, durable consumer products, consumable industrial products, durable industrial products, and semi-manufactures (i.e. intermediate materials, components). Those different categories of goods determine the market in which the firm operates. This is the most important factor in formulating the pricing strategy of a firm.

Therefore, it becomes necessary to define the nature of the product (s) which our hypothetical firm produces. It is assumed that the firm produce an intermediate product(s), i.e. synthetic fibre type, that it enters directly into

the customer's product, becomes physically part of it and in this way passes onwards incorporated in the goods he sells.

(ii) This product is in growth stage.

Generally, each product passes through a life cycle. This cycle is divided into four stages: introduction, growth, stagnation and decline. Each stage poses some special pricing problems, (Oxenfeldt, 1975). Therefore, modification in price strategy should be made as the product moves through different stages. In other words, pricing strategy should be changed every time the product moves from one stage to another. This is what Cravens (1975) called 'marketing strategy positioning'.

This study deals only with products in the growth stage. This stage has been selected for two reasons: (1) it provides the best way to understand the essential price-setting principles and procedures (Oxenfeldt, 1975); and (2) due to the time constraint, the necessary investigation required to modify the model to be suitable to analyse pricing problems of products in their introduction and declining stages can not be accomplished.

(iii) This product is undergoing continuous improvement,

It is assumed that there are extensive efforts from the firm to increase growth and to broaden markets through improving physical qualities (properties) of its products. The justification of this assumption comes from the published information, which shows high percentage of sales revenue devoted to R & D activity and our inferring that the main objective is to improve the existing fibre properties since ^{it is} forecasted

that no new fibres will come to the market up to 1990
(Programmes Analysis Unit, 1973).

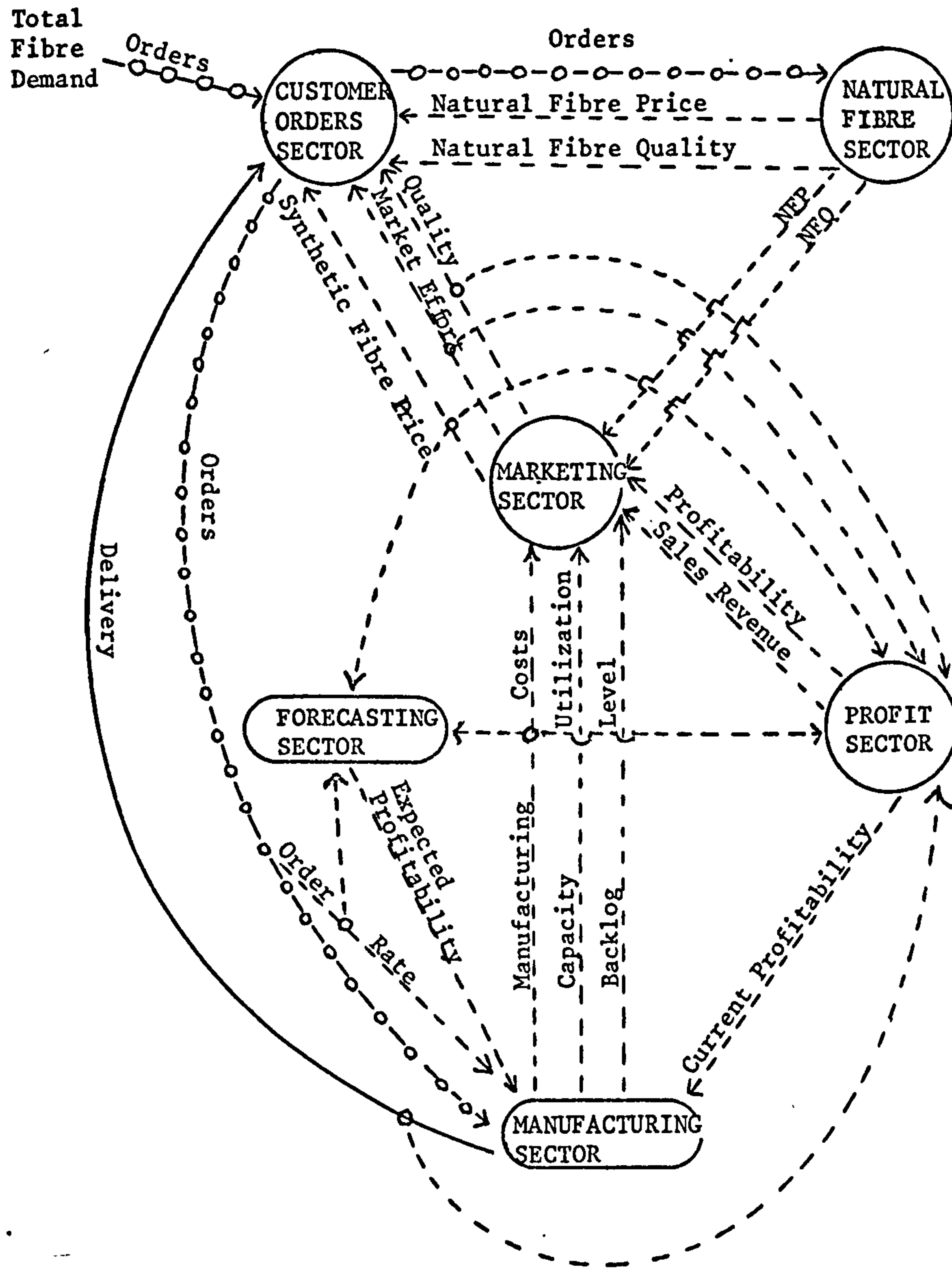
2. No differentiation has been made between the industry and price leader, as we have argued, the behaviour of the industry as a whole follows that of the leader.
3. It is a simplified version of the model. The model and its sectors will be presented in the following chapters.
4. Total fibre demand, natural fibre quality, natural fibre price, prices of raw materials and wages rate exogenous variables in that they vary as a result of factors external to the system.
5. The system is driven by the order rate which may be influenced by exogenous variables such as sudden changes in total fibre demand, prices of natural fibres or by endogenous variables such as changes in price, market effort, synthetic fibre quality ... etc. or by both.
6. The underlying mechanism of this diagram can be briefly explained for the purpose of this chapter as follows:-

a) Pricing, Costing and Volume Interaction:

A decrease in price, is modelled as leading to an increase in synthetic fibre market share (SFMS) and, hence, in incoming order rate (IOR). The latter, eventually results in a substantial decrease in total unit costs (TUC) due to technologies and economies of scale factors:

- (i) The increase in IOR results in an increase in production rate and, as a consequence, to decrease the fixed costs per unit of product.
 - (ii) Meanwhile, the increased IOR stimulates the firm to expand its production capacity (PCL). The addition of PCL in the model is a function of projections of sales trend, size of the order backlog, and expected profitability. The increase in PCL results in technological improvement and, as a consequence, decreases the labour costs per unit of product.
As TUC decrease, the price decreases as well, which produces a further increase in IOR.
- (b) Pricing, Research and Market Effort Interaction:
- (i) The increase in sales revenue stimulates the firm to increase its market effort budget. The latter, presumably, leads to an increase in SFMS which results in a decrease in TUC (and an increase in shipment sent rate). As TUC decreases, the price decreases as well and sales revenue increases.
 - (ii) The underlying mechanism between price and research budget is the same as between price and market effort.
7. The influence diagram indicates the reciprocal interconnection between the model's sectors namely: manufacturing, marketing, profit, natural fibre, forecasting, and customer order sectors. These sectors and their interconnection have been highlighted in Figure 3.6.

Fig. 3.6: The Sectors of the Model and Their Interconnection



Key: ———→ Physical flow
 - - - - -→ Information flow
 -o-o-o- -→ Orders flow

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CHAPTER IV

EQUATION FORMULATION FOR MARKET EFFORT,
MARKET SHARE AND RESEARCH & DEVELOPMENT

CHAPTER IVEQUATION FORMULATION FOR MARKET EFFORT,
MARKET SHARE AND RESEARCH & DEVELOPMENT

This chapter and the following two chapters deal with the translation of the causal relationship among the variables shown in the previous influence diagram (Figure 3.5) into a computer simulation programme. DYSMAP (Ratnatunga, 1977) is selected as a computer language because of its convenience.

This chapter is devoted to examine the way in which the market share and incoming orders, market effort and research and development policies are modelled. The discussion is outlined as follows:-

1. Total fibre demand
2. Incoming orders rate
3. Market effort
4. Research and Development

4.1. Total Fibre Demand

The total potential demand for a synthetic fibre(s) type and its substitutes is treated as an exogenous input to the system. The historical U.K. fibre consumption index (1962 = 100) is used to generate total fibre demand from the initial value in the succeeding months during the simulated period.

$$A \quad \text{TFDL.K} = 520000 * (\text{AUKI.K}) / 100 \quad (1)$$

$$A \quad \text{AUKCI.K} = \text{TABHL}(\text{AFCIT}, \text{TIME.K}, 0, 120, 12) \quad (2)$$

$$A \quad \text{AFCIT} = 100/108/113/119/115/109/116/125/125/123/128 \quad (2-1)$$

where:

TFDL	Total fibre demand	(U/M)	
AUKCI	The UK actual fibre consumption index		(1)
AFCIT	Actual fibre consumption index table		(1)

The model contains most of the firm's activities. Some aspects of these activities, i.e. production and inventory, require monthly decisions while others, i.e. R & D and Capital Investment, require less frequent decisions. The latter has considerable long-range implications on the firm. Therefore, the length of time should be long enough to allow the effects of these decisions to be felt. As a result, the time horizon of the model has been taken to be 10 years, a period which represents the upper limit of what most companies settled on as their long-range planning period (Warren, 1966). The length of the growth stage of products in the synthetic fibre industry, which is chosen as a specific case, is not a constraint since it is greater than 10 years.

A month is chosen as a time unit. The continuous approximation of less frequent decisions is justified mainly on the grounds of simplicity. However, these less frequent decisions could readily be made discontinuous if this was found to affect the model behaviour.

4.2. Incoming orders Rate

Incoming orders of the firm for that fibre depend on:

1. total potential demand of the fibre and its substitutes; and
2. the firm's market share.

The firm's market share, in turn, depends on:

- a) product characteristics (quality,)
- b) advertising, promotion and communication with the fibre users
(market effort)
- c) price.

a) Quality:

It inevitably influences the market share of a product since it limits its usefulness for various purposes and imposes the use of certain processing techniques. Substitution of an industrial product by the other will, therefore, be carried out if the bundle of characteristics embodied in the former are equal to or greater than the characteristics embodied in the latter. The question which should be asked here is:

How can the attribute values of a product^{to} be increased?

There are two ways to increase the attribute values of a product: real improvement in product quality through research and development activities and adding psychological attributes through promotion and advertising. The relative importance of each differs in industrial marketing than in consumer marketing. In this context Copulsky (1976) has pointed out that "whereas in consumer product 80% of the "bundle values" which constitute the product may be psychological, in industrial marketing only about 20% might be called aesthetic or psychological, and the remaining 80% tangible values".

b) Market Effort

It is clear from the previous paragraph that the role of promotion and advertising, or market effort for short, is limited to communication process rather than to increase the attribute values of a product. It is concerned with the transfer of attitudes of prospective customers through the stages of unawareness, awareness, comprehension and finally conviction that the product satisfies their specified needs. Thus, the failure to devote sufficient resources to carry out this process may affect market share.

c) Price

The extent to which price affects market share of an industrial product depends on the importance of a price factor in buying decision making. Generally speaking, it is important as a factor in the following cases:-

- (i) price factor is more important to the buyer if he has two or more optional sources than if he does not, and if he has knowledge of those options. For example, if the price of polyester staple exceeds that of wool which could be used to perform the same function, a weaving mill will substitute the former by the latter and vice versa. This change in volume is likely to take place not on a smooth continuum but in blocks, because of bulk ordering process.

- (ii) the importance of price depends on the extent to which the buyer can pass it on as a cost to his customers.
- (iii) the importance of price factor depends on the extent to which other factors are important to the buyer - such as assured availability (for more details see Corey, 1976).

At this point the difficult and critical question that should be asked is: How are we to quantify the impact of these variables on industry's market share?

Before we proceed to answer this question it is necessary to emphasise that this model is a general one applicable to a wide variety of organisations and situations. However, it has been developed in terms of the synthetic fibre industry so as to make its conclusions more readily comprehensible. It is necessary to judge the model's performance in terms of behaviour modes rather than specific numerical values as the purpose of the model is to study a pattern of evolution rather than to make short-term predictions.

Now we turn back to our question to say it is difficult to answer this question precisely. Indeed, market share is typically the hardest one of the elements to formulate; yet it is crucial in that it will reflect all the assumptions about the company marketing decision variables (Kotler, 1970). This does not, however, imply that there is no way to quantify the relationship between market share and marketing decision variables, but it means that we can not quantify.

such a relationship accurately by using rigorous methods. Skill, experience, and statistical analysis of historical data provide information and knowledge which can help the model builder to draw a general framework of these relations. Then the sensitivity of the overall performance of the system to the assumptions built into the model of those marketing decision variables effectiveness ought to be tested. This is to design a set of robust policies which make that system relatively insensitive to the errors in such assumptions. For the purpose of this research it is possible to say that the preceding verbal description of the relationship between market share and each of quality, market effort and price provides a reasonable basis to quantify these relations. This is due to the unavailability of actual data.

With regard to quality:

The term quality, in this research, means all the physical properties of a fibre; e.g. tensile strength, elastic recovery, water absorption, softening, affect its suitability for end-uses to which it is required, and impose the use of certain processing techniques. In other words, quality refers to the physical properties of a fibre which affect its competitive ability in two ways (Szucht, 1970). Firstly, these properties limit fibre usefulness for various end-uses to which it is required. Secondly, they impose the use of certain processing techniques which, in turn, affect its processing costs. Therefore, the qualities of any two type fibres will be, here, considered the same from the price point of view if they are grouped

equivalent with respect to those two factors.

Consequently, the fraction of fibre market becomes open to a synthetic fibre FFMBOS, and in which the firm can compete with price only, is modelled in equation 3 as being equal to the ratio of this fibre's perceived quality SFQ to the quality of substitutable natural fibres NFQR. The latter, in real life, is subjected to only very little improvement, therefore, it is reasonable to model it as a constant in equation 4. But, the improvement case can easily be accommodated. Fibre market, becoming open to a synthetic fibre FMBOF in equation 5, is equal to FFMBOS times TFDL.

$$A \quad \text{FFMBOS.K} = \text{SFQ.K/NFQR} \quad (3)$$

$$C \quad \text{NFQR} = 1 \quad (4)$$

$$A \quad \text{FMBOF.K} = \text{FFMBOS.K*TFDL.K} \quad (5)$$

where

FFMBOS Fraction of fibre market becomes open to
synthetic fibre (1)

NFQR Natural fibre quality reference (1)

FMBOF Fibre market becoming open to synthetic
fibre (U/M)

With regard to Market Effort:

It is assumed that its role is limited to communication process only. Thus, the fraction of FMBOSF will be communicated FFMC in equation 6 is equal to the ratio of required market effort perceived by customers PME to required market effort for saturation RMES. This ratio will always be equal to or less than one.

$$A \quad FFMC.K = PME.K/RMES.K \quad (6)$$

where

$$FFMC \quad \text{Fraction of fibre market communicated} \quad (1)$$

Price:

It is the major factor in determining the respective shares of the various fibres regarded identical in quality. O.E.C.D. (1976) reported that the replacement of natural by synthetic fibres, or vice versa, is generally dictated more by the relative price variations than by supply consideration.

Before discussing the way in which the relation between price and market share is modelled, it would be appropriate to define the unit measurement used here. Fibres are sold by weight, i.e. £/kg. For the purpose of price comparisons, however Robson (1958) and Programmes Analysis Unit (1973) considered that this is not relevant since the density and diameter differs from one fibre to another. Therefore, there is a need to transfer prices per kg into prices per equivalent unit by taking account of the density and diameter of various fibres. This equivalent unit, they suggested, is unit volume

of yarn. In this research, however, for all practical purposes the price per equivalent unit for each fibre type, synthetic and natural, in both yarn and fibre form is price per kilogram in relation to standard specifications (of quality, denier per filament, and length).

Now we turn back to discuss the formulation of equations of the relation between market share and price.

PR and NRNPR in equations 7 and 8 are the ratios of synthetic fibre list price SFLP and net realized price NRP to perceived natural fibre price NFPPC.

Equation 9 shows that NFPPC is twelve months first order delay. The delay time TCPNFP is used to reflect the fact that customers require some time to observe the nature of fluctuations in natural fibre prices NFP before they change their suppliers. This is because NFP are unstable due to their quite sensitivity to changes of the demand/supply situations (McPherson, 1966). In contrast, SFLP are set by price leader(s) and more stable than those of natural fibres. In fact, SFLP may be held constant one year or possibly more. On the other hand NRP are the outcome of direct negotiation between the company's representatives and the customers. Therefore, we use these informations without any delay.

As the price charged by the synthetic fibre producers decrease relative to that charged by the natural fibre merchants, more customers will shift their orders to the synthetic fibre producers and, vice versa. But, the degree of substitution, which a price change would bring about, is very difficult to measure.

Figure 4.1. shows the possible relationship, which will be tested later on, between (PR and NRNPR) and price multiplier (PMT). This rough curve is based on the common concepts in this respect and general knowledge of the fibre industry. PMT in equation 10 and 11 (price multiplier if list price quoted PM, price multiplier if net realized price quoted NRPM) does not change if the quoted price is list price or net realized price, because it is a function of market. In this figure it can be seen that price effect is not linear, because customers are not always completely rational and there are other factors that affect the rate at which they will shift their orders from one supplier to the others. Also, it can be noticed that this shift will take place on a smooth continuum (even though it may in reality take place in blocks). The figure, on the other hand, reflects the assumption inherent in the model that the price of a synthetic fibre should not be greater than the prices of natural fibres. At the other extreme when the synthetic fibre is far less than the natural fibre price, the fraction shifting does not increase indefinitely. There is a fraction that will not shift whatever the price advantages of synthetic fibres.

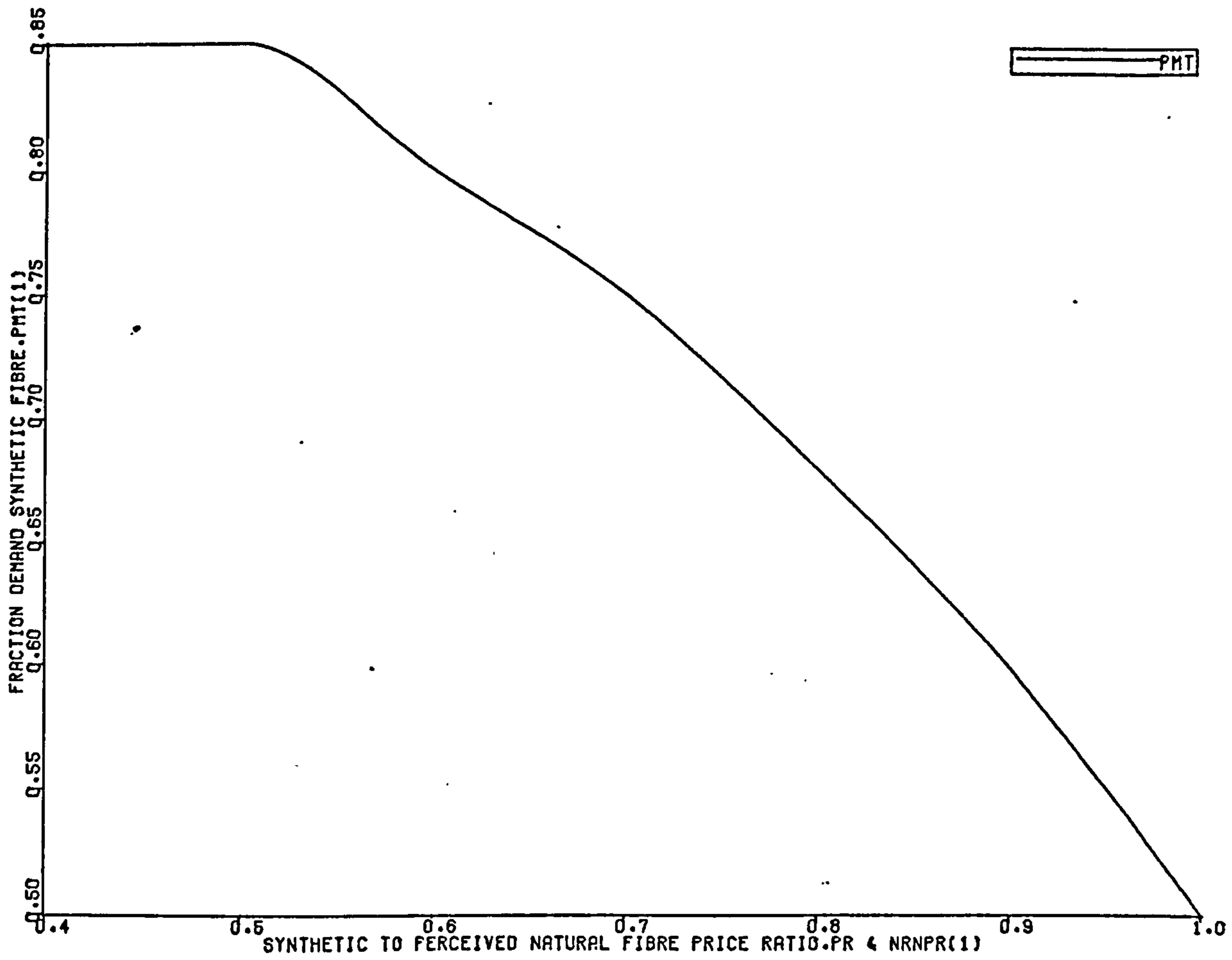


FIG 4.1 : THE RELATION BETWEEN PRICE AND MARKET SHARE

Equation 12 shows that synthetic fibre market share, if list price quoted SFMSL, is function of PM and FFMC. Synthetic fibre market share if net realized price quoted, SFMSN in equation 13, equals to NRPM times FFMC.

$$\begin{aligned}
 \text{A} \quad \text{PR.K} &= \text{SFLP.K/NFPPC.K} & (7) \\
 \text{A} \quad \text{NRNPR.K} &= \text{NRP.K/NFPPC.K} & (8) \\
 \text{L} \quad \text{NFPPC.K} &= \text{NFPPC.J+DT/TCPNFP}^*(\text{NFP.J-NFPPC.J}) & (9) \\
 \text{C} \quad \text{TCPNFP} &= 12 & (9-1) \\
 \text{A} \quad \text{PM.K} &= \text{TABHL(PMT,PR.K,0.5,1,.1)} & (10) \\
 \text{A} \quad \text{NRPM.K} &= \text{TABHL(PMT,NRNPR.K,0.5,1,.1)} & (11) \\
 \text{T} \quad \text{PMT} &= 0.85/0.80/0.75/0.68/0.60/0.50 & (10/11-1) \\
 \text{A} \quad \text{SFMSL.K} &= \text{PM.K*FFMC.K} & (12) \\
 \text{A} \quad \text{SFMSN.K} &= \text{NRPM.K*FFMC.K} & (13) \\
 \text{A} \quad \text{SFBD.K} &= \text{SFMSL.K*FMBOSF.K} & (14) \\
 \text{A} \quad \text{OLS.K} &= (\text{SFMSN.K-SFMSL.K})*\text{FMBOSF.K} & (15) \\
 \text{R} \quad \text{IOR.KL} &= \text{SFBD.K+OLS.K} & (16) \\
 \text{A} \quad \text{SFMS.K} &= (\text{SFBD.K+OLS.K})/\text{TFDL.K} & (17)
 \end{aligned}$$

where

PR	List price to perceived natural fibre price ratio	(1)
NRNPR	Net realized to natural fibre price perceived by customer ratio	(1)
NFPPC	Natural fibre price perceived by customers	(£/U)
TCPNFP	Time for customers to perceive natural fibre price	(M)

PM	Price multiplier depends on PR	(1)
NRPM	Price multiplier depends on NRNPR	(1)
PMT	Table of price multiplier	(1)
SFMSL	Synthetic fibre market share if list price quoted	(1)
SFMSN	Synthetic fibre market share if net realized price quoted	(1)
SFBD	Synthetic fibre basic demand	(U/M)
OLS	Off-list selling	(U/M)
IOR	Incoming orders rate	(U/M)
SFMS	Synthetic fibre market share	(1)

Market share and incoming orders are represented in
Figure 4.2.

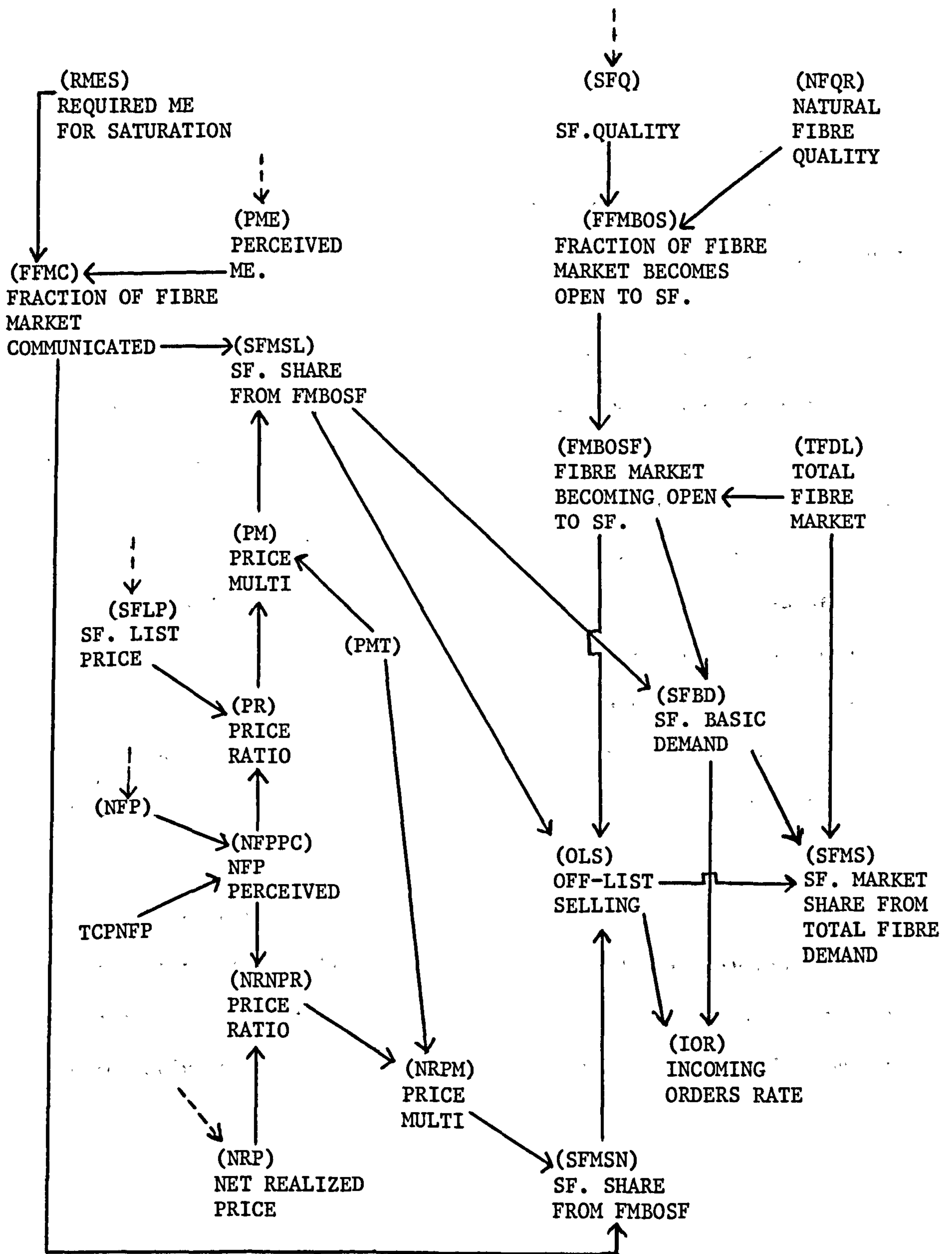


Fig. 4.2: Influence Diagram of Market Share and Incoming Orders Rate

4.3 Market Effort

Generally, market effort, required for saturation, increases as the fraction of fibre market is becoming open to a synthetic fibre "increase", but by how much? To answer this question precisely we need to measure the effectiveness of market effort on market share. It is difficult, indeed, almost impossible to evaluate at present (Rivett, 1972). This does not, however, imply that there is no way to quantify the relationship between the increase in the size of the market and the required market effort for saturation, but it does mean that we cannot quantify such a relationship accurately by using rigorous methods. General indications of the shape of required market effort for saturation curve could be derived from the firm's historical record analysis, field study and the evidence of decision makers' experience. Then, by carrying out a series of experimentations on the model the model builder could deduce this relationship.

For the purpose of this research it is assumed that the relationship between the required market effort for saturation, RMES in equation 18, and the fraction of fibre, is as shown in Figure 4.3. The following points should be noted in connection with this figure:

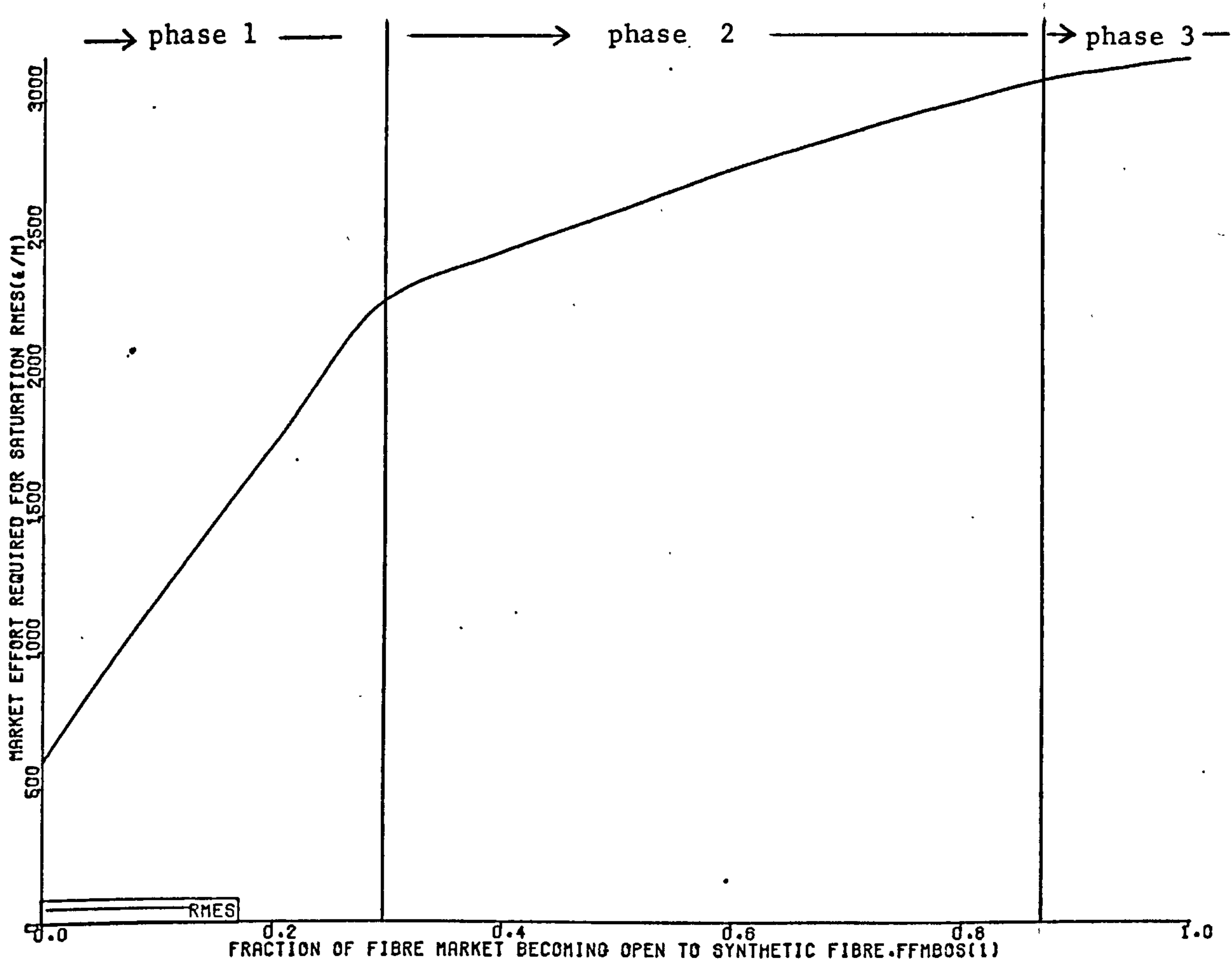


FIG 4.3:RMES VERSUS FFMBOS

- (1) Phase One, which covers the introduction stage of the product, shows an initial high level of RMES with high rate of increase after this. This is due to the effectiveness of market effort which is low. The effectiveness is low due to, partly the presence of a number of external restraining factors such as bad performance of the product and strong established relationship between the suppliers of the existing product(s) and the users, and partly because the spread of knowledge about the product as well as the acceptance of that product is relatively slow during this stage.
- (2) Phase Two, which is synchronised with the growth stage of the product, shows a moderate rate of increase in RMES not proportionally with the increase in FFMBOS. This is due to the fact that the effectiveness of market effort is high. The effectiveness is high due to rapid acceleration of knowledge about the product as well as its acceptance. Moreover, this rapid acceleration reflects the contribution of these factors during the previous phase.
- (3) Phase Three, which is synchronised with stagnation of the growth of the product, show a very low increase in RMES followed by stability.. This is due to the fact that the market has been completely communicated. Any increase in RMES has no effect on market share.

(4) This curve may take other shape(s), depending on the assumed effectiveness of market effort over the product life span.

We proceed now to decide which budget method will be used to determine market effort. It is a common policy in the business world to base market effort on sales. One approach might be by applying rules of thumb; use a constant percentage of sales. These rules are criticised by Lilien and Little (1976) where they indicate that "they fail to provide an explicit, objective rationale for the specific rule that is chosen (e.g. they do not specify how to select an appropriate percentage of sales)".

In this model, market effort is modelled as follows. Sales revenue ASRV in equation 19 is delayed by a three month first order delay. The constant percentage of sales FME in equation 20 is assumed as 2.75%. Meanwhile, to avoid the previous criticism, market effort, ME in equation 21 is chosen as the minimum of RMES and ASRV*FME. By adoption of these decision rules the model provides a great help to choose an appropriate percentage of sales. Funds allocated to market effort are not spent immediately upon allocation. Campaign must be planned AME in equation 22. Responses of customers to AME begin after some delay PME in equation 23.

Market effort is represented as shown in Fig. 4.4 and calculated as below:

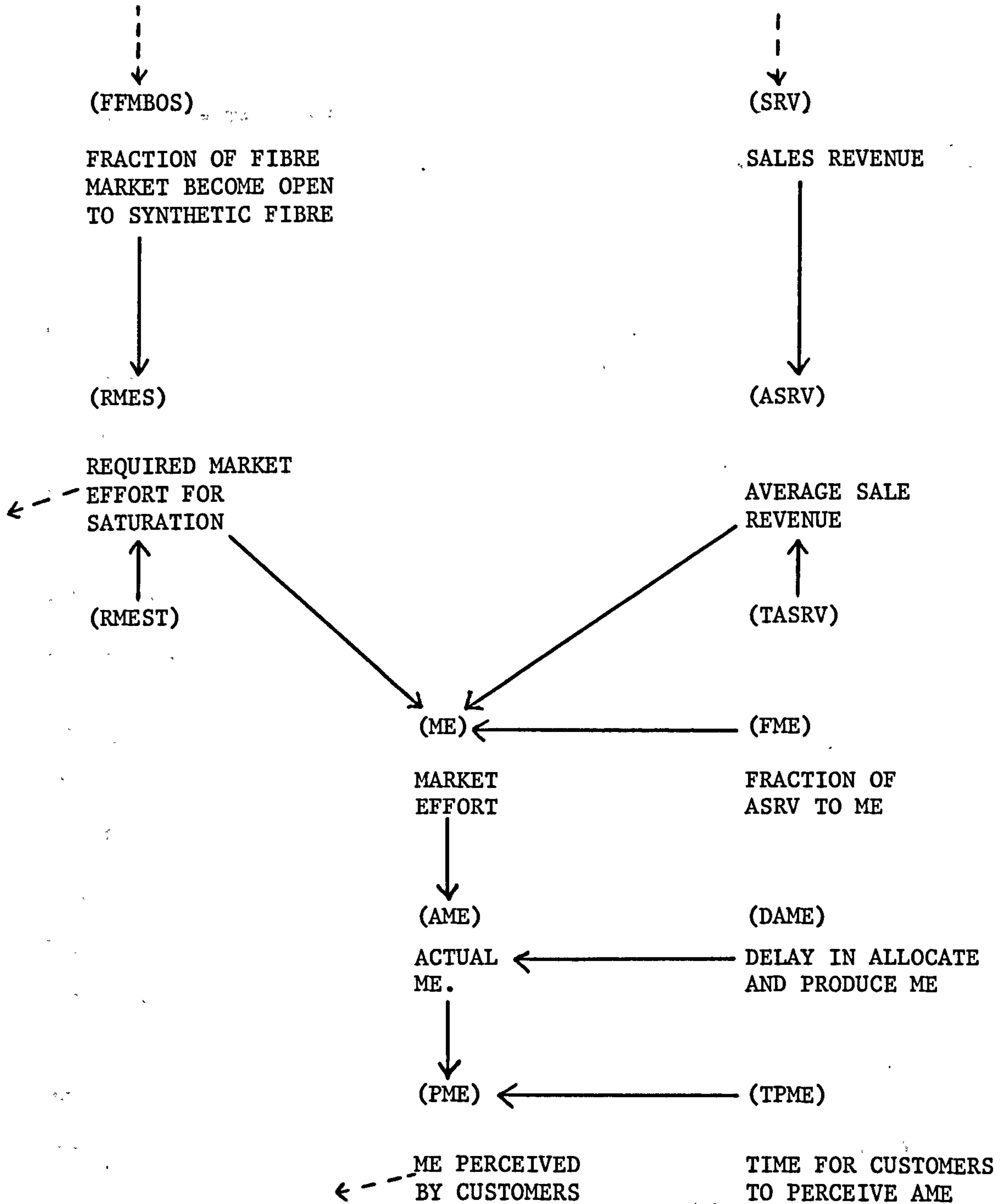


Fig. 4.4: Influence Diagram of Market Effort

- A $RMES.K = TABHL(RMEST, FFMBOS.K, 0, 1, .1)$ (18)
- T $RMEST = 600/1200/1750.1/2283.6/2450/2600/2750/2880/3000/3100/3150$
(18-1)
- L $ASRV.K = ASRV.J + DT/TASR * (SRV.JK - ASRV.J)$ (19)
- C $TASR = 3$ (19-1)
- C $FME = .0275$ (20)
- A $ME.K = MIN((FME * ASRV.K), RMES.K)$ (21)
- L $AME.K = AME.J + (DT/DAME) * (ME.J - AME.J)$ (22)
- L $PME.K = PME.J + (DT/TPME) * (AME.J - PME.J)$ (23)
- C $DAME = 1$ (23-1)
- C $TPME = 3$ (23-2)

where:

RMES	Required market effort for saturation	(£/M)
RMEST	" " " " " table	(£/M)
ASRV	Average sales revenue	(£/M)
TASR	Time to average SRV	(M)
FME	Percent from average sales revenue to market effort	(1)
ME	Allocation fund to market effort	(£/M)
AME	Actual market effort	(£/M)
PME	Market effort perceived by customers	(£/M)
DAME	Delay in allocate and produce market effort	(M)
TPME	Time for customers to perceive market effort	(M)

4.4. Research and Development

It is clear from section 4.2 that the only way to broaden market area is through improvement in product quality. This improvement is a result of the research activity of the firm. This is not all activities of R & D but one of them, namely, the development of product applications via improving its current properties and/or adding new ones. In this research we only deal with this sort of R & D.

Quantification problems of R & D is beyond the scope of this research. Our prime interest is to examine the effect on the firm's growth and profitability and consequently on price, of allocating different amounts of money to research activities. In other words, does the spending level on R & D affect the pricing policy? In this context there are two basic alternative policies. Firstly, an aggressive R & D policy which may result in heavy loss in the short run. If the firm is not ready to accept the loss, it may increase its prices. This, in most cases, has an adverse effect on long run profitability and growth. Secondly, a conservative R & D policy may restrict the firm's growth and profitability in the long run (even though there is no S-R loss and no pressure on price).

The aim of this research is to help the manager to choose acceptable R & D policy from short and long term profitability and growth point of view.

R & D activities are modelled as follows. Generally, the required research expenses should increase as the required application problems to be solved increase. Those problems, in turn, depend on the size of the market potential for an application of this product. Corey (1976) mentions this real world example which may shed more light on this point, "The product manager would analyze the market potential for an application of his product, formulate specific marketing goals, budget funds from his resources, and request DRG (The Development Research Group was concerned with long-range) to do the technical work required to formulate a product which would meet the requirement of the application". This R & D marketing interface is not well developed in many British companies. This partially explains the failure of those firms to exploit the fruit of their R & D capability (Thomas, et al., 1976). R & D and marketing must be brought into a consistent body of policy and action by relating R & D activity to market opportunities.

The market opportunities are measured, here, as the fraction of fibre market not open to synthetic fibres FFMUSF in equation 24. It is modelled that the required research expenses RRE in equation 25 increase as FFMUSF increase. It is assumed that the increase is nonlinear.

The decision rules to choose research spending rate RSR in equation 26 are the same as in the case of ME. Research Spending Becoming Effective RSBE in equation 27 is RSR after some delay, or alternatively it is a function of research pool RP if the outcome of R & D comes in discrete steps. A PULSE function is used to formulate the discontinuous outcome of R & D. Cumulative effective research expenses CERE in equation 29 is the cumulative level of RSBE. Equation 30 shows that synthetic fibre quality SFQ is function of CERE.

Research activity is represented in Fig. 4.6 and calculated as below:

$$A \quad \text{FFMUSF.K} = 1 - \text{FFMBOS.K} \quad (24)$$

$$A \quad \text{RRE.K} = \text{TABHL}(\text{RRET}, \text{FFMUSF.K}, 0, .8, .1) \quad (25)$$

$$T \quad \text{RRET} = 0/3000/5600/8000/10300/12500/ \\ 14500/16200/17350 \quad (25-1)$$

$$R \quad \text{RSR.KL} = \text{MIN}(\text{RRE.K}, \text{PRE.K}) \quad (26)$$

$$A \quad \text{PRE.K} = \text{FSRVR} * \text{ASRV.K} \quad (26-1)$$

$$C \quad \text{FSRVR} = 0.35 \quad (26-2)$$

$$R \quad \text{RSBE.KL} = ((\text{PULSE}((\text{RP.K}/\text{DT}), \text{DORE}, \text{DORE})) * (1 - \text{DM}) + ((\text{DELAY3}(\text{RSBE7.JK}, \\ \text{DORE}/8)) * \text{DM})) \quad (27)$$

$$C \quad \text{DM} = 1 \quad (27-1)$$

$$R \quad \text{RSBE1.KL} = \text{DELAY3}(\text{RSR.JK}, \text{DORE}/8) \quad (27-2)$$

$$R \quad \text{RSBE2.KL} = \text{DELAY3}(\text{RSBE1.JK}, \text{DORE}/8) \quad (27-3)$$

$$R \quad \text{RSBE3.KL} = \text{DELAY3}(\text{RSBE2.JK}, \text{DORE}/8) \quad (27-4)$$

$$R \quad \text{RSBE4.KL} = \text{DELAY3}(\text{RSBE3.JK}, \text{DORE}/8) \quad (27-5)$$

$$R \quad \text{RSBE5.KL} = \text{DELAY3}(\text{RSBE4.JK}, \text{DORE}/8) \quad (27-6)$$

R	$RSBE6.KL = DELAY3(RSBE5.JK, DORE/8)$	(27-7)
R	$RSBE7.KL = DELAY3(RSBE6.JK, DORE/8)$	(27-8)
C	$DORE = 48$	(27-9)
L	$RP.K = RP.J + DT * (RSR.JK - RSBE.JK)$	(28)
L	$CERE.K = CERE.J + DT * RSBE.JK$	(29)
A	$SFQ.K = TABHL(SFQT, CERE.K, 0, 825E3, 75E3)$	(30)
T	$SFQT = .27/.37/.47/.55/.62/.68/.74/.80/.86/.92/.97/1$	(30-1)

where:

FFMUSF	Fraction of fibre market closed to SF	(1)
RRE	Required Research expenses	(£/M)
RRET	" " " table	(£/M)
RSR	Research spending rate	(£/M)
PRE	Planned research expenses	(£/M)
FSRVR	Fraction from ASRV for research	(1)
RSBE	Research spending rate becomes effective	(£/M)
RSBE 1-7	Internal rate to calculate RSBE	(£/M)
DORE	Delay in outcome of research expenses	(M)
RP	Research Pool	(£)
CERE	Cumulative effective research expenses	(£)
SFQ	Synthetic fibre quality	(1)
SFQT	" " " table	(1)

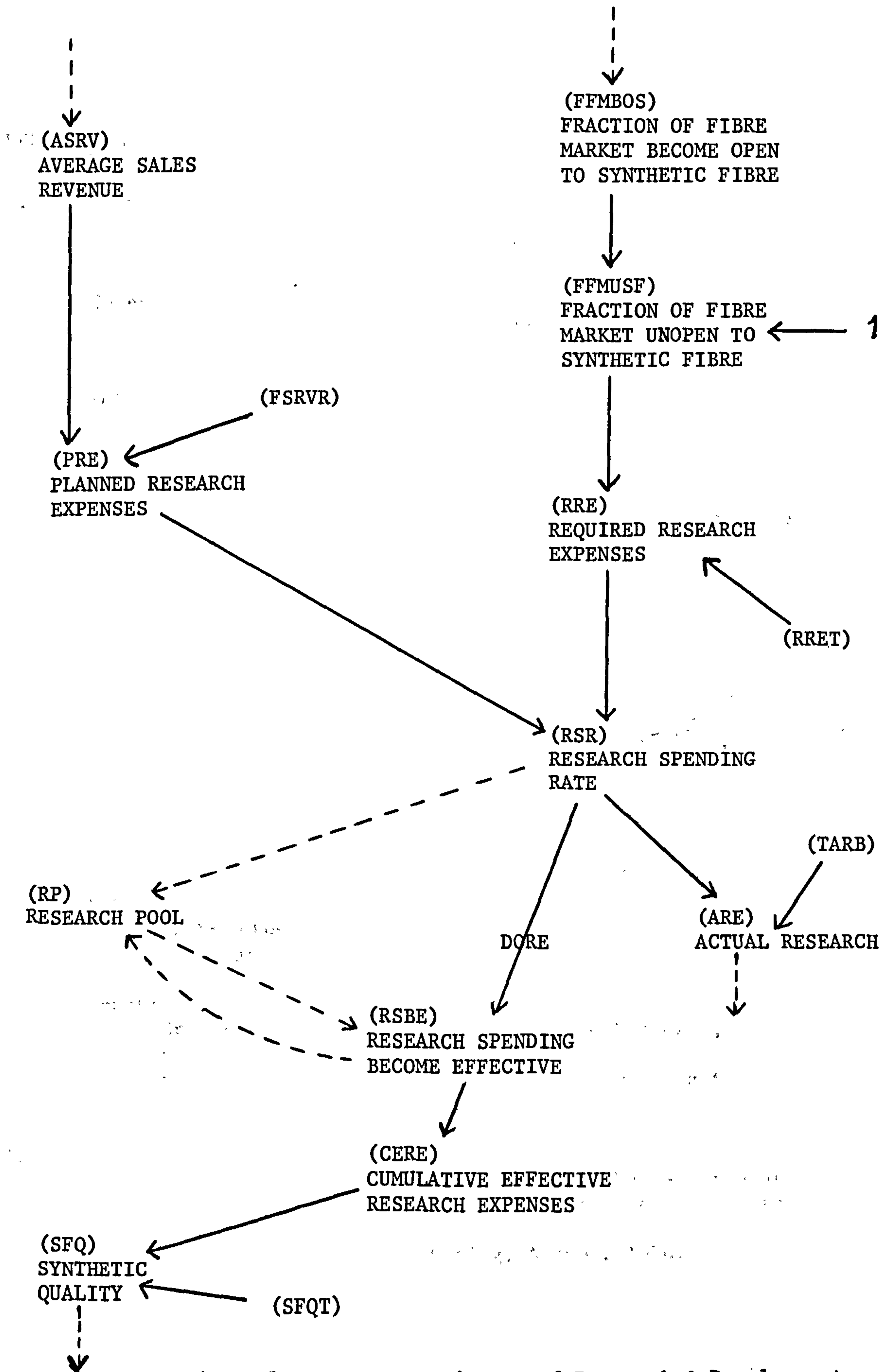


Fig. 4.5: Influence Diagram of Research & Development

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CHAPTER V

EQUATIONS FORMULATION FOR PRICING POLICY

CHAPTER VEQUATIONS FORMULATION FOR PRICING POLICY

This chapter is devoted to examining the way in which pricing policy is modelled.

The discussion is outlined as follows:-

1. Factors affecting price decisions
2. Proposed list price
3. List price

5.1. Factors Affecting Price Decisions:

Price decisions are affected by three factors, namely, costs, demands, and price movements of substitutable natural fibres. The form of interaction between these factors are represented in Fig. 5.1. Each factor is explained individually as follows:

5.1.1. Price Movements of Natural Fibres:

Prices of natural fibres namely, cotton and wool, are introduced as independent input to the system and modelled by means of two table functions that contain price indices of which the wool price index WPI is in equation 1 and cotton price index CPI is in equation 2 (Jan. 1963 = 100). It is difficult to determine the extent to which a particular type of synthetic fibre increases its consumption at the expense of natural fibres consumption; nevertheless, for this model the weighted average of wool and cotton prices NFP in equation 3 will be used as a useful representative of the prices of natural fibres. The weight given to each is arrived at by repeated simulation. However, it is important to point out that the effect of different movements in natural fibre prices will be tested later on.

It may be necessary here to emphasise that we are modelling a general process and the fibre industry is only an example.

To choose initial values of natural and synthetic fibre prices, which are regarded equal from the quality point of view, we need data of their prices. These data are not available for us by any means. Therefore, for this model the initial price of natural fibres is assumed to be equal to the initial price of the synthetic fibres. That is to start the simulation at the

equilibrium point for modelling convenience (i.e. 50% share to each fibre type from the fibre market opened to synthetic fibres FMBOSF). But this initial price is defined as a constant, thus, it can be easily varied and the effect of different values could be tested. This assumption is not, however, unjustified. The average price of major staple fibres in the group of natural fibres is close to that in the group of synthetic fibres as can be seen in Table 5.1. The constant value INFP in equation 4 is chosen to generate return on investment to the synthetic fibre producers of about 13% which, on average, is the actual return on investment in this industry.

$$\begin{array}{ll}
 \text{A} & \text{WPI.K} = \text{TABHL}(\text{WPIT}, \text{TIME.K}, 0, 120, 1) / 100 & (1) \\
 \text{T} & \text{WPIT} = 100 / 98.9 / 101 / 102.7 / 103.5 / \text{----} & (1-1) \\
 \text{A} & \text{CPI.K} = \text{TABHL}(\text{CPIT}, \text{TIME.K}, 0, 120, 1) / 100 & (2) \\
 \text{T} & \text{CPIT} = 100 / 99.7 / 99.5 / 99.3 / 98.9 / \text{----} & (2-1) \\
 \text{A} & \text{NFP.K} = \text{INFP} * ((\text{WPI.K} * (1-D)) + (\text{CPI.K} * D)) & (3) \\
 \text{C} & D = 0.3 & (3-1) \\
 \text{C} & \text{INFP} = 1.1 & (4)
 \end{array}$$

where:

WPI	Wool price index	(1)
WPIT	Wool price index table	(1)
CPI	Cotton price index	(1)
CPIT	Cotton price index table	(1)
NFP	Natural fibre price	(£/U)
D	Dummy to transfer from one price index to another. D can be varied between 0 and 1 to weight the average as desired.	(1)
INFP	Initial natural fibre price	(£/U)

Fibre Type	Price US Dollars/Ton	Average Price US Dollars/Ton
1. <u>Natural Fibres:</u>		
Combing Wool (scoured)	2400 - 2800)	1450 - 1775
Medium - Staple Cotton	500 - 750)	
2. <u>Synthetic Fibres:</u>		
Polyacrylic	1450 - 2200)	1687 - 2125
Polyamide (Nylon)	2000 - 2600)	
Polyester	1850 - 2000)	
Polypropylene	1450 - 1700)	

Table 5.1.: Price of Major Staple Fibres

Source: Szucht, E. "Criteria for the Selection of Textile Fibres", In the Lodz Textile Seminars. 1 : Textile Fibres, United Nations Industrial Development Organization, United Nations, 1972.

Average natural fibre price is the smoothed value of NFP. The smoothing time is chosen very short so that average natural fibre price reflects the recent value of NFP.

$$L \quad ANFP.K = ANFP.J + (DT/TANFP) * (NFP.J - ANFP.J) \quad (5)$$

$$C \quad TANFP = 1 \quad (5-1)$$

where:

ANFP Average natural fibre price (£/U)

TANFP Time to average natural fibre price (M)

The relative change in natural fibre price CANPR in equation 6, which is the ratio of current to average natural fibre prices, is an important determinant of the price which will be charged by the price leader. Since natural fibre prices are unstable, a relatively long time to observe the nature of these fluctuations is required by the price leader to initiate price changes. Therefore, information about the relative change in natural fibre is delayed by a twelve month first order delay CANPP in equation 7.

$$A \quad \text{CANPR.K} = \text{NFP.K/ANFP.K} \quad (6)$$

$$L \quad \text{CANPP.K} = \text{CANPP.J} + (\text{DT/TPCANPR}) * (\text{CANPR.J} - \text{CANPP.J}) \quad (7)$$

$$C \quad \text{TPCANPR} = 12 \quad (7-1)$$

where:

CANPR Current to average natural fibre price ratio (1)

CANPP CANPR perceived by management (1)

TPCANPR Time for management to perceived CANPR (M)

Fig. 5.2 shows the relationship between the perceived natural fibre price ratio CANPP and price multiplier due to natural fibre competition PMC in equation 8. This curve can take different shapes dependent on the adopted management control policy in this respect. The relationship assumed here represents a price leader quite sensitive to small or moderate natural fibre price decreases, meeting them exactly but becoming completely independent if the price decreases are very large. Since, for a growing product the strategic focus should be on market share (Doyle, 1976), it would be practical to say that the price leader will follow small or moderate natural fibre price decreases to protect his market share, but there is no point in pricing to protect this market share if the result is to drive all the profit out of the business as it may be happening in the case of a drastic fall in the natural fibre price.

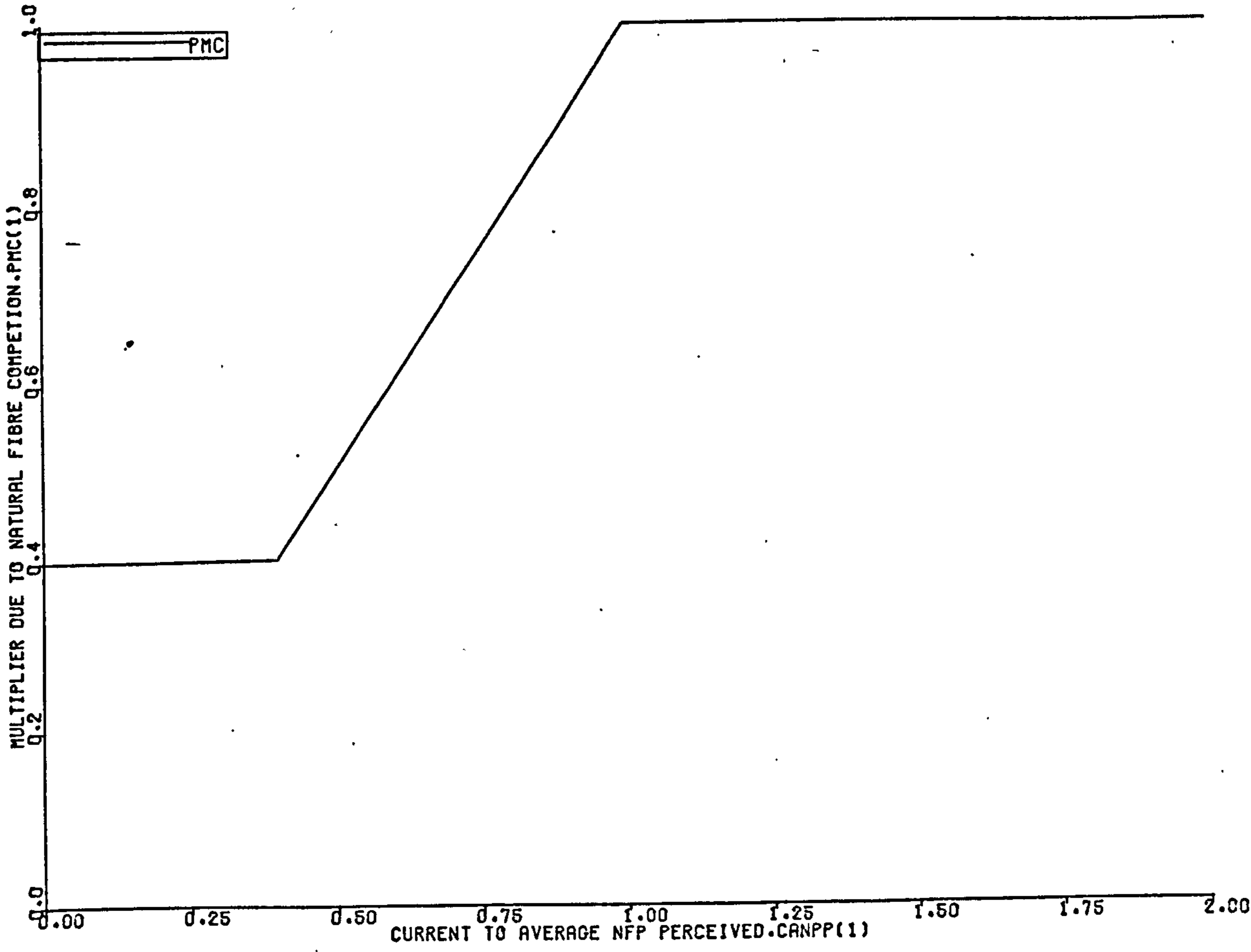


FIG 5.2:PMC VERSUS CANPP

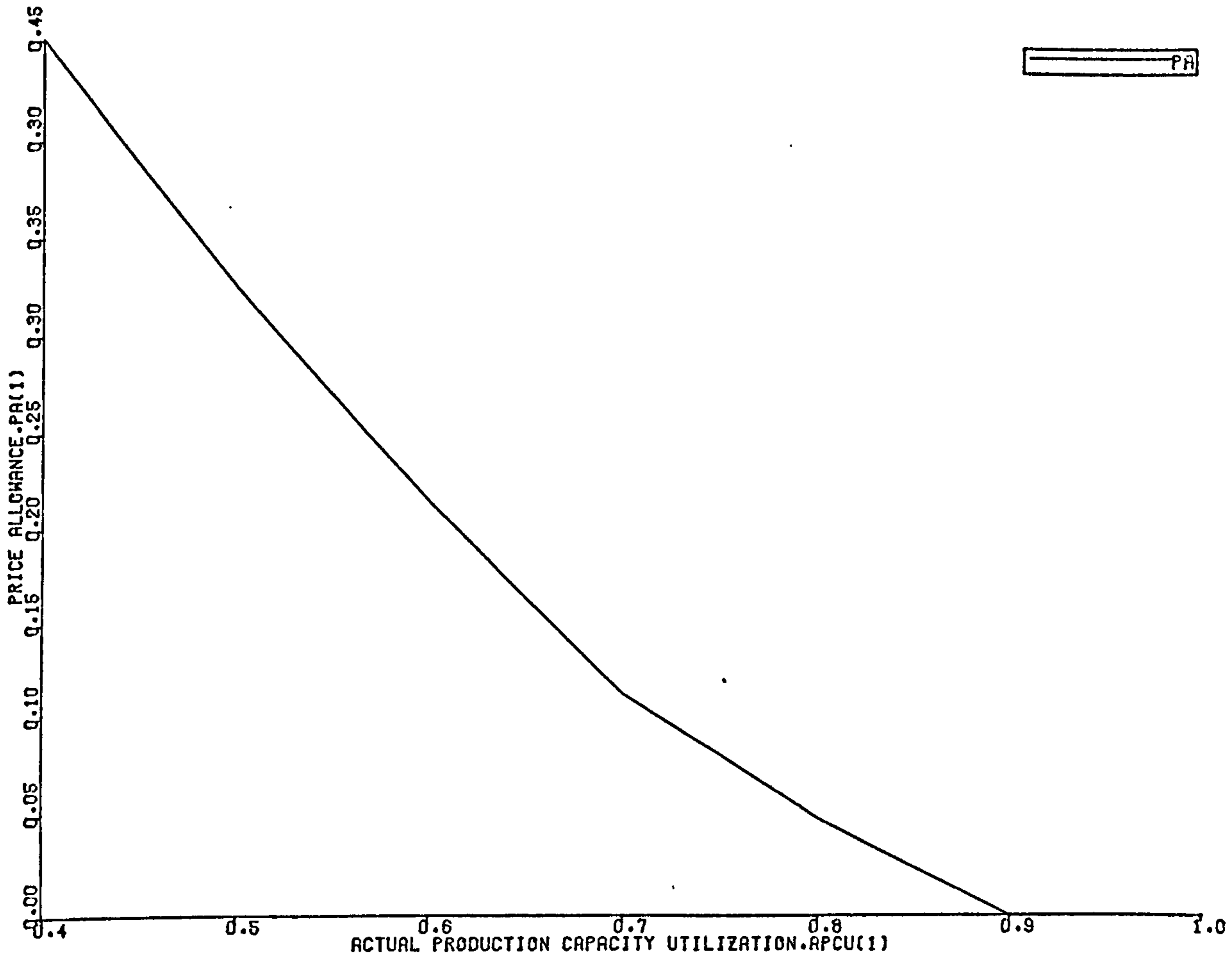


FIG 5.3:PA VERSUS APCU

$$A \quad PA.K = \text{TABHL}(TPA, APCU.K, .4, 1, .1) \quad (9)$$

$$T \quad TPA = .45/.325/.215/.115/.05/0/0 \quad (9-1)$$

where:

PA Price allowance (1)

TPA Price allowance table (1)

It may be necessary, here, to point out that, in real life, price allowances are often given to large buyers, and when trade is very bad they might be given to both large and small buyers. It is not, however, our intention to determine to whom those allowances should be given. Our concern is to develop a set of decision rules to govern the conditions under which these allowances should be given and their amount. By doing so, the model provides a great help to top management which have become increasingly interested to have an effective policy to control price allowances. This is due to the fact that price allowances, since 1964, have become common in the man-made fibre industry to the extent which has made producers' list prices to be regarded by O.E.C.D. (1969) unrelevant as indication of actual prices quoted by the industry.

Practically, the allowance off list price should be limited to what the management consider necessary to cover factory costs per unit, and leaves a gross margin to cover at least a portion of other costs per unit and provides (if any) reasonable net contribution. So that, net realized price NRP, which refers to the price that customers actually pay, is modelled in equation 10 as the maximum of list price adjusted by a price allowance and the floor price FPR. The latter represents the lowest acceptable price from profitability point of view. FPR is, therefore, modelled in equation 11 as a function of average factory costs per unit AFCPU, and a constant margin. The determination of average factory costs per unit will be discussed in Chapter Six.

$$A \quad NRP.K = (\text{MAX}((SFLP.K*(1-PA.K)), FPR.K)) \quad (10)$$

$$A \quad FPR.K = AFCPU.K*(1+MARGIN) \quad (11)$$

$$C \quad MARGIN=0.30 \quad (11-1)$$

where:

NRP Net realized price (£/U)

FPR Floor Price (£/U)

MARGIN Margin over AFCPU required to cover
the costs and profit (1)

The comparison between off list selling OLS and basic demand SFBD (demand at list price) gives a strong indication on the nature of the decreases in demand which forced the firm to give price allowances. If off-list selling, compared with basic demand, is relatively small, the decreases in demand are short term decreases and there is no need to change list price which should only reflect long-term fluctuations in demand. On the other hand, if it is relatively large, the decreases in demand are long term decreases and there is a strong pressure to bring down list price to become equal to net realized price. This is rational if the firm wants its list price to reflect its actual price which is assumed in this work. This is modelled as follows:

The ratio^{of} off-list selling to basic demand, OLSBDR, is calculated in equation 12. But the management need some time to perceive OLSBDR. Therefore, equation 13 gives perceived off-list to basic demand ratio PLSBDR as the first order delay of OLSBDR. Equation 14 shows that list price should be adjusted if OLSBDR is equal to or greater than its reference value RFOBD. The management choose this value. If so, list price will be adjusted to become equal to net realized price by using price multiplier due to demand PMD in equation 18, otherwise the value of PMD will be an equal one.

A	$OLSBDR.K = OLS.K/SFBD.K$	(12)
L	$PLSBDR.K = PLSBDR.J + (DT/TPLSBD) * (OLSBDR.J - PLSBDR.J)$	(13)
C	$TPLSBD = 3$	(13-1)
A	$DV3.K = CLIP(1, 0, PLSBDR.K, RFOBD)$	(14)
C	$RFOBD = 0.5$	(14-1)
A	$NSFLPR.K = NRP.K/SFLP.K$	(15)
A	$DV1.K = (MAX(NSFLPR.K, 1)) * (1 - DV3.K)$	(16)
A	$DV2.K = (MIN(NSFLPR.K, 1)) * DV3.K$	(17)
A	$PMD.K = DV1.K + DV2.K$	(18)

where:

OLSBDR	Off-list selling to basic demand ratio	(1)
PLSBDR	OLSBDR perceived by management	(1)
TPLSBD	Time for management to perceive OLSBDR	(M)
DV3	Dummy variable to control the choice between DV1 and DV2	(1)
RFOBD	Reference value of PLSBDR	(1)
NSFLPR	Net realize to SF list price ratio	(1)
DV1 and 2	The two alternative values of NSFLPR used in PMD	(1)
PMD	Price multiplier due to demand	(1)

If the firm is in short supply, the increase in backlog B over its normal level NB, after some delay, will generate a pressure to increase price. Fig. 5.4 shows a possible relationship between backlog ratio perceived BRP and price multiplier due to backlog PMB.

$$A \quad BR.K = B.K/NB.K \quad (19)$$

$$L \quad BRP.K = BRP.J + (DT/TPBR) * (BR.J - BRP.J) \quad (20)$$

$$C \quad TPBR = 3 \quad (20 - 1)$$

$$A \quad PMB.K = TABHL(PMBT, BRP.K, .5, 3, .5) \quad (21)$$

$$T \quad PMBT = 1/1/1/.2/1.4/1.5 \quad (22)$$

where:

BR Backlog - normal backlog ratio (1)

BRP Backlog ratio perceived by management (1)

TPBR Time for management to perceive BR (M)

PMB Price multiplier due to backlog (1)

PMBT PMB Table (1)

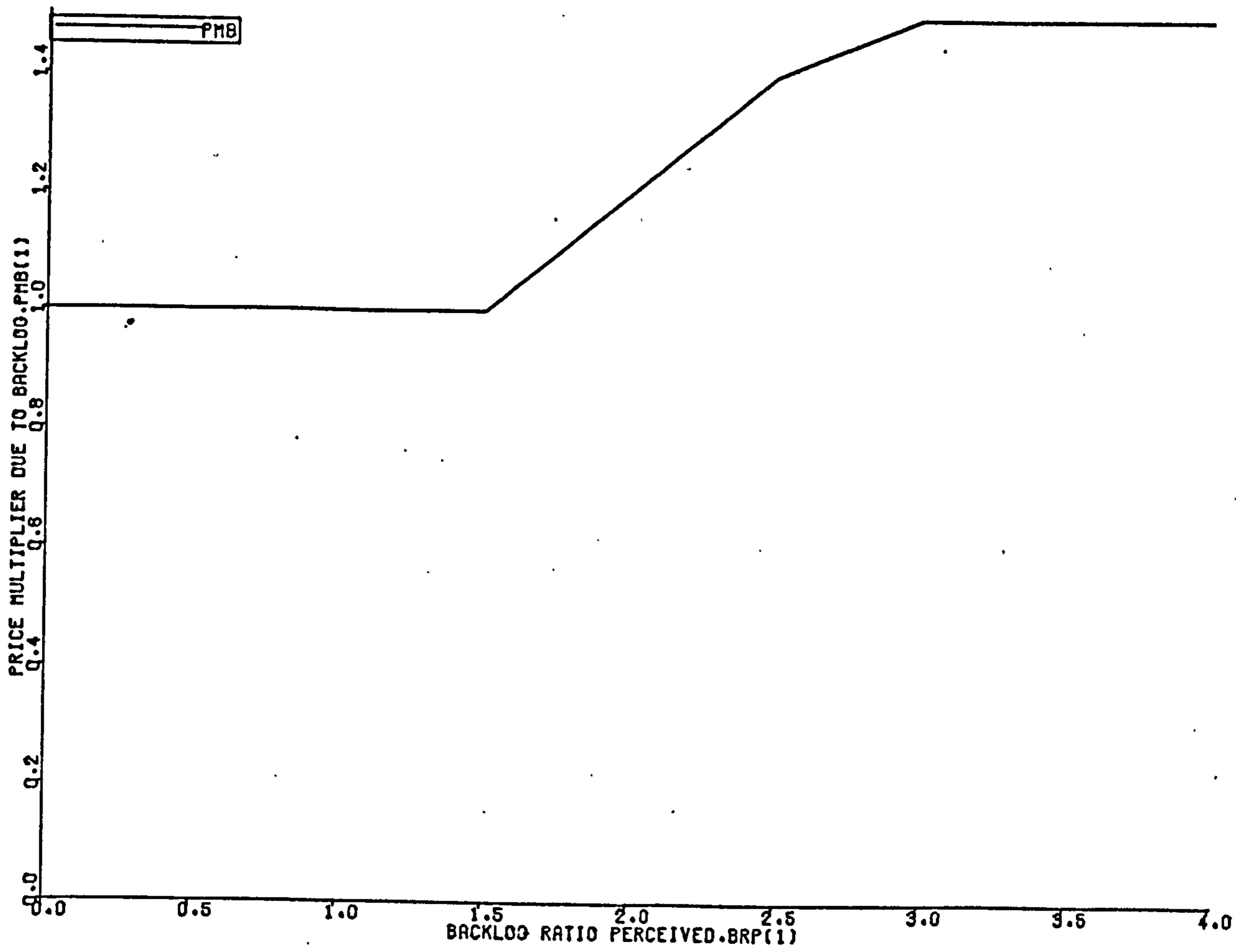


FIG 5.4:BRP VERSUS PMB

5.1.2. Costs (EITUC, EDTUC):

The part which cost factor has in determining the firm's pricing policy and what cost information we need for pricing decision will be discussed in Chapter Six. For the purpose of this chapter it is enough to say that if the firm follows a low price strategy as it is observed in synthetic fibre industry, the decrease in total unit costs, EDTUC, will be transferred to the customers.

The extent to which the firm can pass the increase on to its customers is controlled by pricing code. In this basic system it is assumed there is no price code so the firm will pass all the increase in total unit costs EITUC, on to its customers. The effect of price code will be discussed in Chapter Nine.

$$A \quad EITUC.K = \text{MAX}((TUC.K - ATUC.K), 0) \quad (23)$$

$$A \quad EDTUC.K = \text{MAX}((ATUC.K - TUC.K), 0) \quad (24)$$

where:

EITUC Actual increase in total unit costs (£/U)

EDTUC Actual decrease in total unit costs (£/U)

5.2. Proposed List Price:

In the preceding section the factors affecting price decision have been analysed and quantified. Now, we discuss the way in which the firm use these factors to reach its proposed list price.

Proposed list price PSFLP in equation 25 is modelled as the multiplicative effect of the two first factors - price movement of substitutable natural fibres and demand - plus the change in total unit cost. It is justifiable to assume that natural fibre price NFP sets the upper limit to this value. But management require some time to perceive proposed list price. Equation 26 shows that smoothed proposed list price SPSLP is the smoothed version of PSFLP.

$$A \quad PSFLP.K = \text{MIN}(((SFLP.K*PMC.K*PMB.K*PMD.K)-EDTUC.K+EITUC.K),NFP.K) \quad (25)$$

$$L \quad SPSLP.K = SPLP.J+DT/TPPL*(PSFLP.J-SPSLP.J) \quad (26)$$

$$C \quad TPPL = 1 \quad (26-1)$$

where:

PSFLP Proposed SF list price (£/M)

SPSLP Smoothed proposed SF list price (£/U)

TPPL Time for management to perceive proposed SF list price (M)

5.3. List Price

List price, SFLP, which is the firm's formal offering price for its product, is the output (and the starting point) of the pricing decision process. It is normally adjusted infrequently. Adjustment may be carried out once a year, twice, quarterly, or possibly monthly. Time for adjusting is, indeed, affected by pricing objectives. Owing to the nature of textile industry, where there is a long pipeline between the fibre producers and the end-users, the price fluctuations are inevitably propagated to various textile products in each stage of this pipeline with lags and amplification (McPherson, 1966). Thus, price stability objective is of great importance from the standpoint of fibre producers. Therefore, it is expected that time for adjusting is relatively long. In this model, the time for the price leader to adjust his list price is chosen as quarterly. SAMPLE function is used to formulate the discontinuous decision to adjust list price.

$$A \quad SFLP.K = \text{SAMPLE}(SPSLP.K, PERD, ISFLP) \quad (27)$$

$$C \quad PERD = 3 \quad (27-1)$$

where:

SFLP Synthetic fibre list price (£/U)

PERD Price decision period (M)

Initial list price ISFLP is selected, as we have already pointed out, to be equal to the initial price of substitutable natural fibre.

$$C \quad ISFLP = 1.1 \quad (28)$$

where:

ISFLP Initial SF list price (£/U)

Finally, the general level of synthetic fibre price is calculated as follows:-

$$A \quad APRICE.K = ((SFBD.K * SFLP.K) + (OLS.K * NRP.K)) / (SFBD.K + OLS.K) \quad (29)$$

where:

APRICE General level of synthetic fibre price (£/U)

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CHAPTER VI

EQUATION FORMULATION FOR
COSTING, CAPACITY, PRODUCTION AND INVENTORY,
AND PROFIT

CHAPTER VIEQUATION FORMULATION FOR
COSTING, CAPACITY, PRODUCTION AND INVENTORY,
AND PROFIT

This chapter deals with equation formulation for costing, production and inventory, capacity and profit.

The discussion is outlined as follows:-

1. Costing
2. Production capacity, production and inventory
3. Shipping
4. Profit
5. Financial Ratios
6. Forecasting.

6.1. Costing Sub-Sector

Product costs can be divided into three main categories:

1. Administrative and selling expenses
2. Research and development expenditures
3. Manufacturing costs.

Each of these factors, particularly manufacturing costs, has a significant influence on the price of that product, especially in the long run. Policies of budgeting marketing effort, which represent an item of administrative and selling expenses, and research and development have already been discussed in Chapter Four. Therefore, this section is devoted to discussing the other cost factors as follows:-

6.1.1. Manufacturing Costs:

These can be divided into two groups depending on whether or not they can be directly assigned to specific finished units. They are: 1) direct costs and 2) factory overhead.

The causal relationship between the components of manufacturing costs are represented in Fig. 6.1. Each component is examined individually as follows:-

6.1.1.1. Direct Raw Material

The most important item of the direct costs is the cost of raw material. It is the cost of all raw materials which become an integral part of finished goods and which can be directly assigned to specific physical units. Two points should be examined in connection with the cost of raw material. They are: effect of inflation on raw material cost and how material is valued when taken out of inventory.

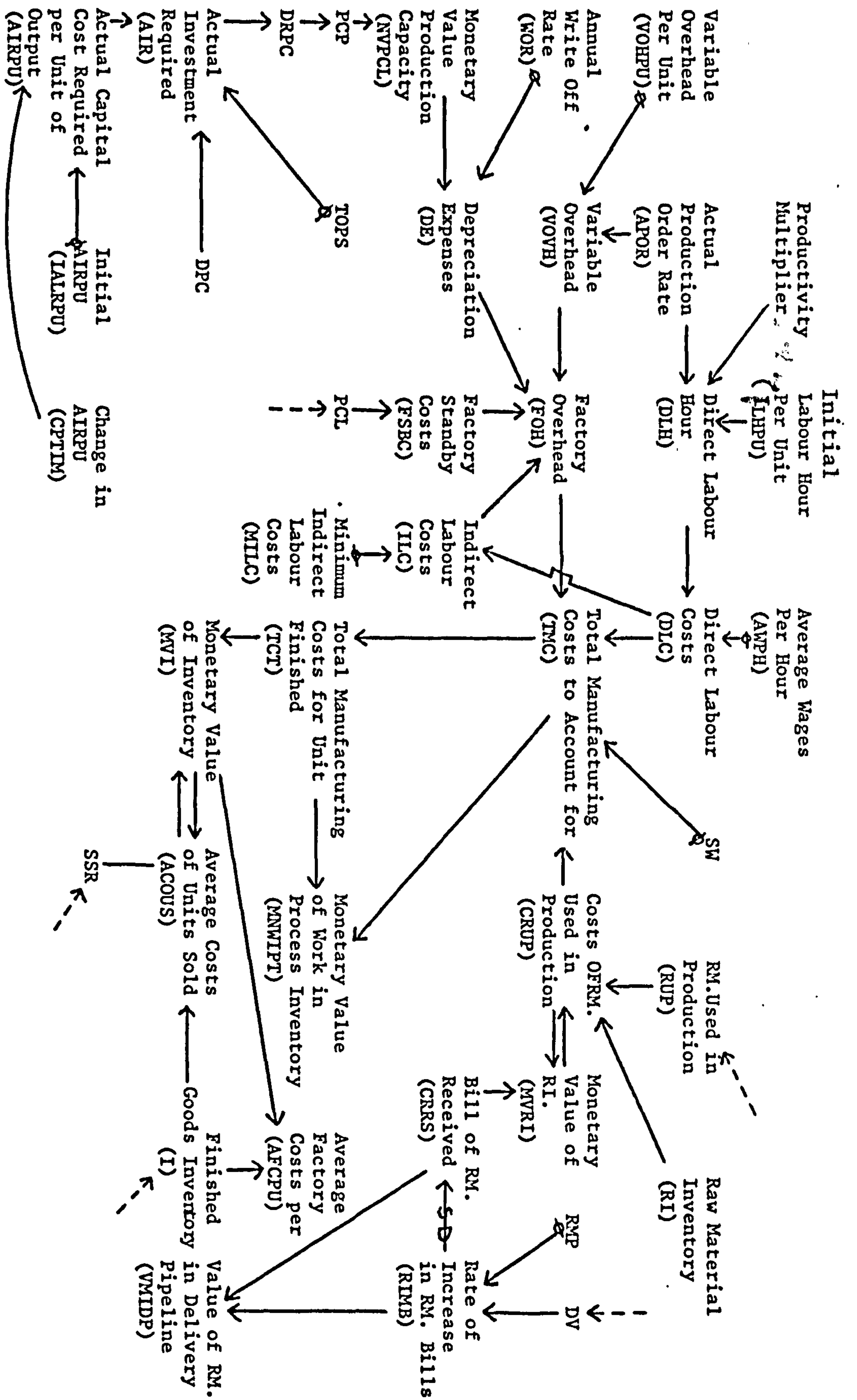


Fig. 6.1.: The Influence Diagram of Costing Sub-Sector

With regard to the first point, because there is substantial increase (from Oct. 1973 onwards) in the price of the petrochemical which forms the basis for the manufacture of synthetic fibres (OECD, 1976), it becomes necessary to study the impact of price increase on production costs. This will be carried out in Chapter 9.

As far as inventory-valuation methods are concerned, there are many accounting methods, the most commonly used being FIFO, LIFO, or some version of an average - inventory method. The choice of any of them will affect the cost of raw material used in production if unit price fluctuates over time. In this work where it is not our intention to tackle the problems associated with inventories valuation, since they are being dealt with by another researcher, it is sufficient to choose one of the traditional and widely used methods. The moving-average method is applied here to calculate the cost of raw material used in production (as well as finished goods).

The equations are formulated as follows:-

Equation 1 shows that rate of increase in raw material bills RIMB is found by multiplying raw material order rate DV by raw material unit price RMP, which is a constant. Bills of raw material received CRRS in equation 2 is the third order delay of RIMB. The delay time SD is the same as receiving raw material. Equation 3 gives cost of raw material used in production CRUP as a product of monetary value of raw material inventory MVRI divided by raw material inventory RI times raw material used in production RUP. MVRI in equation 4 depends on its value in previous time instant and the integral of the difference between CRRS and CRUP.

$$\begin{array}{llll}
 \text{R} & \text{RIMB.KL} & = & \text{DV.K} * \text{RMP} & (1) \\
 \text{C} & \text{RMP} & = & .20 & (1-1) \\
 \text{R} & \text{CRRS.KL} & = & \text{DELAY3}(\text{RIMB.JK}, \text{SD}) & (2) \\
 \text{C} & \text{SD} & = & 2 & (2-1) \\
 \text{A} & \text{CRUP.K} & = & (\text{MVRI.K} / \text{RI.K}) * \text{RUP.K} & (3) \\
 \text{L} & \text{MVRI.K} & = & \text{MVRI.J} + \text{DT} * (\text{CRRS.JK} - \text{CRUP.J}) & (4) \\
 \text{L} & \text{VMIDP.K} & = & \text{VMIDP.J} + \text{DT} * (\text{RIMB.JK} - \text{CRRS.JK}) & (5)
 \end{array}$$

where:

RIMB	Rate of increase in RM bills	(£/M)
RMP	RM Price per unit	(£/RU)
CRRS	Bills of raw material received	(£/M)
SD	Delay at suppliers	(M)
CRUP	Cost of RM used in production	(£/M)
MVRI	Monetary value of RM inventory	(£)
VMIDP	Value of RM in delivery pipeline	(£)

6.1.1.2. Direct Labour Cost:

This is the cost of labour that can be identified directly with a unit of finished product. Such costs are indivisible. They change beyond a certain limit of activity in a stepwise manner. The use of overtime, part-time help, or short work weeks may cause the direct labour cost steps to be very narrow and very small so that they approximate strictly variable costs behaviour pattern. Direct labour may, therefore, be regarded as a variable cost because a small error is caused by using a straight line instead of step function. Depending upon this basic assumption direct labour costs is calculated as follows.

Direct labour hours required DLH is calculated as it is shown in equation 6. The first component of this equation is labour hours per unit LHPU which is the minimum labour hour per unit ILHPU adjusted by the improvement in productivity (equation 7).

The improvement in productivity can arise from (a) changes in work method, (b) product engineering modification, (c) facilities relocation, (d) facilities layout, (e) equipment redesign, (f) change in employee skills, and others (Ebert, 1976). The effect of all these factors is usually referred to as learning rate. The learning rate varies with the firm and type of work (Lofthouse, 1975). The Boston Consulting Group argues that costs appear to decline 20 to 30 per cent every time total production experience doubles (BCG, 1968). The effect of different learning rate will be tested.

Equation 8 gives direct labour cost DLC as a product of direct labour hours times average wages per hour AWP which is modelled as a constant. Inflation factor will be incorporated later on.

$$\begin{aligned}
 \text{A } \text{DLH.K} &= \text{APOR.K} * \text{LHPU.K} & (6) \\
 \text{A } \text{LHPU.K} &= \text{ILHPU} * ((\text{IPOR}/\text{AAPOR.K}) * * \text{A}) & (7) \\
 \text{C } \text{ILHPU} &= .168 & (7-1) \\
 \text{A } \text{DLC.K} &= \text{DLH.K} * \text{AWPH} & (8) \\
 \text{C } \text{A} &= .3
 \end{aligned}$$

where:

DLH	Direct labour hours	(H/M)
LHPU	Labour hours per unit	(H/U)
ILHPU	Initial LHPU	(H/U)
DLC	Direct labour costs	(£/M)
A	It is constant to generate decline in LHPU equal 20% each time production doubled	(1)

6.1.2. Factory Overhead

All factory costs other than direct material and direct labour.

6.1.2.1. Indirect Labour Cost:

Common examples of such costs are foremen, material handling and warehouse labour costs. They are related to the direct labour cost as it can be seen in equation 9. ILC is modelled as 50% of DLC plus a minimum whatever the level of activity MILC.

$$\begin{aligned} \text{A } \text{ICL.K} &= \text{MILC} + .5 * \text{DLC.K} && (9) \\ \text{C } \text{MILC} &= 134.3 && (9-1) \end{aligned}$$

where:

ILC	Indirect labour costs	(£/M)
MILC	Minimum ILC	(£/M)

6.1.2.2. Variable Overheads:

Variable overheads, such as variable maintenance and power, are calculated by multiplying actual production order rate by variable overheads per unit.

$$\begin{aligned} \text{A } \text{VOVH.K} &= \text{VOHPU} * \text{APOR.K} && (10) \\ \text{C } \text{VOHPU} &= .01 && (10-1) \end{aligned}$$

where:

VOVH	Variable overheads	(£/M)
VOHPU	VOVH per unit	(£/U)

6.1.2.3. Fixed Costs:

In a capital intensive industry, such as the synthetic fibre industry (Capon, 1975) which involves large capital investment, the influence of the fixed costs on total product costs is more important than the influence of raw material costs and the other variable costs. The higher the total investment expenditure, the larger the depreciation normally. Other fixed costs, are also considerable, so that for a synthetic fibre manufacturer, fixed costs form a very large proportion of total costs (Hirsh, 1972).

Therefore, the proportion of fixed costs in total costs has an important influence on the cost per unit of synthetic fibre manufactured. Since fixed costs are incurred irrespective of the level of activity from any particular plant, they will be the same regardless of the volume of activity. However, with a large volume of production the fixed costs per unit will be reduced, and as variable costs are approximately constant, total cost per finished unit will fall as output increases. To shed more light on this point, it was found in rayon industry that the plant which is only worked at 15% of its capacity will have total unit costs approximately two times greater than if it produced at full capacity (Fig. 6.2 (curve B)). It should now be higher than this. This is because the size of plant in "process" industries is now greater than its size at that time (Ball, et. al., 1976). As a result, the cost structures of firms in those industries become more fixed in character. Consequently, the increase in total costs per unit will be higher as output decreases.

These economies of scale apply not only to production from a given plant, but also to production from plants of different sizes. Up to a point the larger the plant, the lower will be the total costs per unit of product at full capacity utilization since fixed costs, which may increase but not proportionately, are spread over larger finished units (Fig. 6.2. (curve A)).

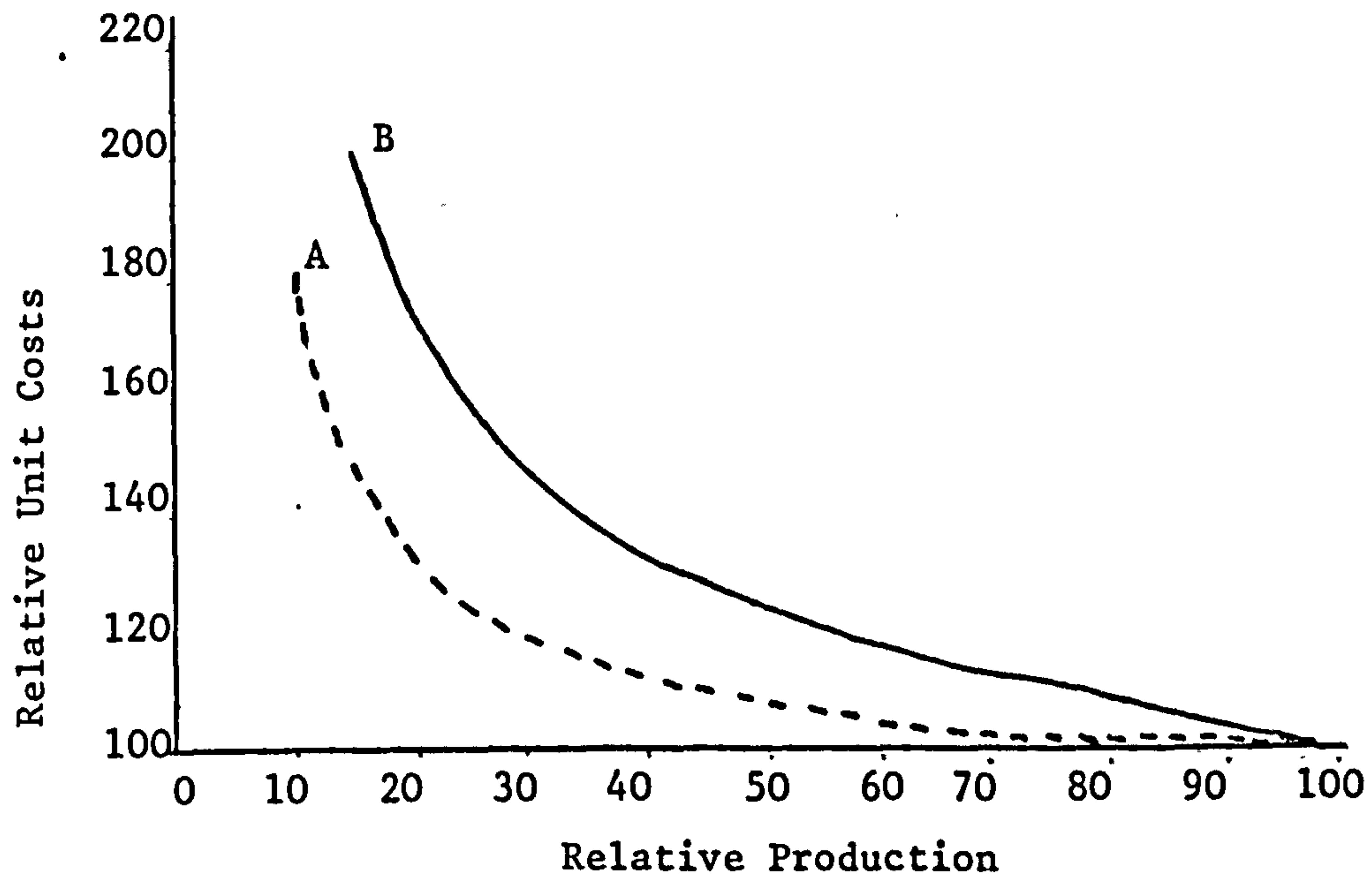


Fig. 6.2.: Variation in Unit Cost (A) with size of Plant and (B) with percentage of Installed Capacity Operated.

Source: Markham, J.W., *Competition in the Rayon Industry*, Harvard University Press, Cambridge, 1952, p. 150.

Moreover, Technological improvements account with the economies of scale discussed above, for the decline of the cost per unit of output. Generally, when a new plant is built, the latest technological improvements are incorporated, and thus there is a tendency for the capital cost per unit of output to decline progressively.

From the foregoing discussion it becomes clear that these costs are partly a function of the size of the plant, which will be represented in this model by production capacity, and partly a function of technological improvements. Our next task is to formulate the required equations.

Factory standby costs FSBC in equation 11 include other factory overheads - excluding depreciation - which are fixed for a given size of production capacity, but may have to be increased if the size of production capacity increased but not proportionately. A Table function is used to formulate this relationship between FSBC and the size of production capacity PCL.

$$\begin{aligned}
 A \quad \text{FSBC.K} &= \text{TABHL}(\text{FSBCT}, \text{PCL.K}, 63180, 315900, 21060) && (11) \\
 T \quad \text{FSBCT} &= 8395/10200/11600/12600/13700/14500/15400/16200/17100 \\
 X1 & \quad /18500/20000/21500/23000 && (11-1)
 \end{aligned}$$

where:

FSBC	Factory standby costs	(£/M)
FSBCT	FSBC Table	(£/M)

With regard to depreciation, it is necessary, first of all, to point out that the purpose of this research is limited to study the connection between standard accounting practices and company growth. Therefore, historical cost is considered as a basis to calculate depreciation charge, and the straight line method is used to allocate this cost over the economic useful life of fixed assets as depreciation expenses.

Thus, actual investment made AIR in equation 12 is the product of production capacity order rate times actual capital cost per unit of output AIRPU. AIRPU in equation 13 is the initial capital cost per unit IARPU adjusted by the decrease in capital cost per unit due to technological improvements CPTIM which is modelled in equation 14 as a function of the time.

An important point to mention here, is that the price of a future facility may decrease because of the availability of a more efficient method of producing the facility, or it may go up as technological improvement demands increasing complexity in the design of the facility (Hinomato, 1965). In this model, it is assumed that the price is decreasing with time. However, the increased case will be tested in Chapter 8. On the other hand, the decrease in price is expected to differ according to facilities of various sizes. However, we simply let CPTIM table represent this technological improvement factor for facilities of all sizes.

Equation 15 gives payment for received production capacity PCP as the third order delay of AIR. The delay DRPC is the same of receiving production capacity. Monetary value of production capacity MVPCL, in equation 16 is the accumulate of PCP. Monthly depreciation expenses, in equation 17, DE is the product of MVPCL times annual write off WOR divided by 12.

R	$AIR.KL = (DPC.K/TOPC)*AIRPU.K$	(12)
A	$AIRPU.K = IAIRPU*CPTIM.K$	(13)
C	$IAIRPU = 12$	(13-1)
A	$CPTIM.K = TABHL(CPTIMT TIME.K, 0, 120, 12)$	(14)
T	$CPTIMT = 1/.92/.85/.78/.72/.66/.61/.56/.52/.51/.50$	(14-1)
R	$PCP.KL = DELAY3(AIR.JK, DRPC)$	(15)
C	$DRPC = 24$	(15-1)
L	$MVPCL.K = MVPCL.J+DT*(PCP.JK)$	(16)
A	$DE.K = ((MVPCL.K*WOR)/12)$	(17)
C	$WOR = .10$	(17-1)

where:

AIR	Actual investment Made	(£/M)
AIRPU	AIR per unit of p.c.u.	(£/(U/M))
IAIRPU	Initial of AIRPU	(£/(U/M))
CPTIM	The decrease in AIRPU due to technological improvements multiplier	(1)
CPTIMT	CPTIM Table	(1)
PCP	Payment for received production capacity	(£/M)
DRPC	Delay in received and installation PC	(M)
MVPCL	Monetary value of PC	(£)
DE	Monthly depreciation expenses	(£/M)
WOR	Annual write off	(1/year)

Total factory overheads FOH in equation 18 is the sum of all the components of factory overheads.

$$A \quad FOH.K = ILC.K + VOVH.K + FSBC.K + DE.K \quad (18)$$

where:

FOH Factory overheads (£/M)

For the purpose of this research it is assumed that the material, labour, and overheads are added at the beginning of the production cycle. The justification is that the variation in costs than if materials, labour and overheads are assumed to be added uniformly as manufacturing progresses, which is more realistic, has no significant effect on total manufacturing costs per unit and consequently on price in the long run. Thus, total manufacturing costs to account for TMC in equation 19 is the sum of all manufacturing costs.

However, there are two main costing policies: direct costing and full costing. The difference between them is factory overheads. According to direct costing policy factory overheads are treated as period costs and written off in the period that they incurred. On the contrary, according to full costing policy they are treated as a production cost. Therefore, the model will be simulated under the two policies to indicate their effect on the price and profitability of the firm.

Equation 20 shows that costs of units finished in the current month TCT is the third order delay of TMC and that the delay PPD is the same as production process. Monetary value of work in process inventory, MVWIPI in equation 21, depends on its value in previous time instant and the integral of the difference between TMC and TCT. Monetary value of finished goods inventory MVI in equation 22 depends on its value in the previous time and the integral of the difference between TCT and average costs of units sold ACOUS. Average factory costs per unit, AFCPU in equation 23 is calculated by dividing MVI on finished goods inventory I. ACOUS is calculated in equation 23 by multiplying AFCPU times very short term average shipment sent rate USSR.

R	TMC.KL	=	CRUP.K+DLC.K+(FOH.K*SW)	(19)
C	SW	=	1	(19-1)
R	TCT.KL	=	DELAY3(TMC.JK,PPD)	(20)
C	PPD	=	3	(20-1)
L	MVWIPI.K	=	MVWIPI.J+DT*(TMC.JK-TCT.JK)	(21)
L	MVI.K	=	MVI.J+DT*(TCT.JK-ACOUS.J)	(22)
A	AFCPU.K	=	MVI.K/I.K	(23)
A	ACOUS.K	=	AFCPU.K*VSSR.K	(23-1)

where:

TMC	Total manufacturing costs to account for	(£/M)
TCT	TMC of unit finished in the current month	(£/M)
SW	Dummy to switch from full to direct costing	(1)
PPD	Production process delay	(M)
MVWIPI	Monetary value of work in process	(£)
MVI	Monetary value of finished goods I	(£)
AFCPU	Average factory costs per unit	(£/U)
ACOUS	Average factory costs of units sold	(£/M)

6.1.2. Administrative and Selling Expenses:

They include three types of expenses: standby administrative and selling expenses, variable selling expenses, and market effort. The former is calculated as a function of the size of production capacity. The second, which includes all the costs incurred after the sales have been made, such as shipping and delivery expenses, is calculated by multiplying variable selling expenses per unit by average shipment sent rate.

The Third is already discussed in Chapter Four.

$$A \quad ASSBE.K = TABHL(ASSBT, PCL.K, 63180, 315900, 21060) \quad (24)$$

$$T \quad ASSBT = 6318/7600/8600/9500/10200/10800/11400/12000/ \\ X1 \quad 12700/13600/14800/15900/17000 \quad (24-1)$$

$$A \quad VSE.K = VSEPU * ASSR.K \quad (25)$$

$$C \quad VSEPU = .05 \quad (25-1)$$

where:

ASSBE Administrative and selling standby expenses (£/M)

ASSBT ASSBE Table (£/M)

VSE Variable selling expenses (£/M)

VSEPU VSE per unit (£/M)

Total unit cost is the sum of all costs. Average total unit cost is the first order delay of total unit costs.

$$A \quad TUC.K = AFCPU.K + (((FOH.K * (1 - SW)) + VSE.K \\ + ASSBE.K + AME.K + ARE.K + ARE.K) / AOR.K) \quad (26)$$

$$L \quad ATUC.K = ATUC.J + DT / TATUC * (TUC.J - ATUC.J) \quad (27)$$

6.2. Production Capacity, Production and Inventory:

In this section, the way in which the production capacity, production and inventory policies are modelled will be examined. The interconnection between these variables are presented in Fig. 6.3. Each variable is examined individually in the following sub-sections.

6.2.1. Production Capacity

In a growing industry such as synthetic fibre, the leader firm(s) expands its production capacity (all fixed productive facilities) to maintain its market share in the growth market. There are many complex factors which the firm must take into account when deciding to expand its production capacity. The most important of these factors are the profitability, availability of funds required and long range demand forecast. In this research, the availability of required funds from internal as well as external resources will be assumed. No figures are available about actual investment in the synthetic fibre industry to justify this assumption but the information about the other sectors of the chemical industry shows that the availability of funds was not a constraint in the past decade (NEDO, 1972). The other two factors are emphasized.

The equations are formulated as follows:-

Production capacity desired PCD in equation 28 is made the function of the expected orders rate EOR, two years ahead plus backlog error correction factor, which is included to represent the expected demand forecasting error measured in terms of the deviation of actual demand from the forecasted one.

Deficit in production capacity DPC in equation 29 is the maximum of zero or the difference between PCD and production capacity level PCL plus production capacity on order PCOO. PCOO, in equation 30, depends on its previous value plus the integral of the difference between production capacity order rate PCOR and production capacity installation rate PCIR. PCOR in equation 31 is the product of DPC divided by the normal time to order production capacity TOPC which is taken as a constant.

But, as it has already been pointed out, the profitability affects expansion in capacity. Therefore, the change in this profitability may well call for some adjustment in production capacity order processing. Thus, an alternative policy is developed in which the firm, when it decides to order new capacity, pays not only attention to demand, but also to change in profitability. In this alternative policy, TOPC is based on profitability by means of profitability multiplier PMLT. PMLT in equation 32 depends on the ratio of the expected to current pretax profit margin on sales. If this ratio is greater than one, TOPC will be decreased and vice versa.

Equation 33 gives production capacity installation rate PCIR as the third order delay of PCOR. The delay time DRPC is chosen to be equal to 24 months, because this is, on the average, the time required between orders for production capacity and its availability for use in the chemical industry (NEDO, 1973).

Production capacity in equation 34 is an accumulation of PCIR. Several different measurements of capacity can be used (Purdy, 1962). For the purpose of this research, it is measured in terms of total output per month to describe the maximum level of capacity (in terms of volume) which could be attained to meet customers demand over a span of time under 'normal' circumstances; e.g. hours typically worked, typical product mix, etc. This capacity concept is required for capacity planning process as well as for pricing purpose. Capacity planning problem has two aspects. Firstly, it is necessary to specify capacity in terms of how much the Company should be prepared to make and to sell. Secondly, the capacity of specific facilities available or to be required must be determined (N.A.A., 1963). Obviously, the two aspects should be measured in the same units. Since the output is often expressed in units (pounds, kgs, tons) per time (week, month, year), it becomes necessary to measure the capacity in the same terms. This approach should also be relevant to pricing purposes, hence, the relationship of actual output as compared to available capacity (capacity utilization) has an important impact on costs and profit, and, consequently, on price (Carrithers, et al., 1967). There is an evidence about the use of this concept in the synthetic fibre industry (Textile Organon, 1973).

Physical depreciation per month PD in equation 35 is the product of PCL times annual write off WOR divided by 12. WOR is the estimated fraction of these assets consumed by using during the year and by their gradual obsolescence. Its value depends on the useful life of the assets, its scrap value and depreciation method used. The useful life is taken as 10 years as it is generally assumed in the chemical industry (Reuben, 1973). The scrap value is assumed to be zero. The straight-line method is applied since it is currently used by the majority of British Companies (Inst. Chart. Accountants, 1976). Accumulated depreciation APD in equation 36 does not deduct from PCL, since the replacement problem is not considered in this research.

$$\begin{aligned}
 A \quad PCD.K &= EOR.K + (B.K - NB.K) / TDBA & (28) \\
 C \quad TDBA &= 12 & (28-1) \\
 A \quad DPC.K &= \text{MAX}(0, (PCD.K - PCOO.K - PCL.K)) & (29) \\
 L \quad PCOO.K &= PCOO.J + DT * (PCOR.JK - PCIR.JK) & (30) \\
 R \quad PCOR.KL &= DPC.K / TOPC * \text{CLIP}(PMLT.K, 1, DVR, 1) & (31) \\
 C \quad TOPC &= 4 & (31-1) \\
 C \quad DVR &= 0 & (31-2) \\
 A \quad PMLT.K &= \text{TABH}(PMLTT, RECPM.K, 0, 2, .5) & (32) \\
 A \quad RECPM.K &= EPSR.K / CPSR.K & (32-1)
 \end{aligned}$$

T	PMLTT	=	$2/1.5/1/.8/.5$	(32-2)
R	PCIR.KL	=	$\text{DELAY3}(\text{PCOR.JK.DRPC})$	(33)
C	DRPC	=	24	(33-1)
L	PCL.K	=	$\text{PCL.J} + \text{DT} * (\text{PCIR.JK})$	(34)
R	PD.KL	=	$(\text{PCL.K} * \text{WOR}) / 12$	(35)
C	WOR	=	.10	(35-1)
L	APD.K	=	$\text{APD.J} + \text{DT} * \text{PD.JK}$	(36)

where:

PCD	Production capacity desired	(U/M)
TDBA	Time to adjust backlog error	(M)
DPC	Deficit in production capacity	(U/M)
PCOO	PC on order	(U/M)
PCOR	Production capacity order rate	(U/M/M)
TOPC	Time for order PC	(M)
DVR	Dummy variable to test the other policy	(1)
PMLT	Profitability multiplier	(1)
RECPM	Expected to current pretax profit margin on sales	(1)
PMLTT	PMLT Table	(1)
PCIR	PC installation rate	(U/M/M)
DRPC	Delay in received and installation PC	(M)
PCL	Production capacity level	(U/M)
PD	Physical depreciation	(U/M/M)
WOR	Write off rate	(1)
APD	Accumulated depreciation	(U/M)

6.2.2. Production and Inventory

Let us now examine the production planning process. Generally speaking, we can say that the common objective of production planning in capital intensive industries is to achieve full capacity utilization, since a substantial fraction of total costs are fixed. On the other hand, the existence of excess inventory, which may be the outcome of a production policy established solely on the basis of the condition of capacity utilization, is undesirable from financial points of view. Therefore, the chosen production policy should satisfy these views. The following policy meets this requirement.

The minimum production rate NPOR, in equation 37, is set equal to the average incoming orders rate plus the stock gap corrected over TAI months. Thus, NPOR may increase as there is a permanent increase in demand or as there is a drop in the level of inventory beyond the minimum desired one MID, which is calculated in equation 38, by multiplying the average shipment rate ASSR times a constant minimum cover MICOV. On the other hand, if there is a decline in the demand and/or an increase in the inventory level over its minimum desired level, at least two alternative courses of action can be carried out.

The first one, is to reduce production as far as possible to bring the level of inventory on line with its minimum desired level. It is undesirable, because in the actual operational situation rapid fluctuations in production level have to be avoided. Moreover, large cutbacks in production cause a sharp rise in average unit costs which is due to high fixed costs. On the other hand, short-term fluctuations in demand and seasonality of demand should be absorbed so far as possible in inventory. Therefore, this course of action will not be considered. The other alternative is to allow the inventory to increase above its minimum desired level up to a specified acceptable limit from management point of view before any decrease in production level takes place. By doing so, the criticisms to the first alternative will be avoided. Therefore, this alternative is adopted in this model.

This is carried out by establishing another production level, the maximum production order rate MPOR in equation 39 in which the minimum desired inventory level MID in equation 37 is replaced by the maximum acceptable inventory level MIL. MIL in equation 40 is the product of multiplying the average shipment sent rate ASSR by the maximum cover MACOV. Equation 41 shows that planned production order rate PPOR is one of the two production rates NPOR and MPOR. The choice depends on the expected capacity utilization EPCU which is in equation 42 the product of NPOR divided by production capacity level PCL.

Two factors may lead to adjusting PPOR. The availability of raw materials and production capacity. There is no shortage in the basic raw materials for the production of synthetic fibres (OECD, 1976), so that, this factor does not affect the level of production. With regard to availability of production capacity, this factor has been introduced by making actual production rate APOR, in equation 43, as the minimum of PPOR and production capacity level PCL. By assuming that there is no significant delay between the issuance of an order and its receipt at factory, production start rate PSR in equation 44 is made equal to APOR. Equation 45 shows that production completion rate PCR is the third order delay of PSR and that the delay PPD is the production process delay.

A	NPOR.K	=	AOR.K+(MID.K-I.K)/TAI	(37)
C	TAI	=	3	(37-1)
A	MID.K	=	ASSR.K*MICOV	(38)
C	MICOV	=	2	(38-1)
A	MPOR.K	=	AOR.K+(MIL.K-I.K)/TAI	(39)
A	MIL.K	=	ASSR.K*MACOV	(40)
C	MACOV	=	6	(40-1)
A	PPOR.K	=	(NPOR.K*DVP.K)+(MPOR.K*(1-DVP.K))	(41)
A	DVP.K	=	CLIP(1,0,EPCU.K,1)	(41-1)
A	EPCU.K	=	NPOR.K/PCL.K	(42)
A	APOR.K	=	MIN(PCL.K,PPOR.K)	(43)
R	PSR.KL	=	APOR.K	(44)
R	PCR.KL	=	DELAY3(PSR.JK,PPD)	(45)
C	PPD	=	3	(45-1)
L	WIPI.K	=	WIPI.J+DT*(PSR.JK-PCR.JK)	(46)
L	I.K	=	I.J+DT*(PCR.JK-SSR.J)	(47)

where:-

NPOR	Minimum production order rate	(U/M)
TAI	Time to adjust inventory	(M)
MID	Minimum inventory desired	(U)
MICOV	minimum cover	(M)
MPOR	Maximum POR	(U/M)
MIL	Maximum acceptable inventory level	(U)
MACOV	Maximum cover	(M)

PPOR	Planned POR	(U/M)
DVP	Dummy to control POR	(1)
EPCU	Expected PC utilization	(1)
APOR	Actual POR	(U/M)
PSR	Production start rate	(U/M)
PCR	Production completion rate	(U/M)
PPD	Production process delay	(M)
WIPI	Work in process	(U)
I	Finished goods inventory	(U)

With regard to raw materials, its ordering mechanism should be designed to hold raw material inventory at its desired level the same as in the finished goods inventory case. The desired level DRI is determined in the model in two ways in equation 48, it is the product of multiplying desired raw materials cover RCOV times the average raw materials which has been taken into production ARUP (equation 49), or the required raw material for the average order rate. The quantity of raw material to be ordered ROR is made in equation 50 as the function of ARUP plus the correction factor of the difference between the actual RI and the desired raw materials inventory DRI. Raw material received from suppliers RRS in equation 51 are the third order delay of ROR. The delay time SD depends on the agreement between the firm and its suppliers. Equation 52 gives

raw materials which have been taken into production RUP as a product of actual production order rate multiplying by raw materials required per unit MRUPU. The assumption here is that the exact quantities required will be ordered once APOR is determined. Raw material inventory RI in equation 53 is built up by RRS and depleted by RUP.

A	DRI.K	=	$(D1*(AOR.K+MRUPU)+(1-D1)*ARUP.K)*RCOV$	(48)
C	RCOV	=	2	(48-1)
C	MRUPU	=	1.075	(48-2)
C	D1	=	1	(48-3)
L	ARUP.K	=	$ARUP.J+DT/TAPUP*(RUP.J-ARUP.J)$	(49)
R	ROR.KL	=	DV.K	(50)
A	DV.K	=	$ARUP.K+(RRI.K-RI.K)/TARI$	(50-1)
C	TARI	=	3	(50-2)
R	RRS.KL	=	DELAY3(ROR.JK,SD)	(51)
C	SD	=	2	(51-1)
A	RUP.K	=	APOR.K*MRUPU	(52)
L	RI.K	=	$RI.J+DT*(RRS.JK-RUP.J)$	(53)

where:

DRI	Desired raw materials inventory	(RU)
RCOV	Desired raw materials cover	(M)
MRUPU	Minimum raw materials permit	(RU/U)
D1	Dummy to transfer between the - DRI policies	(1)
ARUP	Average raw material used in production	(RU/M)
ROR	Raw material order rate	(RU/M)
DV	Raw material order rate	(RU/M)
TARI	Time to adjust RM inventory	(M)
RRS	RM received from suppliers	(RU/M)
SD	Delay at suppliers	(M)
RUP	RM used in production	(RU/M)
RI	RM inventory	(RU)

6.3. Shipping Sub-Sector:

The shipment desired SSRD in equation 54 is limited to Backlog B on hand divided by months desired in Backlog MDSB which is regarded as a constant. MDSB represents the desired time to keep the distribution system loaded with work. Obviously, SSRD may exceed the finished goods inventory I, so that actual shipment sent rate SSR in equation 55 is made the minimum of SSRD and I. Therefore, the actual delivery delay DD which is calculated in equation 56 will be greater than the desired one MDSB if SSR drops below SSRD.

$$A \quad SSRD.K = B.K/MDSB \quad (54)$$

$$C \quad MDSB = 1 \quad (54-1)$$

$$L \quad B.K = B.J+DT*(IOR.JK-SSR.JK) \quad (54-2)$$

$$A \quad SSR.KL = \text{MIN}(SSRD.K, I.K/DT) \quad (55)$$

$$A \quad DD.K = B.K/VSSR.K \quad (56)$$

$$L \quad VSSR.K = VSSR.J+DT/CTTS*(SSR.JK-VSSR.J) \quad (56-1)$$

$$C \quad CTTS = .250 \quad (56-2)$$

where:

SSRD	Desired shipment sent rate	(U/M)
MDSB	Months desired in Backlog	(M)
B	Backlog	(U)
SSR	Actual shipment sent rate	(U/M)
DD	Delivery delay	(M)
VSSR	Smoothed shipment sent rate	(U/M)
CTTS	Time to smooth shipment sent rate	(M)

6.4. Profit Sub-Sector:

To generate the required profitability information for pricing and capacity expansion decisions and for the purpose of calculating financial ratios which are used to evaluate the model performance, it is crucial to deal with the quantitative aspects of profit. Two points related to this process should be clarified, the first of which is the measurement of expenses and revenues. The general accounting practice which is applied to measure expenses will be applied to measure revenues. It treats revenue as arising only when a sale is made. The second point is profit appropriation. The percentage from after-tax profit distributed as dividend varies widely within the industry. It also varies over time for the same firm. It is assumed here that 40% from after-tax profit is distributed as dividend and the balance is retained.

Fig. 6.4. shows the profit sub-sector. The equations used to determine profit are as follows:-

$$\begin{aligned}
 L \quad MVB.K &= MVB.J + DT * (MVOR.JK - SRV.JK) & (57) \\
 R \quad MVOR.KL &= (SFBD.K * SFLP.K) + (OLD.K * NRP.K) & (58) \\
 R \quad SRV.KL &= DELAY3(MVOR.JK, DD.K) & (59) \\
 A \quad PBT.K &= VSRV.K - (ACOUS.K + AME.K + ASSBE.K + VSE.K \\
 &\quad + IOD.K + ARE.K) - (FOH.K * (1 - SW)) & (60) \\
 L \quad APL.K &= APL.J + DT / TAPR * (PBT.J - APL.J) & (61) \\
 C \quad TAPR &= 3 & (61-1) \\
 A \quad PAT.K &= (1 - TAX.K) * APL.K & (61) \\
 A \quad TAX.K &= .40 & (62) \\
 A \quad RE.K &= PAT.K - DIV.K & (63) \\
 A \quad DIV.K &= .4 * PAT.K & (64) \\
 L \quad VSRV.K &= VSRV.J + DT / CTTS * (SRV.JK - VSRV.J) & (64-1)
 \end{aligned}$$

where:

MVB	Monetary value of backlog	(M)
MVOR	Monetary value of incoming orders rate	(U/M)
SRV	Sales revenue	(£/M)
PBT	Pre-tax profit	(£/M)
APL	Average profit level	(£/M)
TAPR	Time to average pre-tax profit	(M)
PAT	Profit after tax	(£/M)
TAX	Tax rate	(1)
RE	Retained earning	(£/M)
DIV	Dividend	(£/M)
VSRV	Smoothed sales revenue	(£/M)

6.5. Financial Ratios:

The performance of this model will be evaluated mainly in terms of the following financial ratios:

1. Break-even ratios
2. Profitability ratios.

The equations used to determine these ratios for the purpose of this study are as follows:-

1. Break-Even Ratios Equations:

$$A \quad \text{BEP.K} = \text{TSBC.K} / \text{VCPR.K} \quad (65)$$

$$A \quad \text{TSBC.K} = \text{FSBC.K} + \text{MILC} + \text{DE.K} + \text{ASSBE.K} \quad (66)$$

$$A \quad \text{VCPR.K} = \text{VCPU.K} / \text{APRICE.K}$$

$$A \quad \text{VCPU.K} = (\text{MRUPU} * \text{RMP}) + (\text{LHPU.K} * \text{AWPH}) + ((\text{ILC.K} - \text{MILC}) / \text{APOR.K}) + ((\text{AME.K} + \text{ARE.K}) / \text{AOR.K}) + \text{VSEPU} + \text{VOHPU} \quad (67)$$

$$A \quad \text{MOS.K} = \text{ASRV.K} - \text{BEP.K} \quad (68)$$

$$A \quad \text{MOSP.K} = \text{MOS.K} / \text{ASRV.K}$$

$$A \quad \text{CSR.K} = (\text{VCPU.K} * \text{SSR.K}) / \text{ASRV.K} \quad (69)$$

where:

BEP	Break even point	(£/M)
TSBC	Total standby costs	(£/M)
VCPR	Variable costs to price ratio	(1)
VCPU	Variable costs per unit	(£/M)
MOS	Margin of safety	(£/M)
MOSP	MOS as percentage of sales revenue	(1)
CSR	Contribution to sales revenue ratio	(1)

2. Profitability Ratios Equations:

$$A \quad ROI.K = PMG.K * AT.K \quad (70)$$

$$A \quad PMG.K = PAT.K / ASRV.K \quad (71)$$

$$A \quad AT.K = (ASRV.K * 12) / AST.K \quad (72)$$

$$A \quad AST.K = MVRI.K + MVI.K + MVWIPI.K + ACR.K + CASHB.K + (MVPCL.K - ADE.K) \quad (73)$$

$$A \quad CPSR.K = PBT.K / ASRV.K \quad (74)$$

where:

ROI Return on investment (1)

PMG After tax profit margin on sales (1)

AT Assets turnover (1)

AST Total assets (£)

CPSR Pre-tax profit margin on sales (1)

6.6. Forecasting:

It is already pointed out that the criteria for ordering new capacity are the forecasted incoming order rate two years ahead and pre-tax profit margin on sales. Expected incoming order rate, price and costs per unit are estimated by linear extrapolation of past value of these variables. Forecasts are generated by the exponential smoothing commonly used in system dynamics models (Forrester, 1961). Obviously, there are more sophisticated methods that can be used to increase the accuracies of these forecasts. However, it is noted, in several system dynamics studies, that the performance of a properly

designed system that depends on a forecast is relatively insensitive to forecast error (Sharp, 1976). Some of these studies are described by Winch (1975). For that, there is no need to depart from the smoothing method. This method is described fully in Coyle (1977). The equations are formulated as follows:-

$$L \quad AOR.K = AOR.J + (DT/TAOR) * (IOR.JK.AOR.J) \quad (75)$$

$$L \quad PAOR.K = PAOR.J + (DT/DAOF) * (AOR.J - PAOR.J) \quad (76)$$

$$A \quad ECOR.K = ((AOR.K - PAOR.K) / DAOF) * (FT + TAOR) \quad (77)$$

$$C \quad TAOR = 3 \quad (77-1)$$

$$C \quad DAOF = 18 \quad (77-2)$$

$$C \quad FT = 24 \quad (77-3)$$

$$A \quad EOR.K = AOR.K + ECOR.K \quad (78)$$

$$L \quad ATUC.K = ATUC.J + DT/TATUC * (TUC.J - ATUC.J) \quad (79)$$

$$L \quad PATUC.K = PATUC.J + DT/DATUCF * (ATUC.J - PATUC.J) \quad (80)$$

$$A \quad ECTUC.K = ((ATUC.K - PATUC.K) / DATUCF) * (FT + TATUC) \quad (81)$$

$$N \quad TATUC = TAOR \quad (81-1)$$

$$N \quad DATUCF = DAOF \quad (81-2)$$

$$A \quad ETUC.K = ATUC.K + ECTUC.K \quad (82)$$

$$L \quad AAPRI.K = AAPRI.J + (DT/TASFP) * (APRICE.J - AAPRI.J) \quad (83)$$

$$L \quad PAAPRI.K = PAAPRI.J + (DT/DAASFP) * (AAPRI.J - PAAPRI.J) \quad (84)$$

$$A \quad ECASFP.K = (AAPRI.K - PAAPRI.K) / DAASFP * (FT + TASFP) \quad (85)$$

$$N \quad TASFP = TAOR \quad (85-1)$$

$$N \quad DAASFP = DAOF \quad (85-2)$$

$$A \quad ESFPR.K = AAPRI.K + ECASFP.K \quad (86)$$

$$A \quad ESRV.K = EOR.K * ESFPR.K \quad (87)$$

$$A \quad EPBT.K = ESRV.K - (EOR.K * ETUC.K) \quad (88)$$

$$A \quad EPSR.K = EPBT.K / ESRV.K \quad (89)$$

where:

AOR	Average Orders Rate	(U/M)
PAOR	Past Average orders rate	(U/M)
ECOR	Expected change in incoming OR	(U/M)
TAOR	Time to AOR	(M)
DAOF	Delay in AOR for forecasting	(M)
FT	Forecasting time	(M)
EOR	Expected incoming order rate	(M)
ATUC	Average total unit costs	(£/U)
PATUC	Past ATUC	(£/U)
ECTUC	Expected change in TUC	(£/U)
ETUC	" TUC	(£/U)
AAPRI	Average synthetic fibre price	(£/U)
PAAPRI	Past Average synthetic fibre price	(£/U)
ECASFP	Expected change in synthetic fibre price	(£/U)
ESFPR	" " " "	(£/U)
ESRV	Expected Sales revenue	(£/M)
EPBT	Expected pre tax profit	(£/M)
EPSR	Expected pre tax profit margin on sales	(1)

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CHAPTER VII

FEEDBACK LOOP ANALYSIS

CHAPTER VIIFEEDBACK LOOP ANALYSIS

In this chapter we shall analyse the feedback loops included in the system developed in the previous three chapters, in terms of their components: Polarity, Gain, Delay, Pure integration and Action. (These concepts are discussed in Coyle (1977), Forrester (1961) and Swanson (1968)). That is to show how the characteristics of these loops and the interaction among them affect the dynamic behaviour of the system. This analysis is also necessary in simulation results interpretation and policy redesign. The chapter is ended by a table containing the summary of the components of the feedback loops analyzed to show their commonalities.

This chapter is therefore outlined as follows:

- 7.1. Loop Analysis
- 7.2. Summary of the Loop Components

7.1. Loop Analysis:

For this complex system, the analysis of all its loops is impossible. The analysis, therefore, is limited to some of the most important loops for the purpose of this study.

The loops analyzed are labelled A, B, C, D, E, F, G, H and I. The components of every loop are summarized in a table below it. This is followed by some remarks on each loop.

The signs on the arrowheads indicate the direction of the effect of one variable on the other for each pair of variables. The arrowheads indicate which variable operates on the other. The type assignment rule is; plus sign is used, if the change in the variable at the arrowtail leads to change the variable at arrowhead in the same direction. Minus sign is used, if the change is in the opposite direction. The existence of an odd number of minus signs results in a negative loop, but if there is an even number of minus signs, the loop is positive one. (For more details, see Coyle 1977).

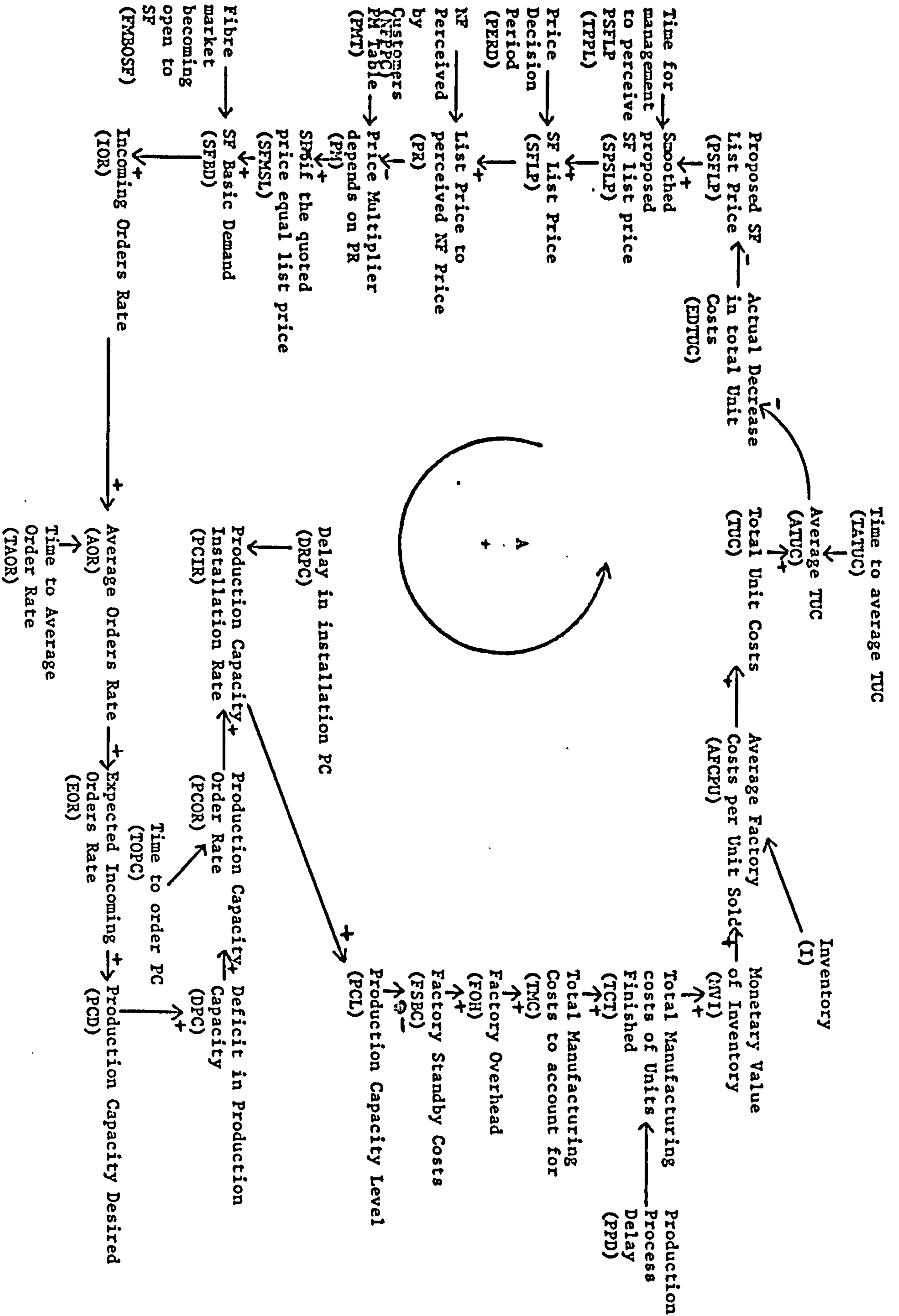
Before we proceed to analyse the loops, it would be appropriate to highlight how the loops characteristics affect the dynamic behaviour of the system, (Coyle, 1977).

In the Case of Positive Loop:

- 1) Its general effect is to amplify the input
- 2) Increasing gain leads to more rapid growth
- 3) Decreasing delay leads to more rapid growth

In the Case of Negative Loop:

- 1) It should be a stabilizing loop
- 2) Increasing gain leads to decrease damping
- 3) Decreasing delay leads to decrease damping



<u>Loop A:</u>	
Polarity:	Positive
Gains:	PMT
Delays:	TATUC, TPPL, PERD, TAOR, TOPC, DRPC, PPD
Pure Integ.:	PCL, MVI
Action :	It produces growth via the pricing policy and the economies of scale.

Remarks on Loop A:

- 1) This loop shows that a lower price for a product resulting from economies of scale will stimulate substitution of that product for another. This is leading, in turn, to build a bigger plant.
- 2) It acts in the following manner. A decrease in price SFLP leads to increase in market share SFMSL and, hence, in incoming orders rate, IOR. The latter stimulates the firm to expand its production capacity PCL. The increase in PCL may result in an increase in factory standby costs FSBC but not proportionally, and as a consequence to decrease average factory costs per unit AFCPU (on the assumption that the firm works at near full capacity). This eventually results in a substantial decrease in total unit costs TUC. As TUC decreases, the price decreases too. Thus, produces a further increase in IOR.

- 3) The input variables are the fibre market becoming open to synthetic fibre FMBOSF and natural fibre price perceived by customers NFPPC.
- 4) The important controllable parameters are the time to order production capacity TOPC, the time to perceive proposed price TPPL, and the pricing decision period PERD. TOPC is affected by the expansion policy. TPPL and PERD reflect the objective of management to stabilize price.
- 5) It should be noted that the action of this loop in inflationary cases is to decrease the effect of inflation on price.

Time to average TUC
(TATUC)

Time for Management to Perceive (TPPL) → Smoothed SF List Price (SFLP) (SFSLP) → Proposed SF List Price (PSFLP) → Actual Decrease in Total Unit Costs (EDTUC) → Average Total Unit Costs (ATUC)

Price Decision Period (PERD) → SF List Price (SFLP)

NF Perceived by Customers (NFPPC) → List Price to Perceived NF Price (PR)

PM Table (PMT) → Price Multiplier depends on PR (PM)

SFMS is the quoted price equal list price (SFMSL)

Fibre Market becoming open to SF (FMBSF) → SF Basic Demand (SFBBD)

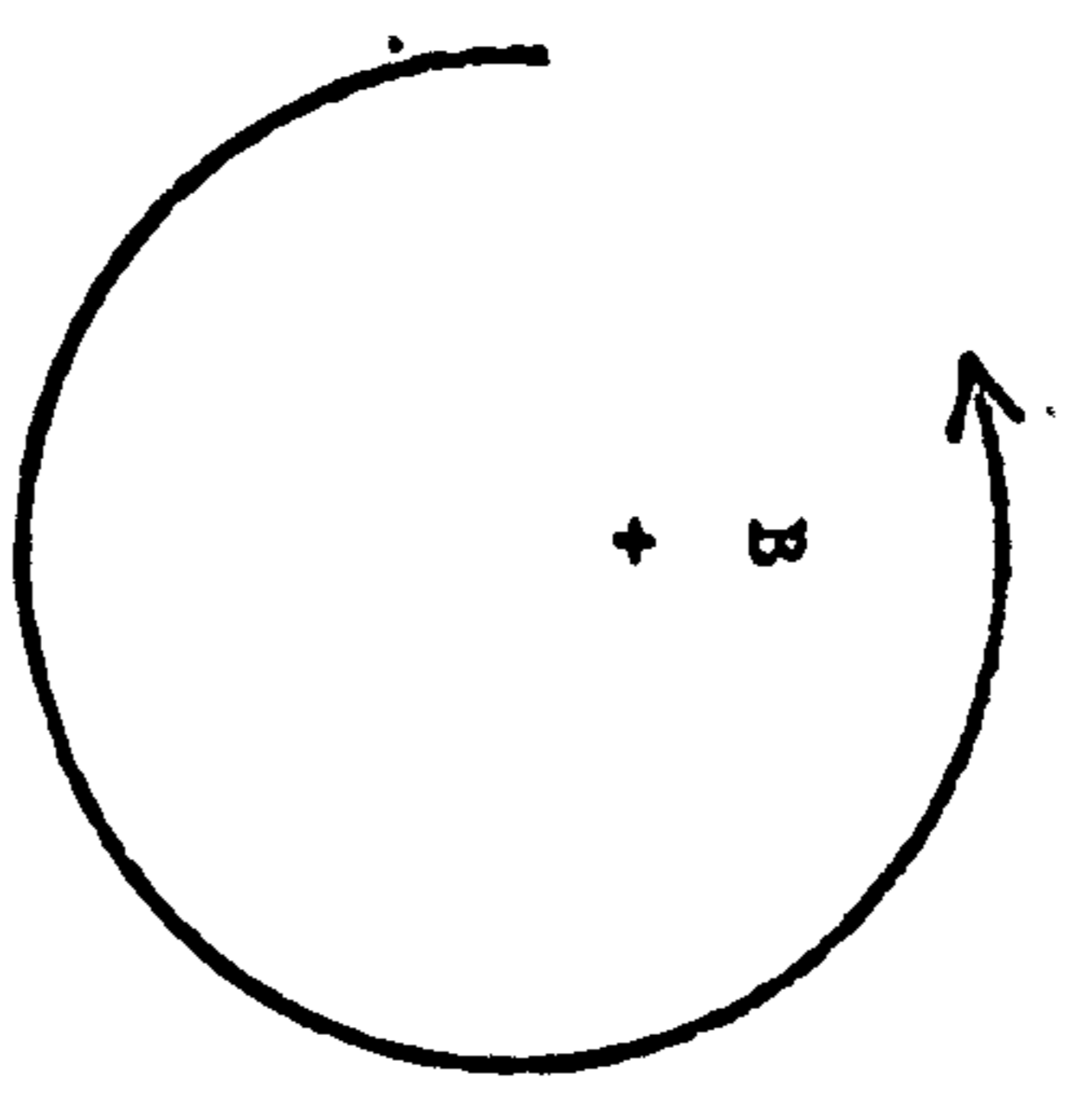
Incoming Order Rate (IOR)

Time to Average Order Rate (TAOR) → Average Orders Rate (AOR)

Expected Incoming Orders Rate (EOR) → Production Capacity Desired (PCD) → Deficit in Capacity (DPC)

Total Unit Cost (TUC) → Average Factory Costs per Unit Sold (AFCPU) → Inventory (I) → Production Process Delay (PPD) → Total Manufacturing Costs of Units Finished in the Current Month (TCT) → Total Manufacturing Costs to Account (TMC) → Factory Overheads (FOH) → Depreciation Expenses (DE) → Monetary Value of PCL (MVPCL) → Payment for received Production Capacity (PCP) → Delay in receive & installation PR Capacity (DKPC) → Actual Investment Order Rate (AIR) → Actual Capital rqd. per unit of Output (AIRPU) → Time for Order PC (TOPC)

Annual Write-off Rate

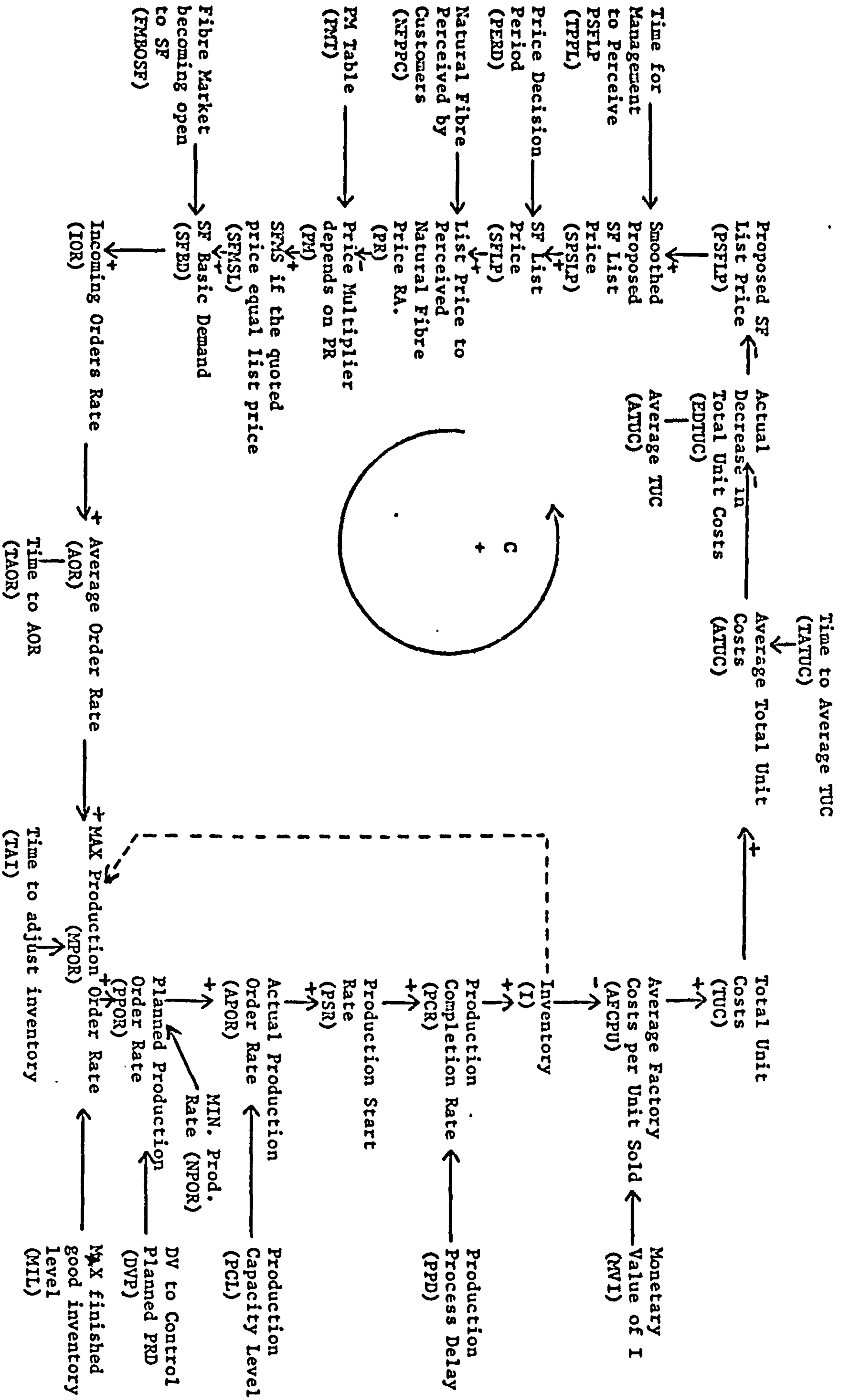


<u>Loop B:</u>	
Polarity:	Positive
Gains:	PMT, AIRPU, WOR
Delays:	TATUC, TPPL, PERD, TAOR, TOPC, DRPC, PPD
Pure Integ.:	MVPCL, MVI
Action:	It generates growth via pricing policy, the economies of scale, and technological improvement

Remarks on Loop B:

- 1) This loop shows how the economies of scale and technological improvement result in the decrease of capital costs per unit of output leading, via pricing policy, to build more bigger plant.
- 2) A decrease in price SFLP leads to increase in market share SFMSL and, hence, in incoming orders rate IOR. The latter, eventually, stimulates the firm to expand its production capacity (measured in monetary terms) MVPCL, but, the increase in MVPCL is not proportional to the increase in PCL. This is due to the decrease in actual capital costs required per unit which affects actual investment order rate AIR. The ultimate result is the decrease in depreciation charge per unit of output and, hence, in AFCPU (at near full capacity utilization). This results in substantial decrease in TUC. As TUC decreases, the price decreases as well, which produces a further increase in IOR.

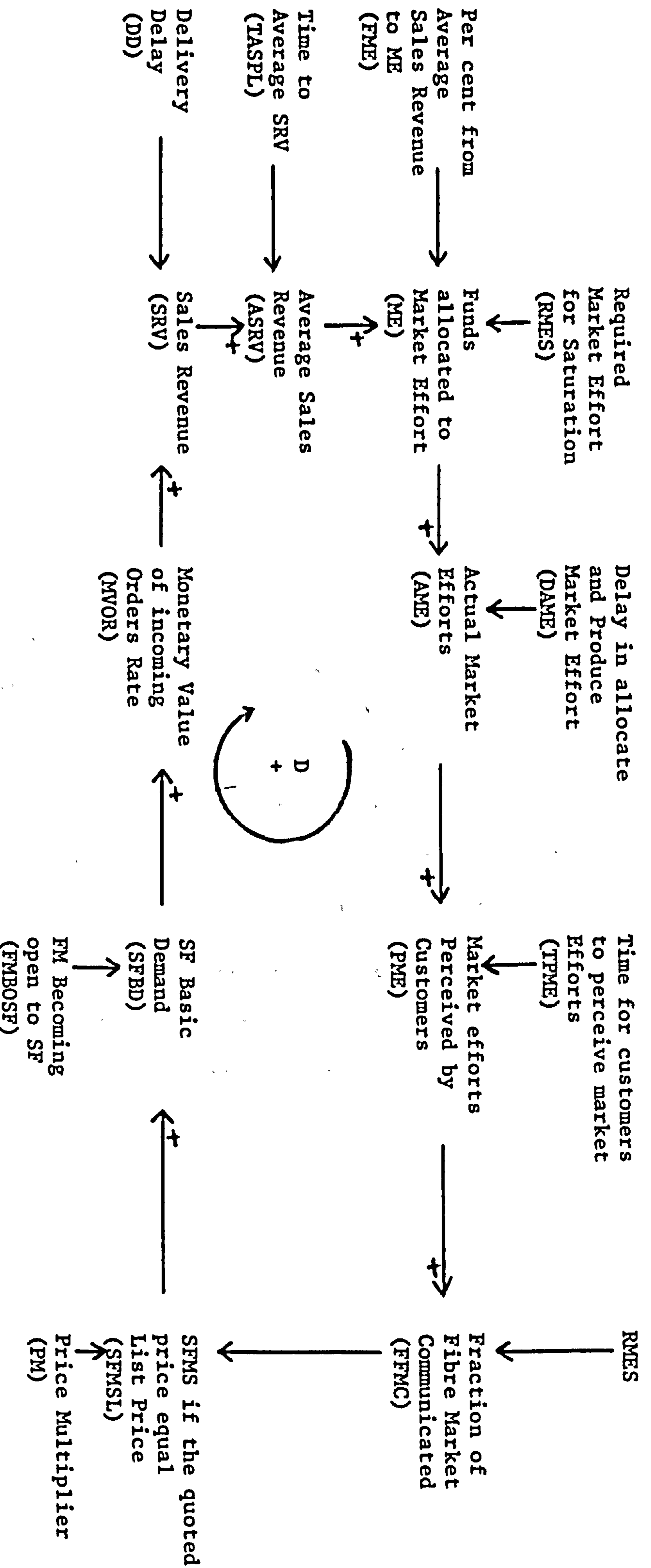
- 3) The input variables are FMBOSF and NFPPC.
- 4) The important controllable parameters are TOPC, TPPL, PERD and WOR.
- 5) The effect of inflation which may decrease the rate of growth produced by this loop (or to switch it off) will be discussed in Chapter 9.



<u>Loop C:</u>	
Polarity:	Positive
Gains:	PMT, MIL
Delays:	TATUC, TPPL, PERD, TAOR, TAI, PPD
Pure Integ.:	I
Action:	It produces growth if the firm lowers its price by the decrease in total unit costs resulting from increasing the level of activity.

Remarks on Loop C:

- 1) This loop is very important in any capital intensive firm. It shows the impact of the level of activity on average costs per finished unit. It highlights the fact that the advantages of economies of scale (Loop A and B) achieve only if the firm works at full or near capacity.
- 2) It acts in the following manner. As price SFLP decreases market share SFMSL increases and, consequently, production order rate MPOR increases. The latter leads to a decrease in AFCPU. This is due to the decrease of the fixed costs per unit. The decrease in AFCPU results in a further decrease in price.
- 3) The input variables are FMBOSF and NFPPC.
- 4) The important controllable parameters are MIL and TAI.



<u>Loop D:</u>	
Polarity:	Positive
Gains:	FME, PM
Delays:	DD, TASR, DAME, TPME
Pure Integ.:	NIL
Action:	It shows the effect of allocating different percentage of sales revenue to market effort on the firm's growth.

Remarks on Loop D:

- 1) It shows the speed with which the market effort ME achieves its saturation level.
- 2) It acts as follows. An increase in market effort budget results in an increase in market share and, hence, in incoming orders rate. The latter, eventually, results in increased sales revenue which leads to a further increase in market effort budget.
- 3) It should be noted that this loop produces only growth as long as the fraction of fibre market communicated FFMC is less than one (at which point there is no extra growth by the extra ME).

- 4) The action of this loop, after the point mentioned previously, is to maintain expenditures on market effort at its saturation level to maintain the existing market share.
- 5) The input variable is FMBOSF.
- 6) The important controllable parameter is the percentage of sales revenue allocated to market effort FME.

<u>Loop E:</u>	
Polarity:	Positive
Gains:	FSRVR, SFQT
Delays:	DORE, DD, TASR
Pure Integ.:	CERE
Action:	It shows the effect of different research policies on the firm's growth.

Remarks on Loop E:

- 1) It connects sales revenue, research spending, synthetic fibre quality and fibre market becoming open to synthetic fibre.
- 2) It generates growth in the following manner. The increase in synthetic fibre quality SFQ leads to increase the end uses (and wider acceptance) FMBOSF. As FMBOSF increases, the incoming orders rate increases too, and hence, sales revenue. The increase in the latter leads to an increase in planned research spending PRE. The increase in PRE leads to further improvement in SFQ.
- 3) The regenerative growth process continues until the SFQ becomes equal to natural fibre quality reference NFQR (it is a constant equal to 1).

- 4) The important controllable parameters are FSRVR, SFQT, and DORE. The rapidity of growth depends on the value of these parameters. The increase in the values of the first two and the reduction of the third lead to more rapid growth and vice versa.
- 5) Thus, to achieve the long-run growth rate target more rapidly it is important to ensure the dominance of this loop through increasing the value of FSRVR and the effectiveness of research expenses (SFQT), and shortening DORE.
- 6) The input variable is total fibre demand TFDL.

<u>Feedback Loop F:</u>	
Polarity:	Negative
Gains:	RRET, SFQT
Delays:	DORE
Pure Integ.:	CERE
Action:	It attempts to control research spending in relation to the required research expenses.

Remarks on Loop F:

- 1) This loop acts as a controller on Loop E in the following manner. It ensures that research spending rate RSR does not exceed the required one RRE. Furthermore, the achievement of RRE to Zero (at which point there is no further improvement in SFQ by the extra research spending) leads to switch off Loop E.
- 2) The input variable is planned research expenses PRE.
- 3) The crucial controllable parameters are SFQT and DORE.

<u>Feedback Loop G:</u>	
Polarity:	Negative
Gains:	PMT, MIL, TPA
Delays:	TAOR, TAI, TPLSBD, TPPL, PERD
Pure Integ.:	NIL
Action:	It attempts to bring down the firm's list price to the level which stimulates demand to the extent which enables the firm to work near capacity

Remarks on Loop G:

- 1) It shows how the long-run decrease in demand is considered in arriving at a pricing decision.
- 2) This loop acts as follows. Whenever off-list to basic demand ratio PLSBDR is equal to or greater than its reference value RFOBD, list price SFLP is decreased to equal net realized price. This, in turn, leads to the decrease of PLSBDR below its reference value.
- 3) The input variables are FMBOSF and NFPPC.
- 4) The important controllable parameters are TPLSBD and RFOBD. They refer to the attitude of management towards taking the correction action.

<u>Feedback Loop H:</u>	
Polarity:	Negative
Gains:	PMT, PMBT, NB
Delays:	PERD, TPBR, TPPL
Pure Integ.:	B
Action:	This loop regulates demand through backlog if the firm is in short supply

Remarks on Loop H:

- 1) It shows how capacity limit is considered in arriving at a pricing decision.
- 2) It works as follows. A substantial increase in backlog to normal backlog ratio would stimulate the firm to increase the price which, in turn, leads to decrease in incoming orders rate and, hence, improvement in this ratio.
- 3) The input variables are FMBOSF and NFPPC.
- 4) The important controllable parameters are TPBR, PMBT, TPPL and PERD.
- 5) It is desirable to prevent this loop from becoming dominant by ensuring the availability of the capacity necessary to meet the long-run increase in demand.

<u>Feedback Loop I:</u>	
Polarity:	Negative
Gains:	TPA, PMT, MIL
Delays:	TAOR, TAI
Pure Integ.:	NIL
Action:	This loop attempts to keep production to capacity under control.

Remarks on Loop I:

- 1) It shows how the short-term fluctuations in demand is absorbed via the discount policy.
- 2) If the production to capacity ratio (Actual capacity utilization) ACPU decreases substantially, price allowances, PA will be given to stimulate demand which, in turn, leads to improvement in this ratio.
- 3) The input variables are FMBOSF and NFPPC.
- 4) The important controllable parameters are TPA and MIL.
- 5) The failure of most industries, in recent years, to stabilize prices through list price vehicle indicates the dominance of this loop in real systems.

7.2. Summary of the Loop Components:

Table 7.1. summarizes the components of the feedback loops analyzed so far. It sheds light on the commonalties among these loops. This is important in policy redesign processes.

Table 7.1.: Summary of Loop Components

Loop's Label	Polarity	Gains	Delays	Pure Integ.	Action
A	Positive	PMT	TATUC TPPL PERD TAOR TOPC DRPC PPD	PCL MVI	It produces growth via the pricing policy and the economies of scale.
B	Positive	PMT AIRPU WOR	TATUC TPPL PERD TAOR TOPC DRPC PPD	MVPCL MVI	It generates growth via pricing policy, the economies of scale and technological improvement.
C	Positive	PMT MIL	TATUC TPPL PERD TAOR TAI PPD	I	It produces growth if the firm lowers its price by the decrease in total unit costs resulting from increasing the level of activity
D	Positive	FME PM	DD TASR DAME TPME		It shows the effect of allocating different percentage of sales revenue to market effort on the firm's growth
E	Positive	FSRVR SFQT	DORE DD TASR	CERE	It shows the effect of different research policies on the firm's growth.
F	Negative	RRET SFQT	DORE	CERE	It attempts to control research spending in relation to the required research expenses
G	Negative	PMT MIL TPA	TAOR TAI TPLSBD TPPL PERD	NIL	It attempts to bring down the firm's list price to the level which stimulates demand to the extent which enables the firm to work near capacity.
H	Negative	PMT PMBT NB	PERD TPBR TPPL	B	This loop regulates the demand through backlog if the firm is in short supply.
I	Negative	TPA PMT MIL	TAOR TAI	NIL	This loop attempts to keep production to capacity under control

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CHAPTER VIII

THE MODEL VALIDATION, PERFORMANCE AND TESTING

CHAPTER VIIITHE MODEL VALIDATION, PERFORMANCE AND TESTING

In this chapter the way in which the validity of this model should be judged will be established. The performance of the model then will be examined in order to find out the possibility of improving its behaviour through policy and/or structure changes. The testing process will be carried out on the system after it has been improved.

Therefore, the discussion in this chapter is outlined as follows:-

8.1. Validation of the Model

8.2. Model Performance

8.3. Improving the System

8.4. The Model Testing

8.1. Validation of the Model:

When testing the system dynamics model considered in this research, two levels of validation may be distinguished. These include tests focusing on (i) construction of the model, and (ii) its behaviour.

(i) Construction of the Model:-

This includes the formulation of the problem as well as its parameters.

Testing the formulation of the problem is concerned with the definition of the problem and with the appropriateness, relevance and proper interconnection of the variables. The objectives are to ensure that the suitable boundary is chosen, the influence diagram includes the fundamental variables required to represent the problem, the causal relationships between the variables have been well defined and justified and the level of aggregation is adequate for the purpose of this study. Since these aspects of validity test have been discussed in detail in preceding chapters (Chapters 3 to 6), we will turn to discussing the other aspects of the validity test.

Testing the model parameters is concerned with the justification of the chosen values for these parameters as well as the sensitivity of the model to them. With regard to the values of these parameters, some of them were obtained from the literature about the fibre industry as well as the annual reports of large fibre firms and the others, in particular, marketing ones were assumed. The sensitivity tests to the errors in these parameters will be carried out on the redesigned model.

(ii) Model Behaviour:-

The model behaviour validity is concerned with the extent to which the model behaviour already agrees with the actual system behaviour throughout the ten simulated years (from 1962-1972) with certain limits.

Before we pass on to a comparison of model behaviour with actual behaviour, a remark should be made concerning this validity test.

Since this model was designed to represent a leading synthetic fibre firm, it will be validated with reference to the behaviour observed in the synthetic fibre industry. The degree of similarity between the simulated and actual behaviour depends upon the extent to which the model is supplied with data and policies equivalent to those existing in the actual system. With regard to this point, it was found that information about some policies and parameters was difficult if not impossible to get. Taking into consideration this fact, it is expected that the model behaviour is broadly consistent with behaviour in real world rather than its duplicate.

This does not mean that the model does not fulfil its function, since the usefulness of this model as an experimental tool for studying the effect of structure, and policy changes in actual system rests on its satisfactory representation of the system's patterns of growth, oscillations and time-phasing relationships between change in variables, or what can be called dynamic characteristics of the model, rather than its duplicate to the observed behaviour (Forrester, 1961).

There are, of course, some writers who do controvert this view. In this respect, Ansoff and Selvin (1968) consider that the failure to rigorously duplicate the observed behaviour of the system, placed the model in a status of doubtful validity. They also regard that validity test based on a general correspondence between the dynamic characteristics of simulated and actual behaviour, is qualitative and largely subjective. That is because the system dynamicist is left with less rigorous methods to carry out this test.

The authors however have not proposed any real alternative approach. In the meantime, many difficulties arise with the attempts to obtain a good fitting between simulated and actual time series as a measure of validity of the model. Any proper statistical test requires more data than was available. Moreover, the state of the real system often changes substantially over fairly short periods of time. Therefore, it is difficult to find data covering time long enough for the proper statistical test during which there were no system changes.

Owing to these difficulties and others (see Forrester, 1968; Coyle, 1977), formal statistical techniques cannot be used to validate the model and therefore only a broad consistency with the actual behaviour is looked for.

Fig. 8.1. represents a comparison of simulated with actual prices. From the small data in our possession (see Appendix A), the actual price trends of two types of synthetic fibres, Polyester and Nylon which they initially set equal to simulated price, are generated.

As can be seen the simulated price declines slower than the actual prices from 1963 onwards. However, it becomes closer and closer to those actual prices until it meets the nylon price at about Mid 1970 and approaches the average of those actual prices.

Fig. 8.2. compares actual and simulated synthetic fibre market share of the U.K. actual fibre consumption during the simulated period.

The comparison shows that the simulation produced a smoother market share than in actuality.

The difference between the simulated and actual market share may be attributed to two factors. Firstly, speculative factor: massive purchases by customers as a hedge against any shortage of fibres during the upward phase of the textile cycle (see Appendix A). Our model currently ignores this factor. Secondly, in the model we assume that the shift of an order from a synthetic to a natural fibre supplier (and vice versa) will take place on a smooth continuum, whereas in reality, may take place in blocks.

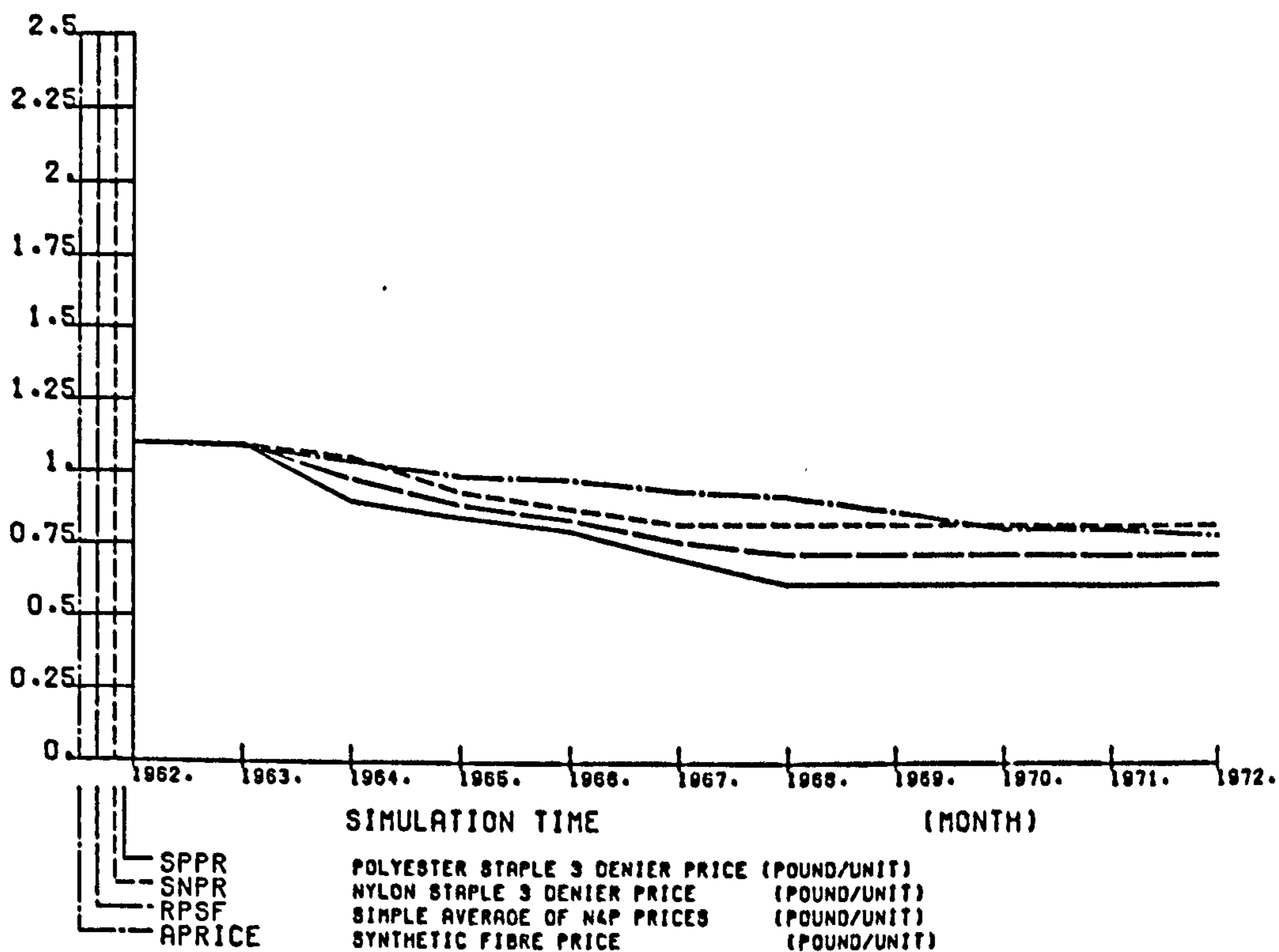


FIG 8.1: SIMULATED VERSUS SYNTHETIC FIBRE PRICES THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

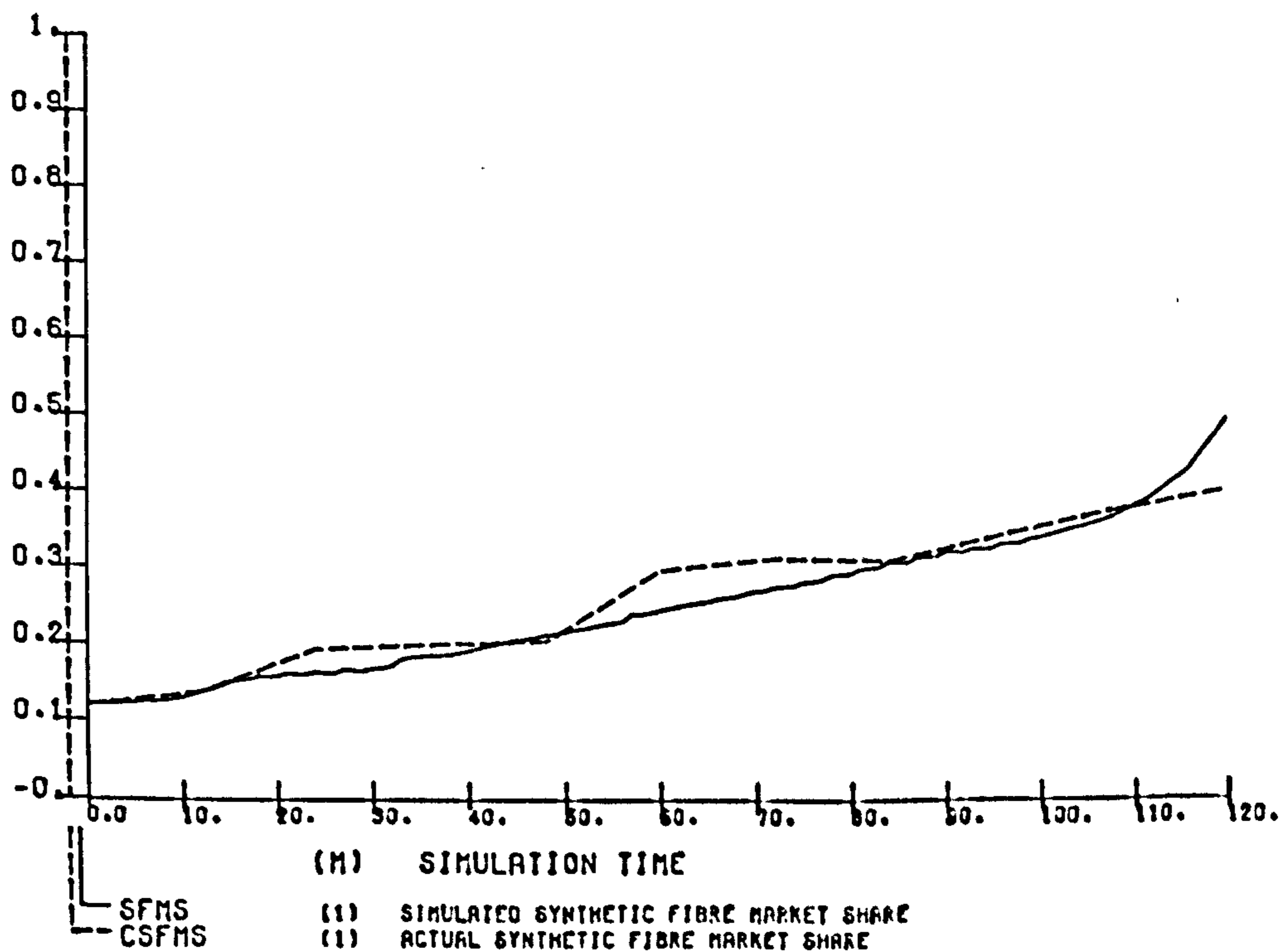


FIG 8.2
COMPARISON OF ACTUAL AND SIMULATED MARKET SHARE THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

In spite of these variations between simulated and actual behaviour of prices and market shares, the model succeeded to reproduce the essential characteristics of reality and its behaviour pattern is strongly similar to the actual system. Therefore, it is possible to conclude that the model, with the assumptions embodied in it is simulating well the way in which the decisions are made by the firm.

Once the model behaves similarly to actual system performance different policies can be tried. This will be carried out after the discussion of the model performance.

8.2. Model Performance:-

The way in which the model performance is evaluated will be discussed first, then simulation results will be analyzed.

8.2.1. Evaluating Model Performance:

A multiple performance index (as well as some simple performance measures) will be used to evaluate the performance of this multiple-objective model. It is an appropriate performance measure to distinguish between one control strategy and another. The approach to the formulation of this performance index PINX, is suggested by Coyle (SDRG).

The PINX reflects the balance between two factors; the sum of the final values of specified variables at the end of a run and the sum of instability penalties to be associated with the departure of specified other variables relative to their trends during this run. Attention should be given to the choice of the variables which form this index and the weight given to each.

The variables chosen^{to} calculate the sum of the final value SFV are the averages of shipment sent rate ASSR, synthetic fibre market share ASFMS, and before tax profit ABTP. It is assumed that the achievement of high values of ASSR and ASFMS is twice as important as the attainment of a high value of ABTP.

The variables, whose instability penalties are to be measured, are the instability penalty to be associated with variation in price IPPRIC, and in return on investment IPROI. We take instability of return on investment IPROI as twice as serious of price IPPRIC.

It is assumed that the attainment of final value SFV is twice as important as the avoidance of instability SIP.

The choice of the factors mentioned above reflects the fact that the most common objectives of pricing strategy in the real systems are growth, profitability and price stability. The weight assigned to each factor is purely subjective. In the real situation, the weights represent management opinion. It is convenient to have PINX in the basic case of approximately 100 (the equations are in Appendix B).

8.2.2. Simulation Results:

The simulation results are shown in figures 8.3, 8.4, 8.5, 8.6 and Table 8.1. from which the following observations can be made.

1. The steady decrease in total unit costs TUC is due to the decrease in average factory costs AFCPU and non-manufacturing fixed costs per unit of product.
2. The steady decrease in synthetic fibre price APRICE, is a result of the decline in TUC and after delay, the downward trend in NFP which follows its upward trend throughout the simulation period.

3. There is a continuous increase in synthetic fibre market share SFMS which becomes rapid from month 108 onwards. Two factors caused this increase in SFMS,
 - (i) the improvement in synthetic to natural fibre prices ratio over time which increased by the great increase of NFP from about month 92 onwards and consequently price multiplier PM.
 - (ii) the increase in penetration rate caused by the improvement in fibre quality SFQ and the increase in market effort budget AME.
4. There is a stair-step growth in sales revenue SRV which turns to a rapid surge growth from about month 108 onwards. Its dynamics synchronised with SFMS and incoming order rate IOR.
5. The sharp increase in pretax profit PBT from about month 10 up to month 20 is due to the increase in sales volume and consequently SRV. This increase in SRV is greater than the required increase to offset the decrease in pretax profit margin caused by the decrease in APRICE. The contrary is true from about month 20 to month 60.

6. Pretax profit margin on sales CPSR reflects the relative change in PBT compared with the relative change in SRV.
7. Return on investment ROI follows CPSR (indeed after tax margin PMG), but with different amplitude because of the effect of assets turnover AT. For instance, from the beginning up to month 15 the slight decrease in ROI is relatively greater than in CPSR because of the decrease in AT. This decrease is caused partly by the continuous increase in the level of inventory I from month 5.
8. There is a continuous increase in the gap between SRV and break even point BEP from month 60 onwards (margin of safety).
9. Productive capacity level PCL is approximately in line with its desired level PCD up to month 110 when the gap started to exist.
10. There is a slight fluctuation in production order rate APOR from month 30 up to the end of the simulated period. The reason is, the inventory has approached its maximum level MIL and therefore APOR has been cut. Thus, the firm becomes working at less than full capacity during this period apart from few months at the end. The actual capacity utilization percentage, however, is not the same. It achieves its minimum value at about month 60.

11. The high level of inventory throughout the ten years simulated period is due to the attempt to achieve full capacity utilization by allowing the inventory to reach its maximum acceptable level MIL. However, the problem of under capacity utilization started to appear from month 30 onwards.

In conclusion two remarks can be made from the previous analysis:-

- A) It can be noticed that the acquisition policy was very successful in bringing productive capacity level in line with its desired level. However, it causes the problem of under capacity utilization which has its impact on profitability and price. The production policy adopted here, does not succeed in eliminating this problem. Moreover, it creates excess inventory in the system which can be seen from the increase in this inventory over its minimum desired level MID. This excess inventory, which may be unnecessary, has its financial impact represented in heavy investment in stock building in addition to the cost of stock holding.

B) The pricing and the other marketing policies succeeded to increase market share but this was at the expense of profitability measured in terms of return on investment and pretax profit margin which were at their minimum values during most of the simulated period.

The two remarks mentioned above do correspond to what is observed in the real system.

It is possible to conclude that there is a need to change policy, structure, or both which will lead to an improvement in the overall system behaviour. This will be tried in the next section.

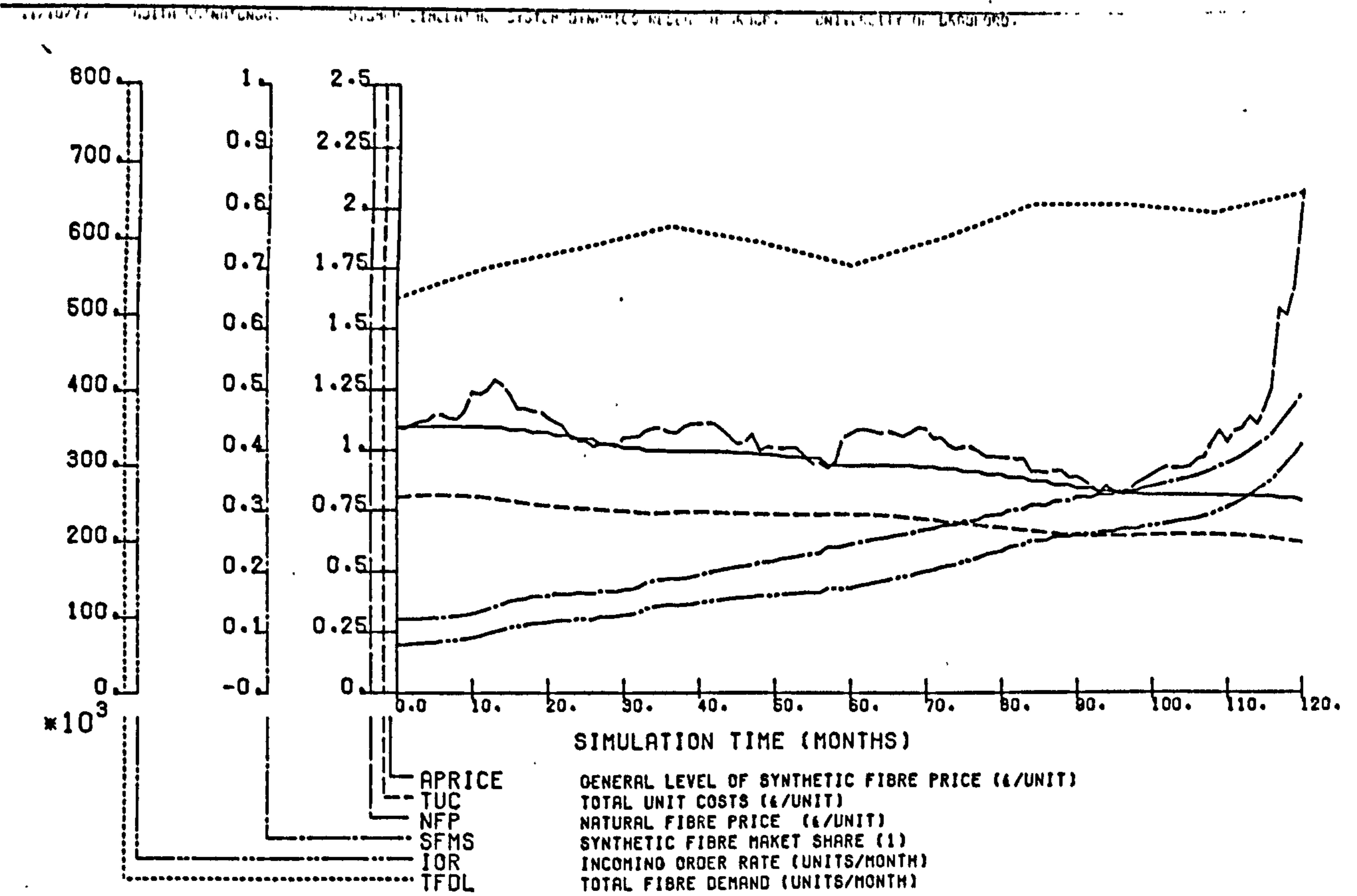


FIG 8.3: THE BEHAVIOUR IN THE BASIC CASE THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

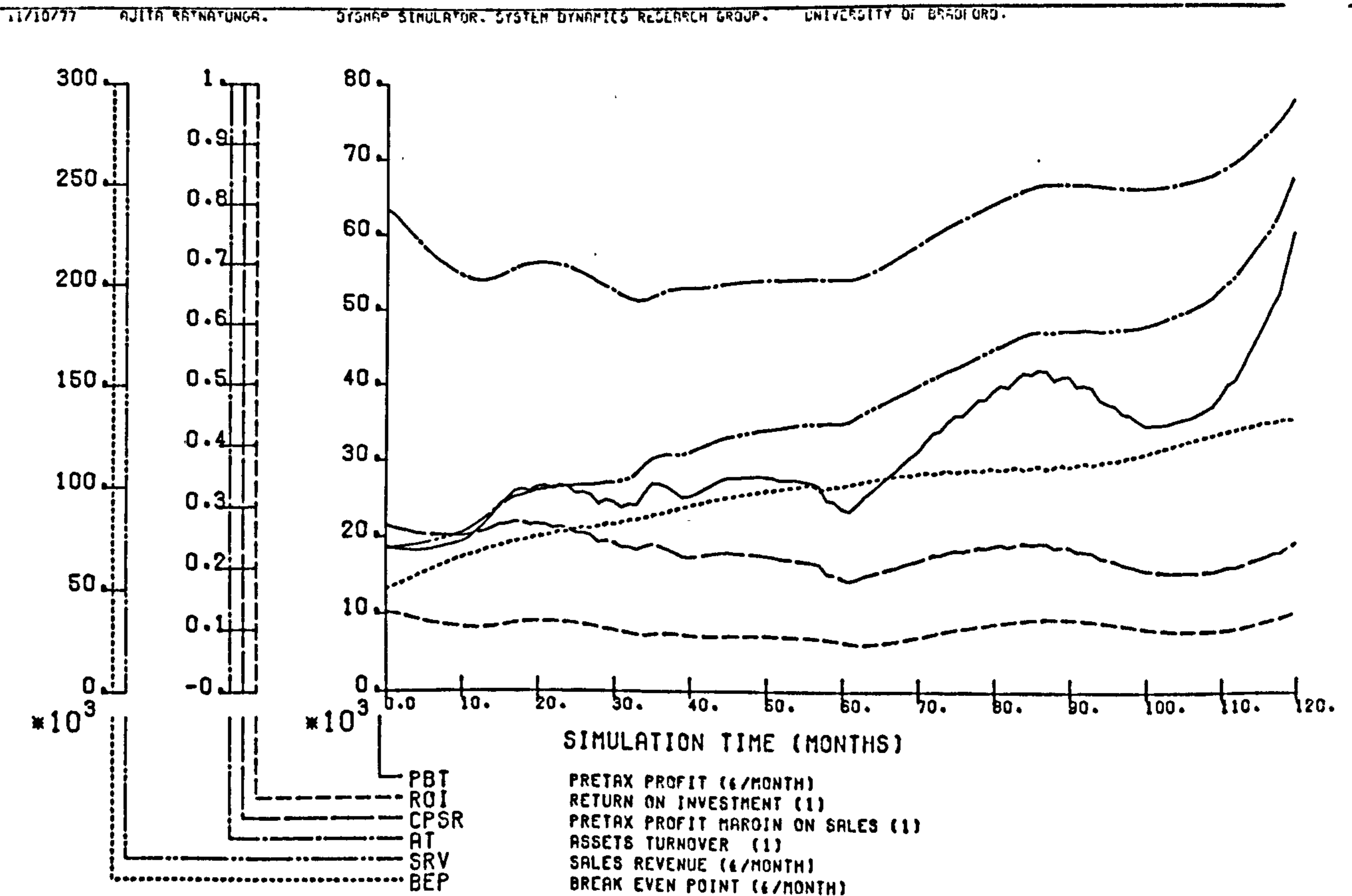


FIG 8.4: THE BEHAVIOUR IN THE BASIC CASE THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

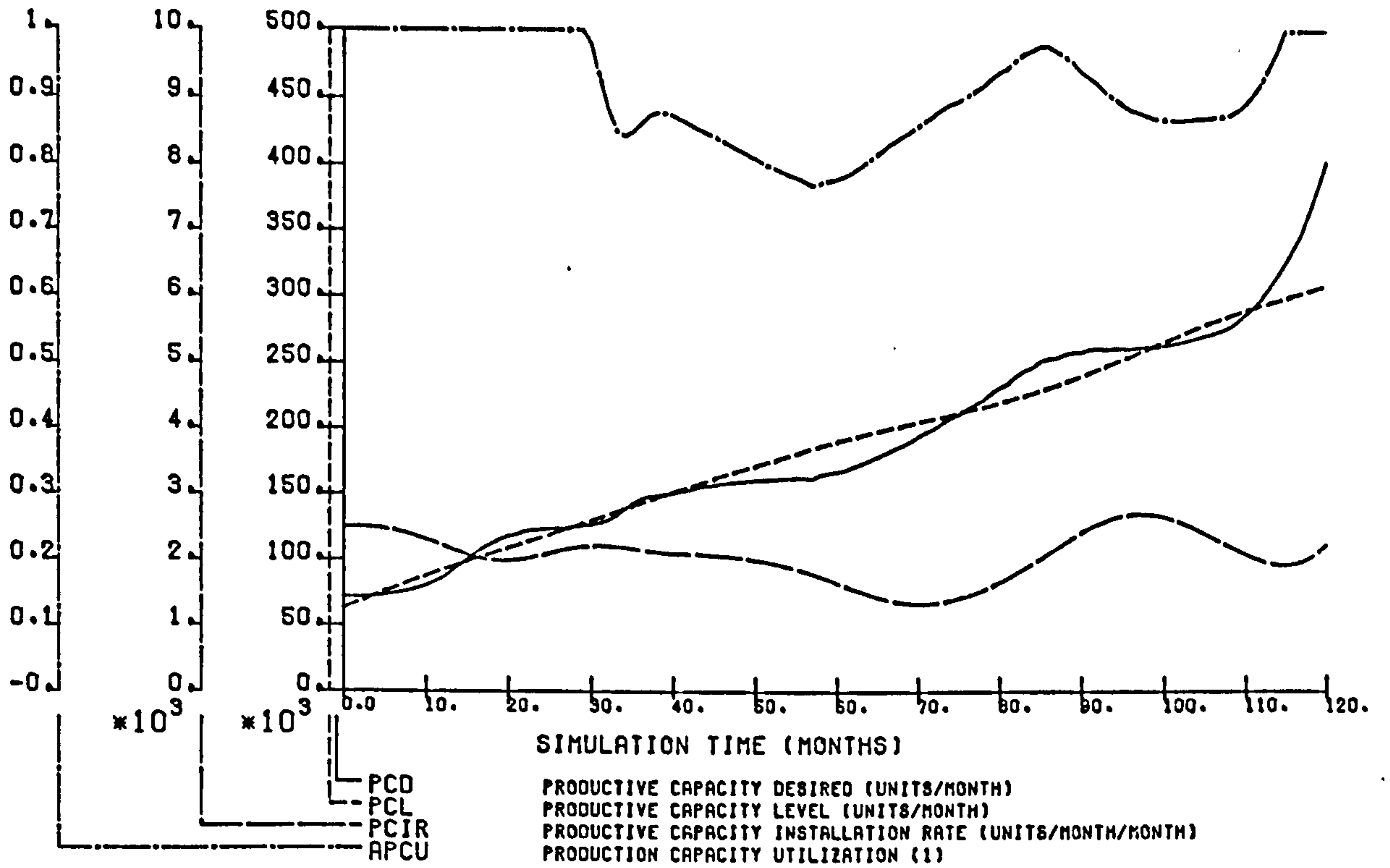


FIG 8.5: THE BEHAVIOUR IN THE BASIC CASE
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

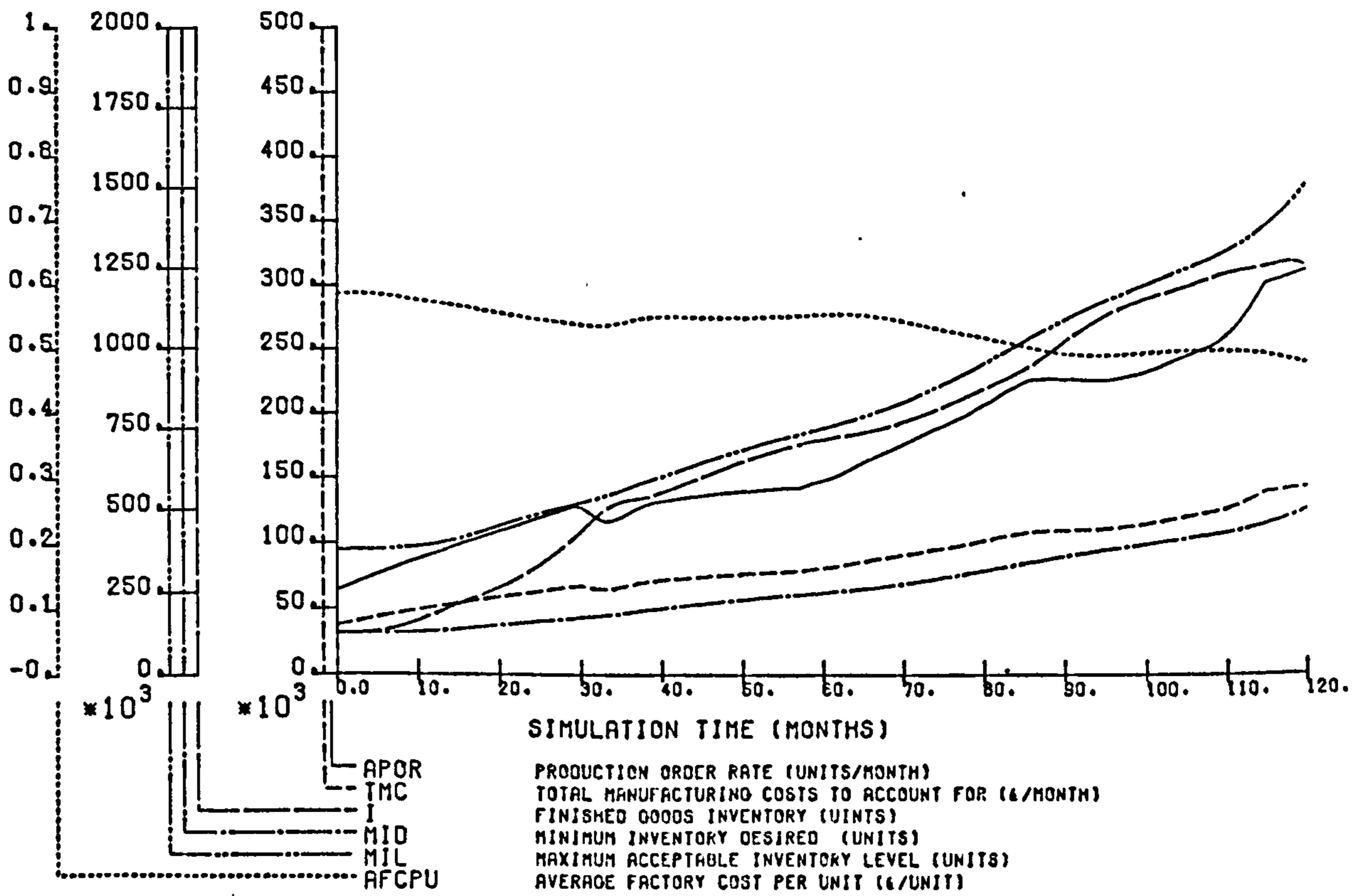


FIG 8.6: THE BEHAVIOUR IN THE BASIC CASE
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

Table 8.1: "Some Numerical Output"

Variable Name		Initial	MIN	MAX	Variation* %
1. Demand and Market Share:					
Total fibre demand	TFDL	520000	520000	665600	28
Incoming Order	IOR	63180	63180	328521	420
SF Market Share	SFMS	.1215	.1215	.49357	306
2. Promotion, Quality and Price:					
Market effort	AME	1911.2	1911.2	2806.1	47
Research spending	RSR	2432.4	2432.4	8108.8	233
SF list price	SFLP	1.1	.79187	1.1	(39)
Net realized price	NRP	1.1	.79187	1.1	(39)
Actual price	APRICE	1.1	.79187	1.1	(39)
Natural fibre price	NFP	1.1	.82225	2.0884	154
SF quality	SFQ	.27	.27	.64726	140
3. Production Capacity:					
Production order rate	APOR	63180	63180	309279	390
Productive capacity level	PCL	63180	63180	309279	390
Inventory	I	126360	126211	1265110	902
PC Utilization	APCU		.76732	1.0000	30
Total unit costs	TUC	.80975	.61882	.81246	(31)
Average factory costs	AFCPU	.586	.47673	.586	(23)
4. Profitability:					
Pre-tax profit	PBT	18659	18127	60023	231
Sales revenue	SRV	69498	69498	253350	265
Pre-tax profit margin	CPSR	.26841	.17865	.27581	54
Return on investment	ROI	.12777	.076	.12898	70

* The variation is calculated as follows: $((MAX-MIN)/MIN)*100$

8.3. Improving the System:

In this section we shall try to find the possibilities for improving the system by altering its parameters and/or its structure. The objectives of this process should be to reduce the excess inventory and to improve the profitability measured in terms of return on investment and pre-tax profit margin on sales.

8.3.1. Inventory Control Policy:

We have already pointed out that there is an excess inventory in the system which may be unnecessary. The source of this excess inventory is the production policy operating through the negative feedback loop, shown in Fig. 8.7, which attempts to keep the inventory at its maximum acceptable level.

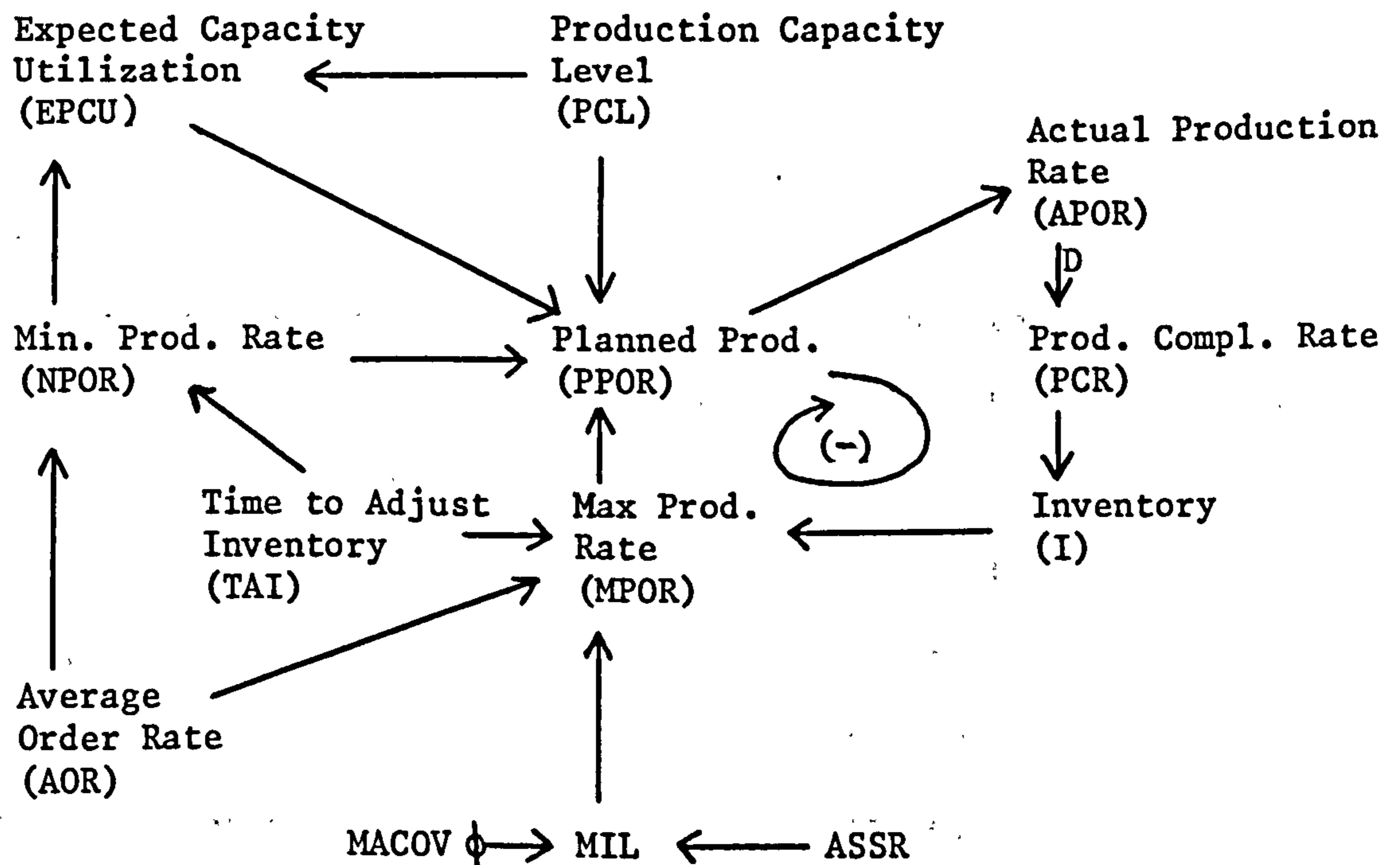


Fig. 8.7: Inventory Control Policy

Since, there are high gain (through the maximum acceptable level) and short adjustment time in this loop, one would expect this high level of inventory, in particular, if production capacity level constraint does not slow effectively its work. Indeed, it does not operate from month 30 onwards. Therefore the decrease of inventory level can be realized by decreasing the gain, lengthening the delay and make production capacity level constraint operate effectively. In order to adjust these parameters, only a few runs on the model were made. The most suitable values which result in substantial reduction in the inventory level and, in the meantime do not affect the availability of goods which are not acceptable from a practical point of view, have been chosen as follows:-

- 1) The maximum acceptable cover (MACOV) is decreased by 33%, from 6 to 4;
- 2) The inventory adjustment time (TAI) is increased by 233%, from 3 to 10;
- 3) The time for order production capacity (TOPC) is increased by 75%, from 4 to 7.

8.3.2. New pricing policy:

In the preceding section we have seen that the net effects on the measures of performance are that the market share (and consequently, the sales volume) grows rapidly and that the profitability (measured in terms of pre-tax profit margin on sales and return on investment) decline initially, and then settle at its minimum value over most of the simulated period. The source of the high increase in market share, and low profitability is the current pricing policy, which its structure simplified is in Fig. 8.8. The main equation in pricing policy is:

$$A \quad PSFLP.K = \text{MIN}(((SFLP.K * PMD.K * PMC.K * PMB.K) - EDTUC.K + EITUC.K), NFP.K)$$

where:

PSFLP	Proposed synthetic fibre list price
SFLP	Synthetic fibre list price
PMD	Price multi. due to demand
PMC	Price multi. due to competition
PMB	Price multi. due to backlog
EDTUC	Actual decrease in total unit costs
EITUC	Actual increase in total unit costs
NFP	Natural fibre price

The following points on this current pricing policy should be noted:

- (i) Three factors which affect pricing decision are EDTUC, PMC and NFP.
- (ii) Three other factors are inactive in this case: PMB because actual backlog is on line with normal backlog; PMD because there is no considerable off-list sales; and EITUC because there is no substantial increase in total unit costs and therefore no increase in price due to short term costing increase from a practical point of view.

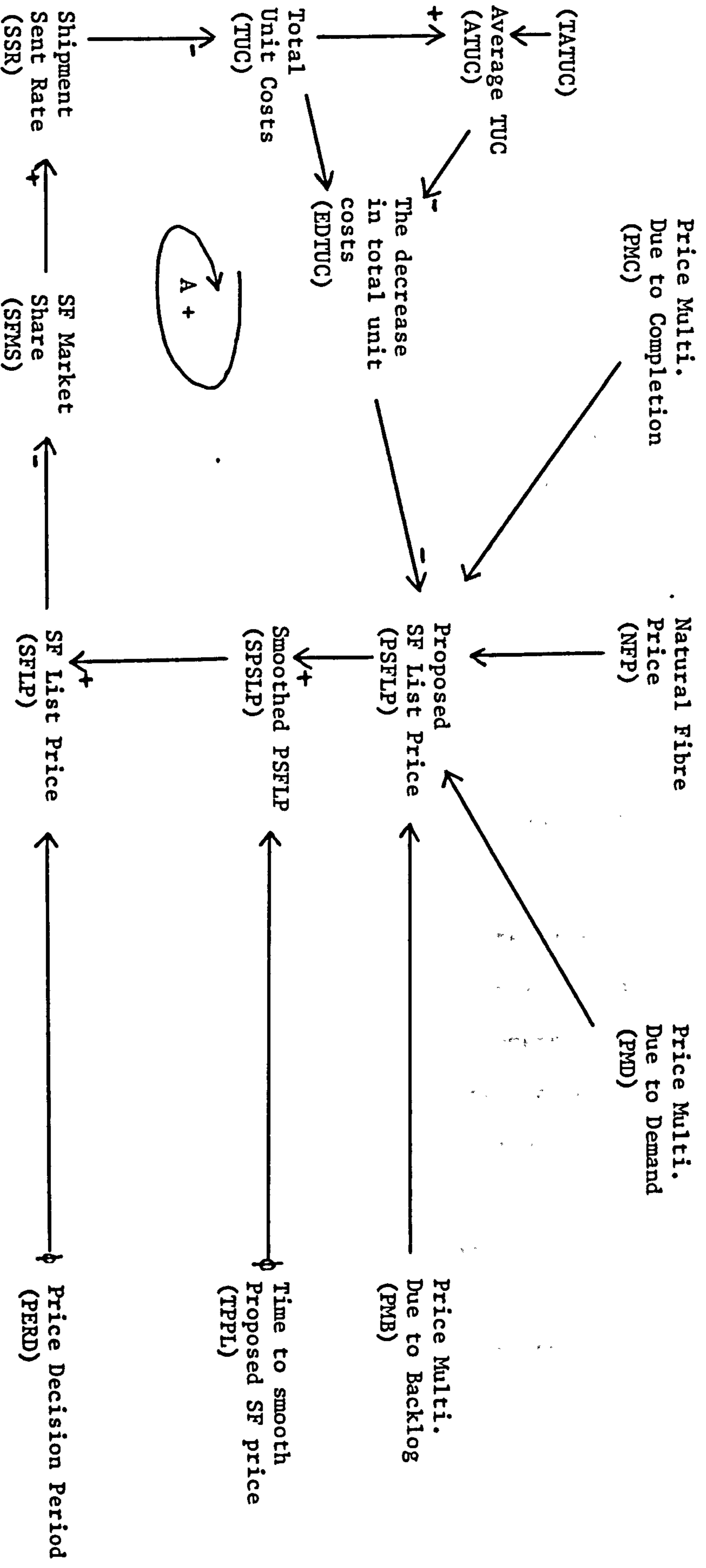


Fig. 8.8.: Pricing Control Policy

- b) an entirely new negative loop B in Fig. 8.9. (and some inner loops) is added. This loop is designed to provide the necessary balance between profitability and market share objectives in determining price changes. The information about profitability is introduced for use in pricing decision as follows:-

The pre tax profit margin on sales and pre tax profit are smoothed. The smooth times should be relatively long to de-seasonalise them. This is because, from a practical point of view, the seasonality should have no bearing on the pricing decision. By running the model in the case of seasonality the relevant time to smooth them was arrived at. It was 12 months.

$$L \quad \text{APSR.K} = \text{APSR.J} + (\text{DT}/\text{TPSR}) * (\text{CPSR.J} - \text{APSR.J})$$

$$C \quad \text{TPSR} = 12$$

$$L \quad \text{ABTP.K} = \text{ABTP.J} + \text{DT}/\text{TABTP} * (\text{PBT.J} - \text{ABTP.J})$$

$$C \quad \text{TABTP} = 12$$

where:

APSR	Smoothed pre-tax profit margin on sales	(1)
TPSR	Time to smooth pre-tax profit margin on sales	(M)
ABTP	Smoothed pre tax profit	(£/M)
TABTP	Time to smooth pre tax profit	(M)

The ratio of smoothed to current pre tax profit margin on sales is used to calculate pre tax profit which should be generated over ABTP to cover profit deviation in the previous month. This amount is divided by average shipment sent rate to calculate the required increase in price.

$$A \quad ACPSR.K = \text{MIN}((CPSR.K/APSR.K),1)$$

$$A \quad RIP.K = ((ABTP.K*((1/ACPSR.K)-1))/ASSR.K)$$

where:

ACPSR	Smoothed to current pre tax profit margin on sales ratio	(1)
RIP	Required increase in price	(£/U)

RIP is used to modify pricing decision after it has given a specific weight. This weight is affected by the nature of the variables which form this new loop, namely pre tax profit and pre-tax profit margin on sales. They are seasonal variables. So that, when the model was tested with heavy weight to RIP, there was substantial improvement in profitability with relative decrease in market share, but, when the seasonality factor in fibre demand was incorporated, there were fluctuations in price and consequently in market share. This is not acceptable from practical standpoint. Therefore, the chosen value of the weight given to RIP is the one which leads to maximum improvement in the system performance and, in the meantime, eliminates undesirable effect of seasonality on price and market share. The main equation will be:

$$A \quad PSFLP.K = ((\text{MIN}(((SFLP.K * PMD.K * PMC.K * PMB.K) - PRDCD.K), NFP.K) * PSW) + ((1 - PSW) * (SFLP.K + RIP.K)))$$

$$C \quad PSW = .65$$

The term (1-PSW) represents the weight given to the profitability situation in pricing decision.

8.3.3. Performance of the improved System:

The performance of the improving system is shown in Fig. 8.3A, 4A, 5A and 6A which should be compared with Fig. 8.3, 8.4, 8.5 and 8.6 respectively. Also some of the numerical performance measurements of the system in the basic case and in the new policy case are tabulated in Table 8.2.

It can be noticed that the performance of the improved system is better than the performance in the basic case:

- 1) The PINX is clearly better, because of the large decrease in the SIP.
- 2) There is a large decrease in the level of inventory which has major financial implication.
- 3) There is no significant excess capacity in the system.
- 4) Production order rate is smoother.
- 5) The profitability position is substantially improved.

Pre-tax profit margin on sales and return on investment are sustained at higher values over the most simulated period.

- 6) However, there is a slight decrease in growth rate measured in terms of synthetic fibre market share and sales volume.

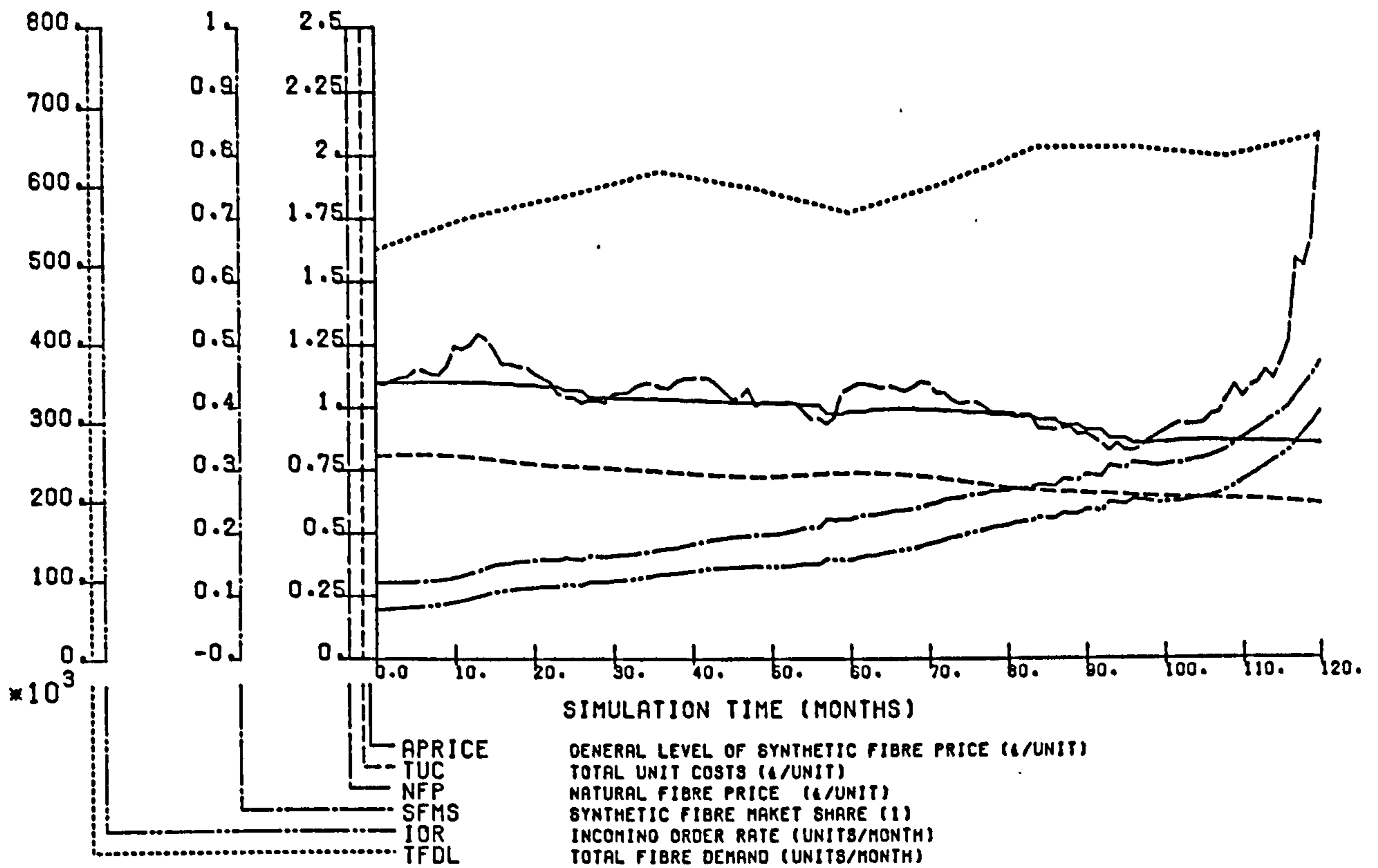


FIG 8-3A: THE BEHAVIOUR IN THE NEW POLICY CASE THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

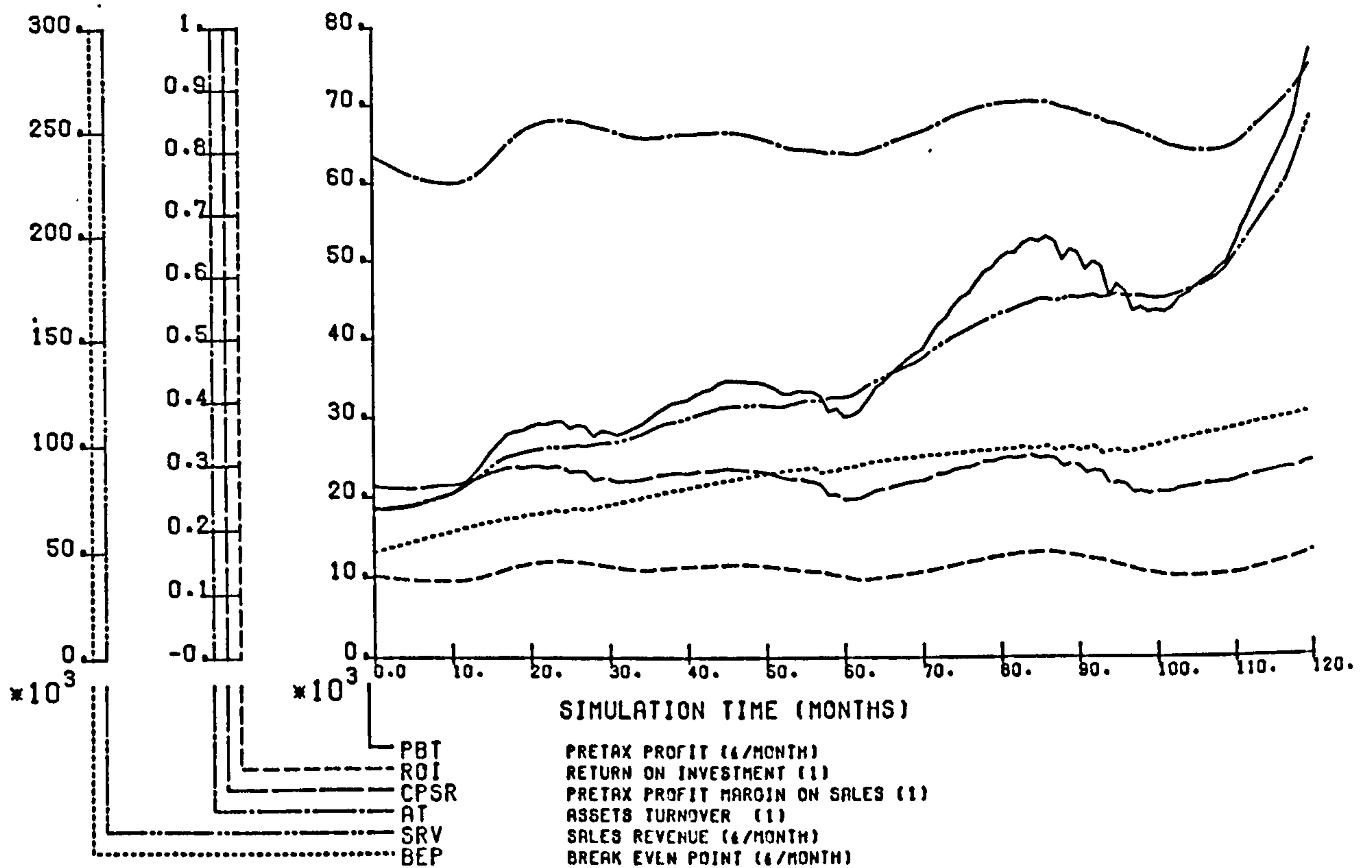


FIG 8-4A: THE BEHAVIOUR IN THE NEW POLICY CASE THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

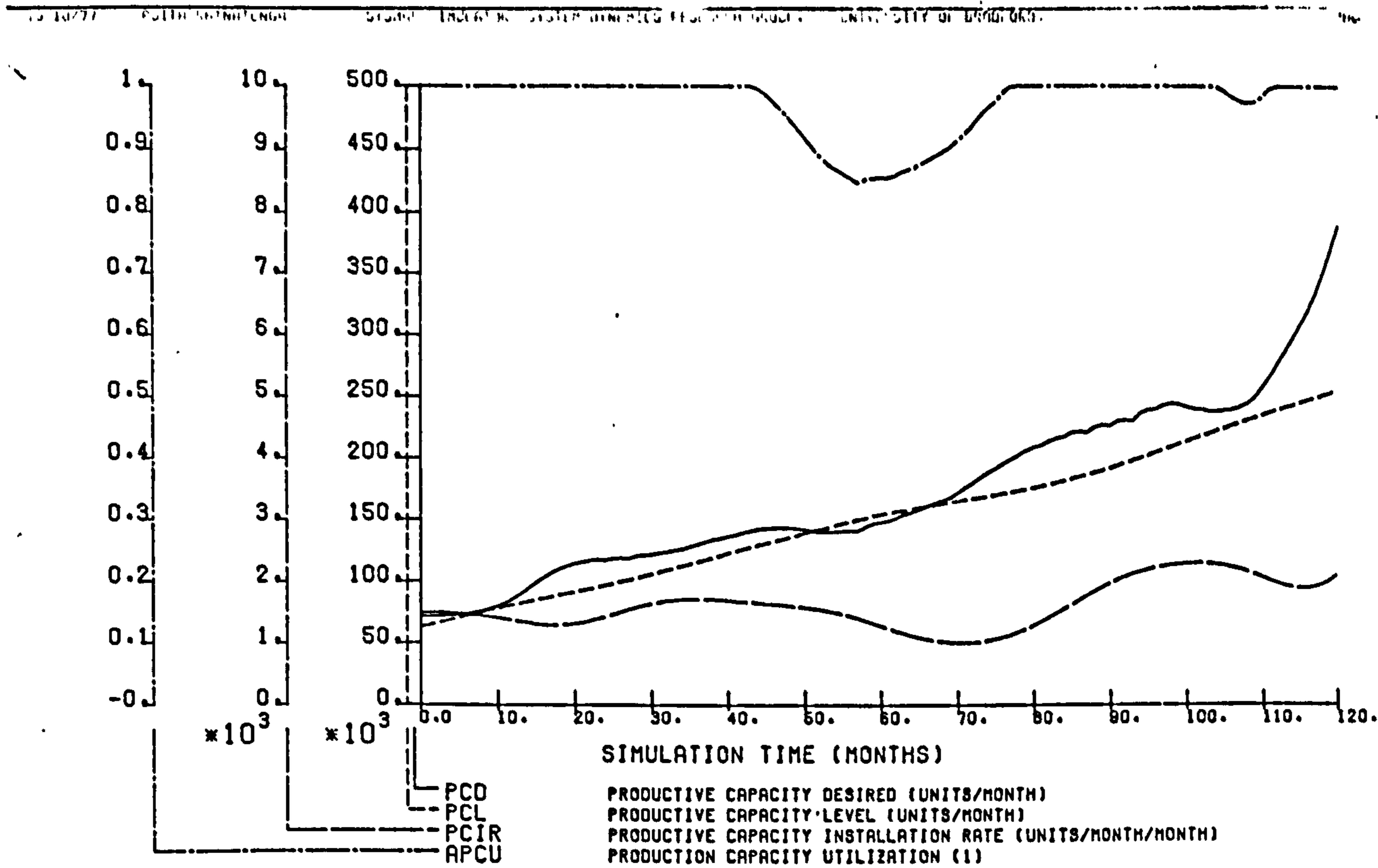


FIG 85A: THE BEHAVIOUR IN THE NEW POLICY CASE
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

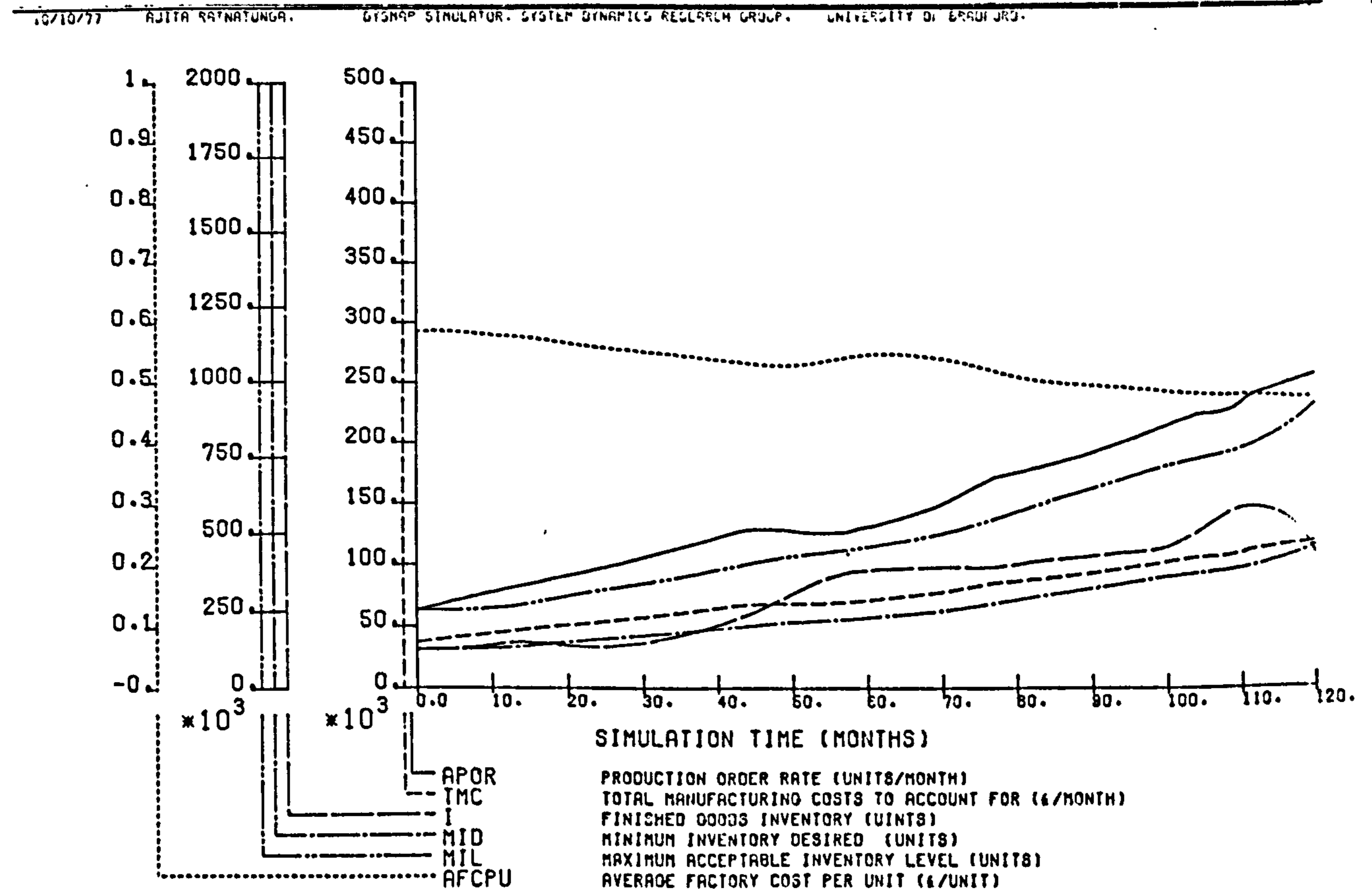


FIG 86A: THE BEHAVIOUR IN THE NEW POLICY CASE
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

Table 8.2.: The Numerical Performance Measurements
of the System in the Basic and New Policy Cases

Variables		Value	Basic Case	New Policy Case
Inventory	(I)	MAX	1265110	588331
		MIN	126211	126037
Accumulated profit	(AATP)	-	2159210	2650190
Performance index	(PINX)	-	100.17	145.5
Sum of final values	(SFV)	-	200.17	200.48
Sum of the instability penalties	(SIP)	-	100.0	54.982
Shipment sent rate	(SSR)	MAX	315493	299024
		MIN	63180	63180
Pre-tax profit	(PBT)	MAX	60023	76898
		MIN	18127	18481
Synthetic fibre market share	(SFMS)		.49	.47
General level of SF price	(APRICE)	MAX	1.10	1.1016
		MIN	.79	.85
Return on investment	(ROI)	MAX	.12	.16
		MIN	.07	.11
Pre-tax profit margin on sales	(CPSR)	MAX	.27	.31
		MIN	.17	.24

8.4. The Model Testing:

The model has been tested to see its response to disturbances in the prime input (total fibre demand level) and to certain parameter changes. The main results of this test will be discussed firstly and after that an attempt will be made to draw conclusions from these results about the sensitivity and robustness of this system.

8.4.1. Testing the response of the system to the external disturbances:

The model has been tested to see its response to seasonal and random disturbances in its prime input (total fibre demand level), by using SINE WAVE and NOISE functions respectively. The following is a brief overview of the results.

8.4.1.1. SINE WAVE input case:

This case shows the behaviour mode of the system in the case of the seasonal demand. It is therefore assumed that:

The amplitude of seasonality is 10%

The period of the cycle is 12 months

It should be noted that these short-term cyclical variations couple with the long-term ones, (Business cycle) with a period of about 45 months and changeable amplitude.

Figs. 8.10, 8.11, 8.12 and 8.13 show the behaviour of the system, from which the following observations can be made.

- i) The synthetic fibre market share and price have behaved in the same pattern as the new policy case. As a result, the seasonality in demand has reflected in the incoming orders rate IOR. Such behaviour is the desirable one in real life.
- ii) The oscillations in sales revenue and profit are due to the fluctuations in IOR but without any amplification. The system, here, is doing what it is expected from it.
- iii) There is approximately no change in the behaviour of production except slight fluctuations in the period from months 40 to 70. The oscillations in inventory indicate its success considerably in isolating production from the short-term variations in demand.

8.4.1.2. NOISE Test:

This case shows how the system behaves if the total fibre demand is subjected to noise variations.

The analysis of the results presented in Figs. 8.14, 8.15, 8.16 and 8.17 has indicated that the system is insensitive to noise variations.

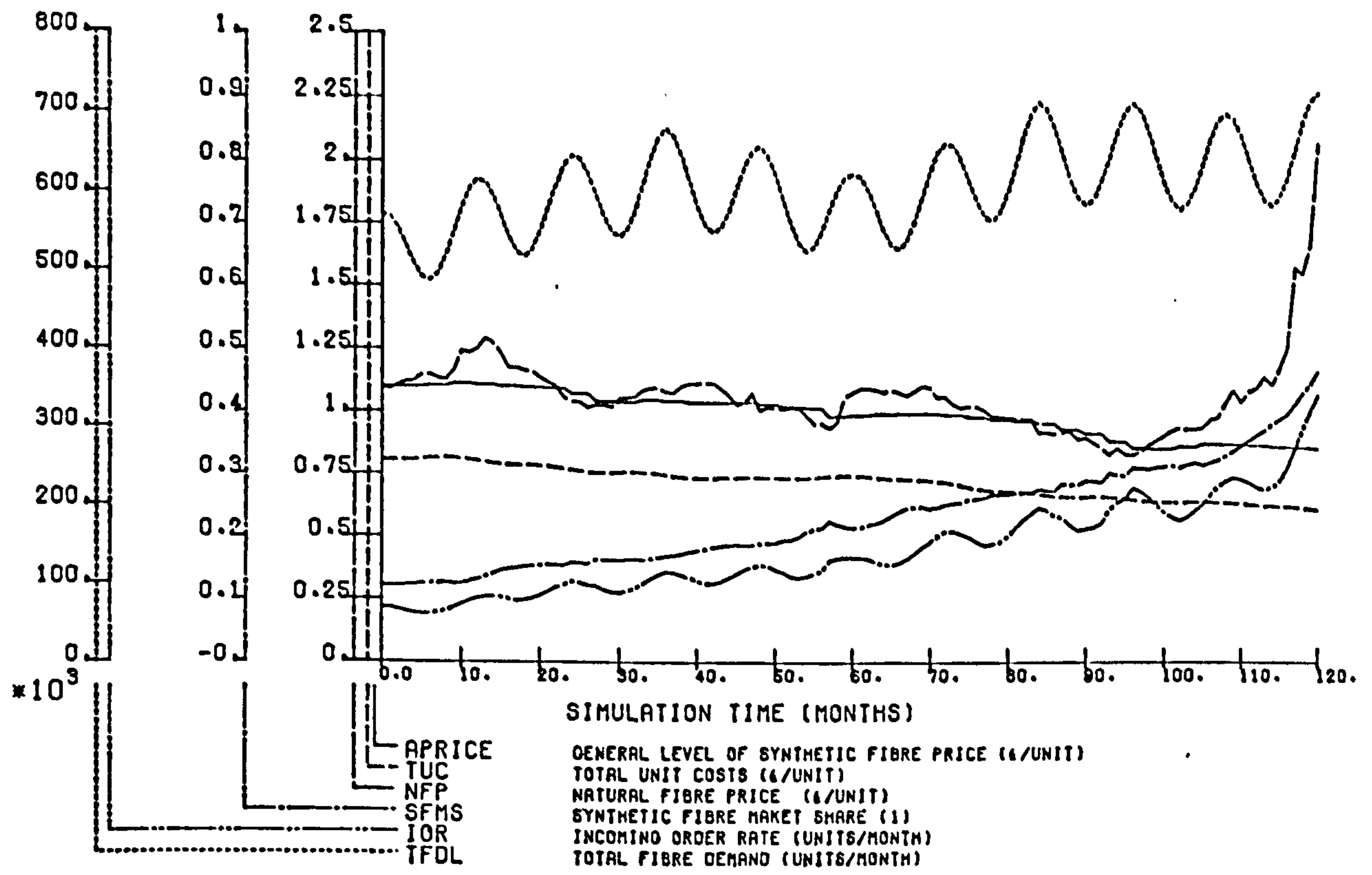


FIG 8-10: THE BEHAVIOUR IN THE SEASONALITY CASE THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

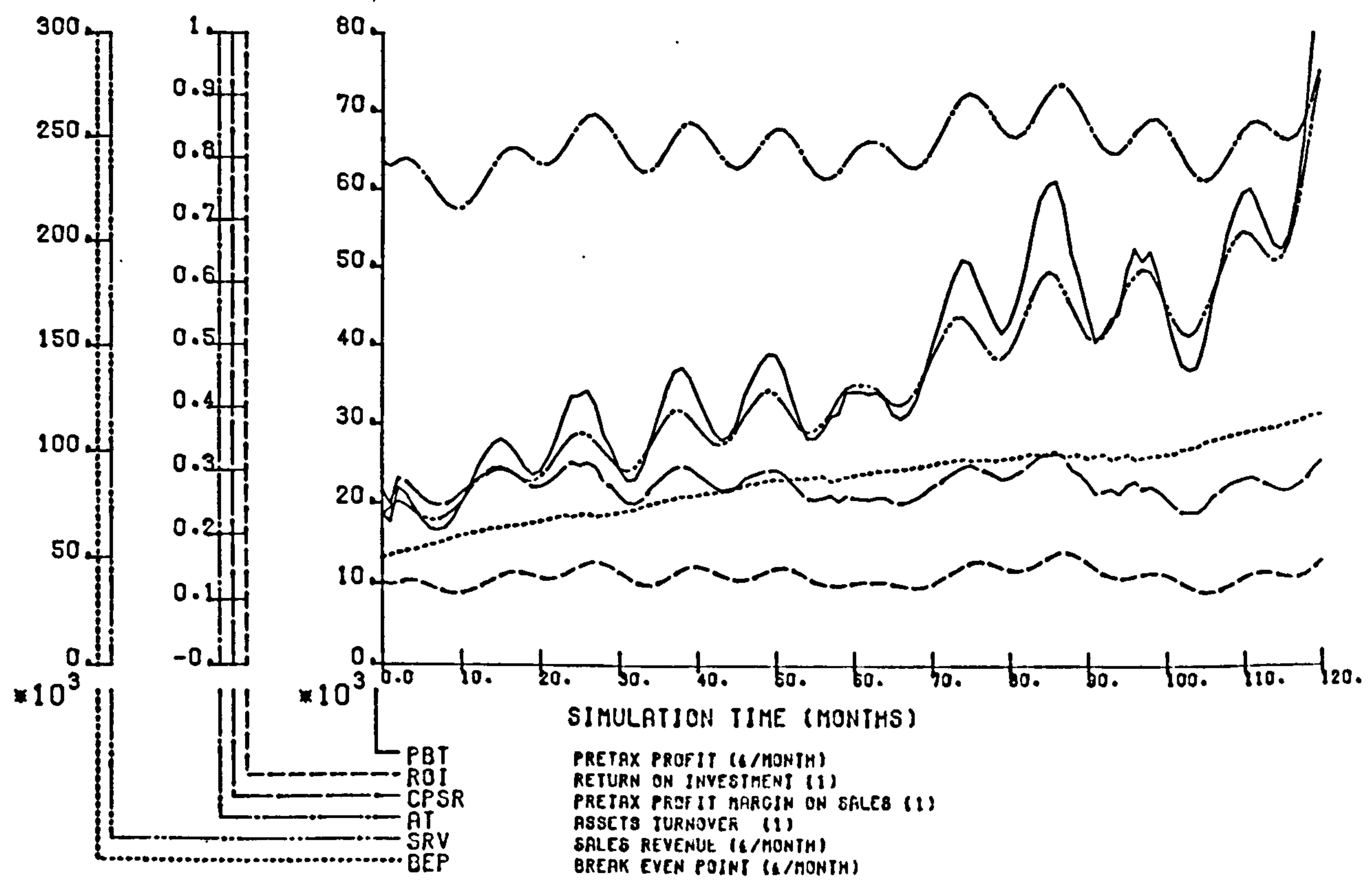


FIG 8-11: THE BEHAVIOUR IN THE SEASONALITY CASE THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

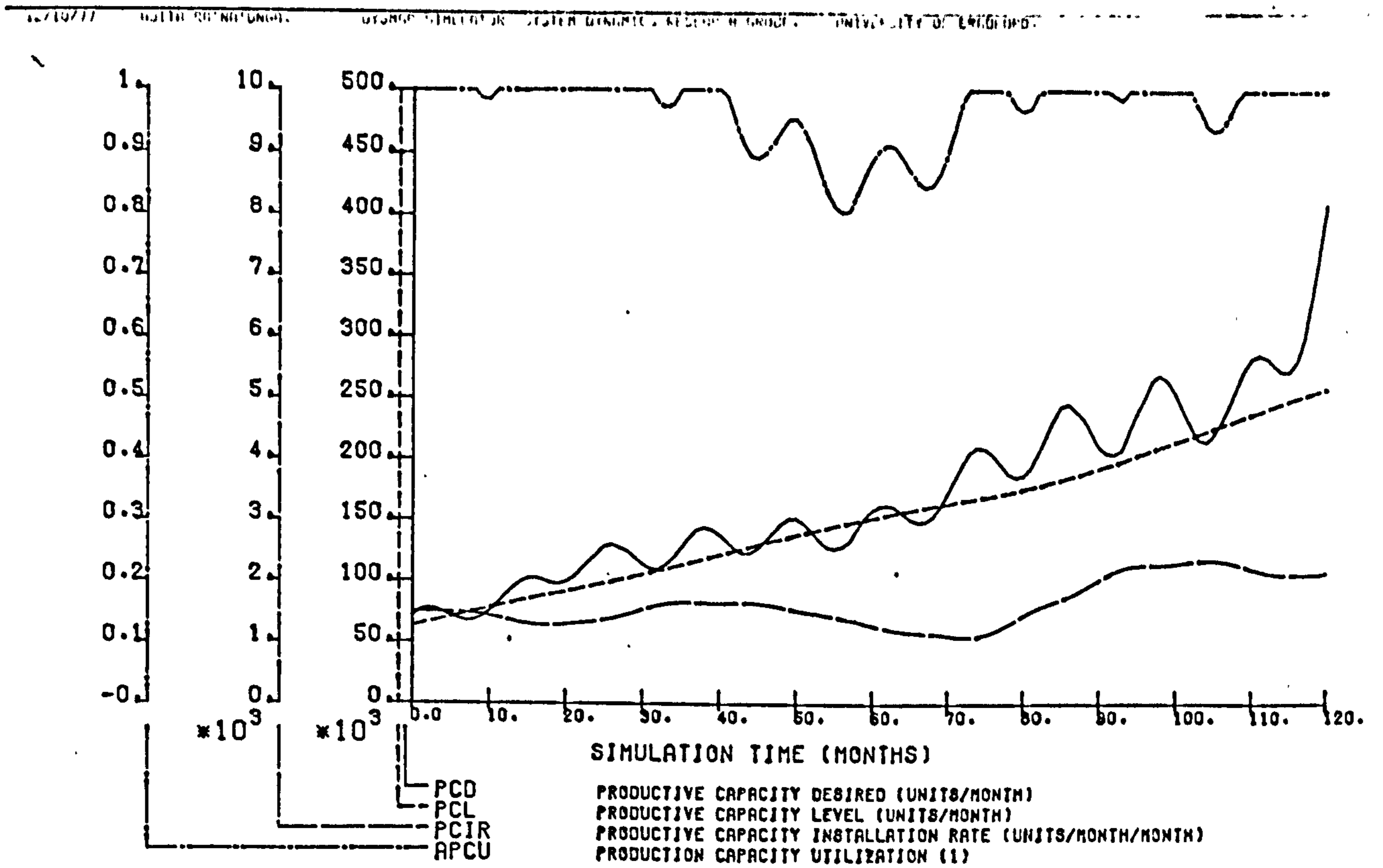


FIG 8.12: THE BEHAVIOUR IN THE SEASONALITY CASE
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

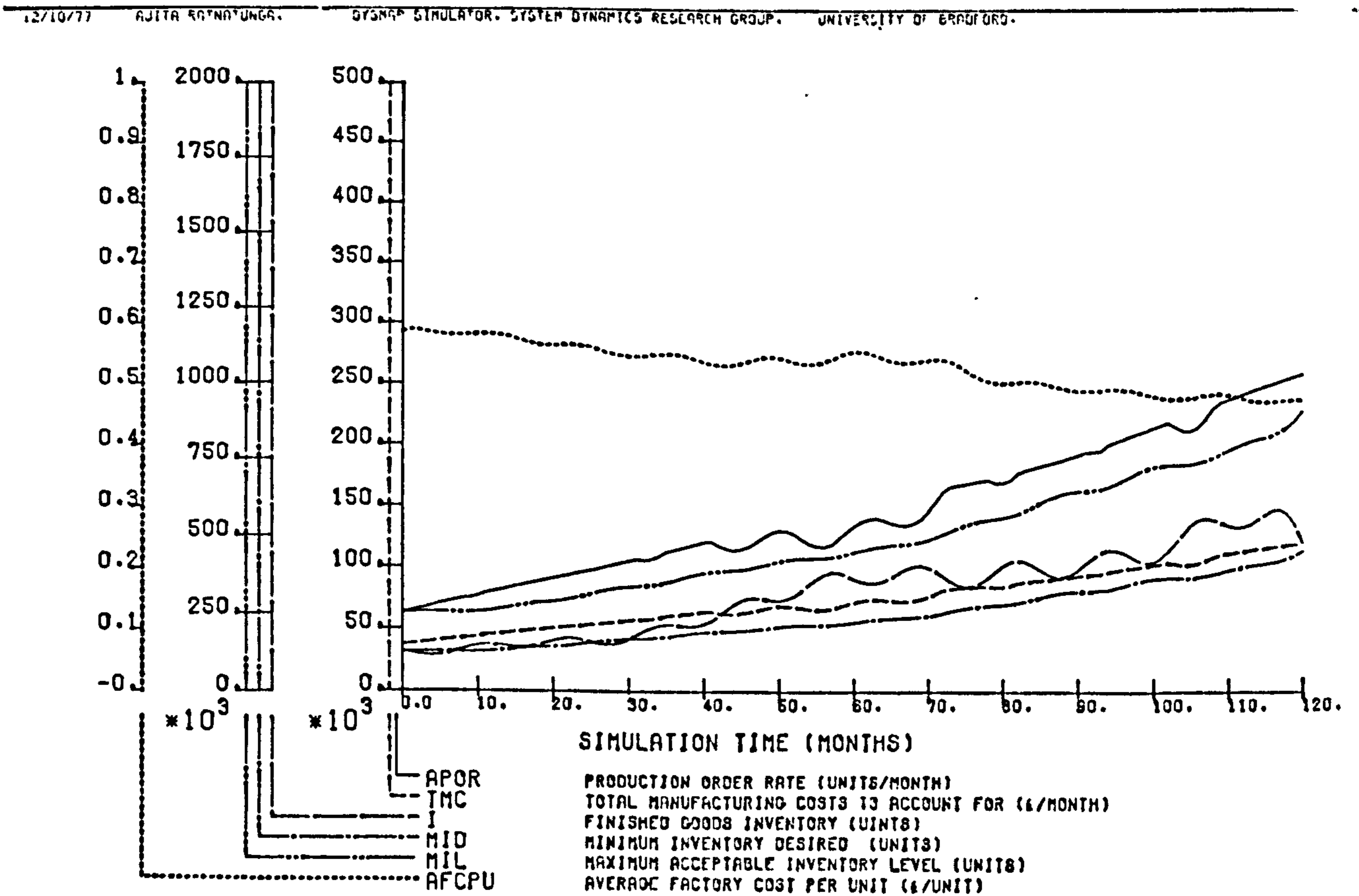


FIG 8.13: THE BEHAVIOUR IN THE SEASONALITY CASE
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

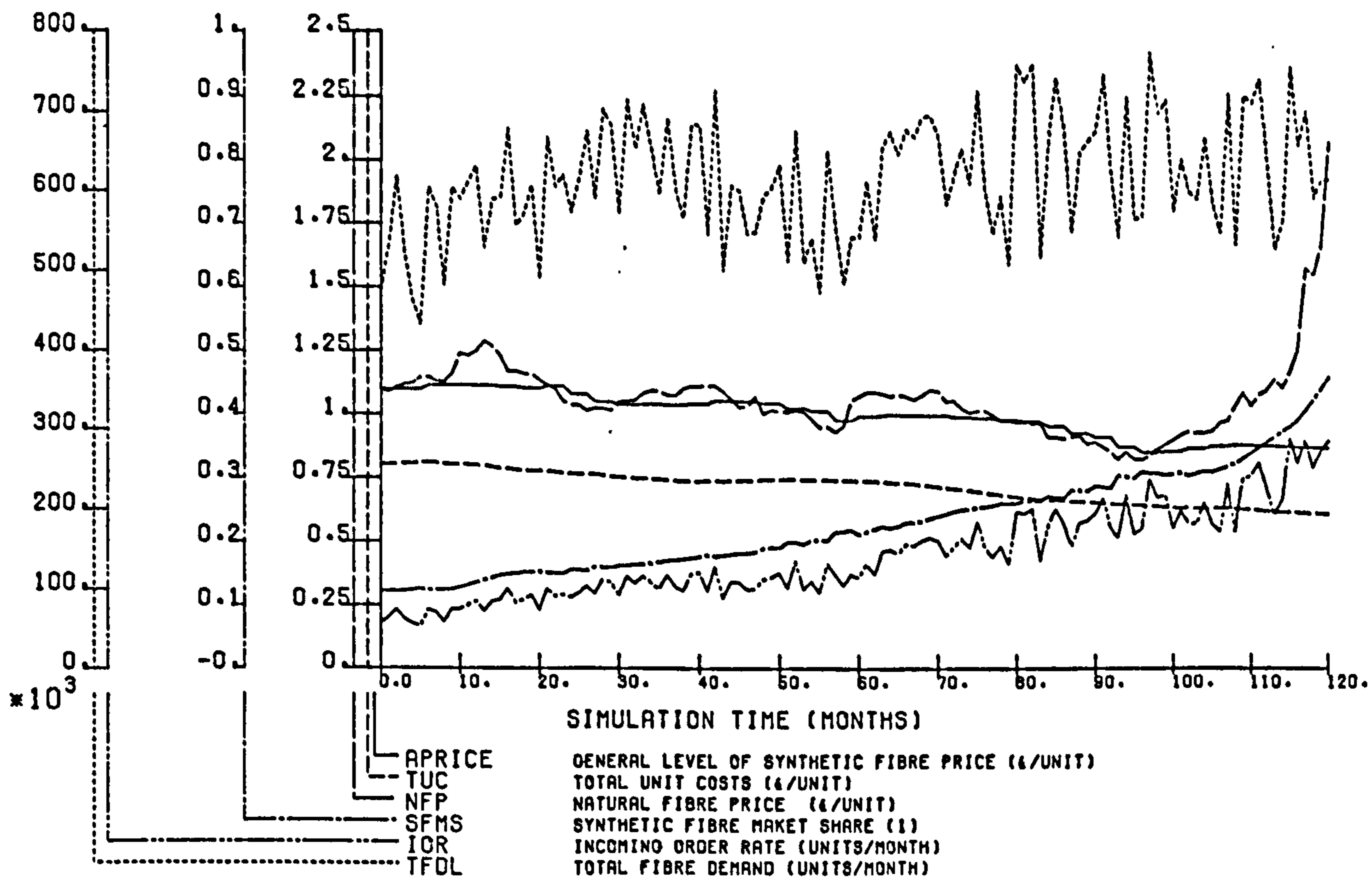


FIG 8.14 NOISE IN DEMAND THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

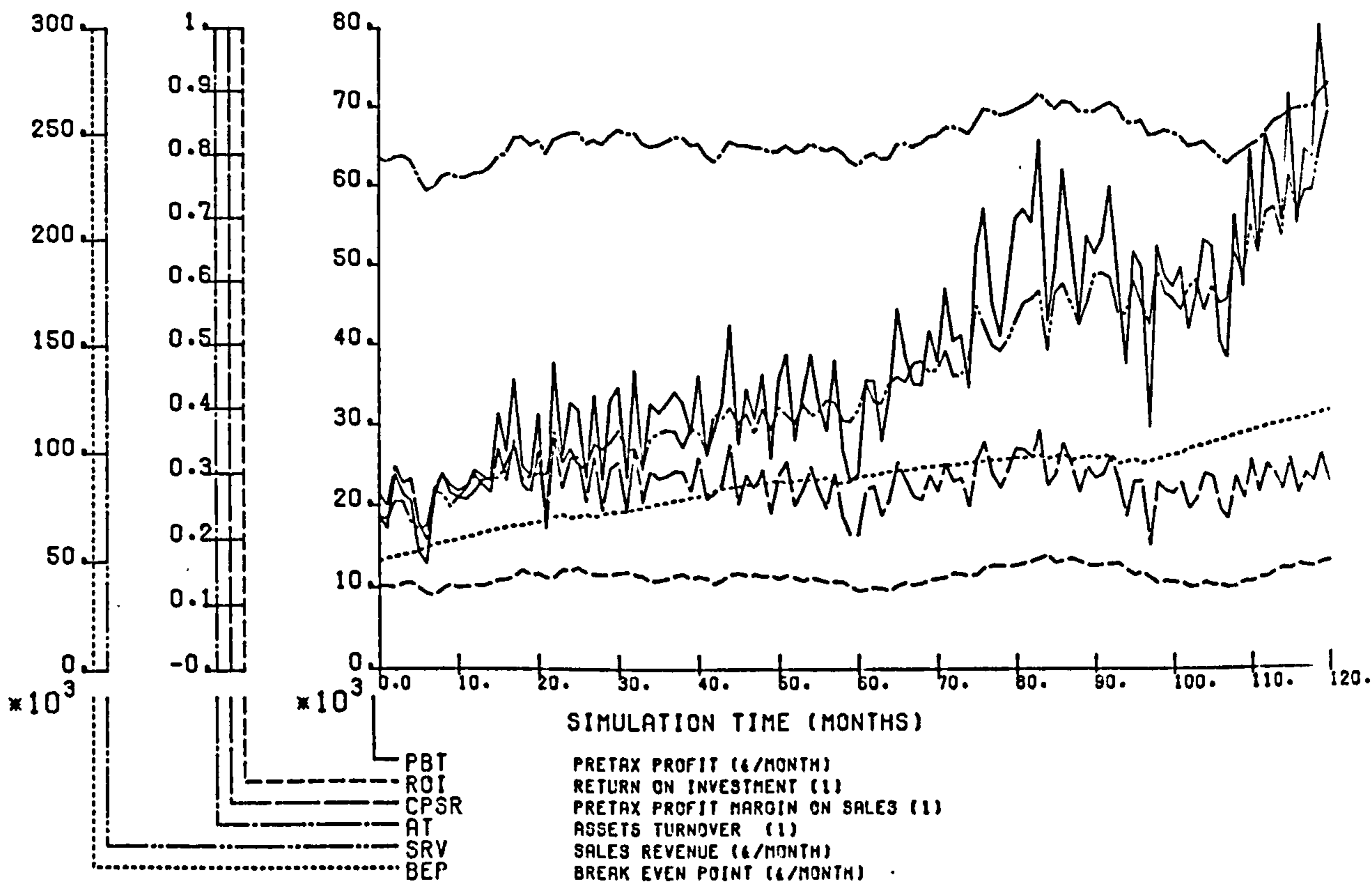


FIG 8.15 NOISE IN DEMAND THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

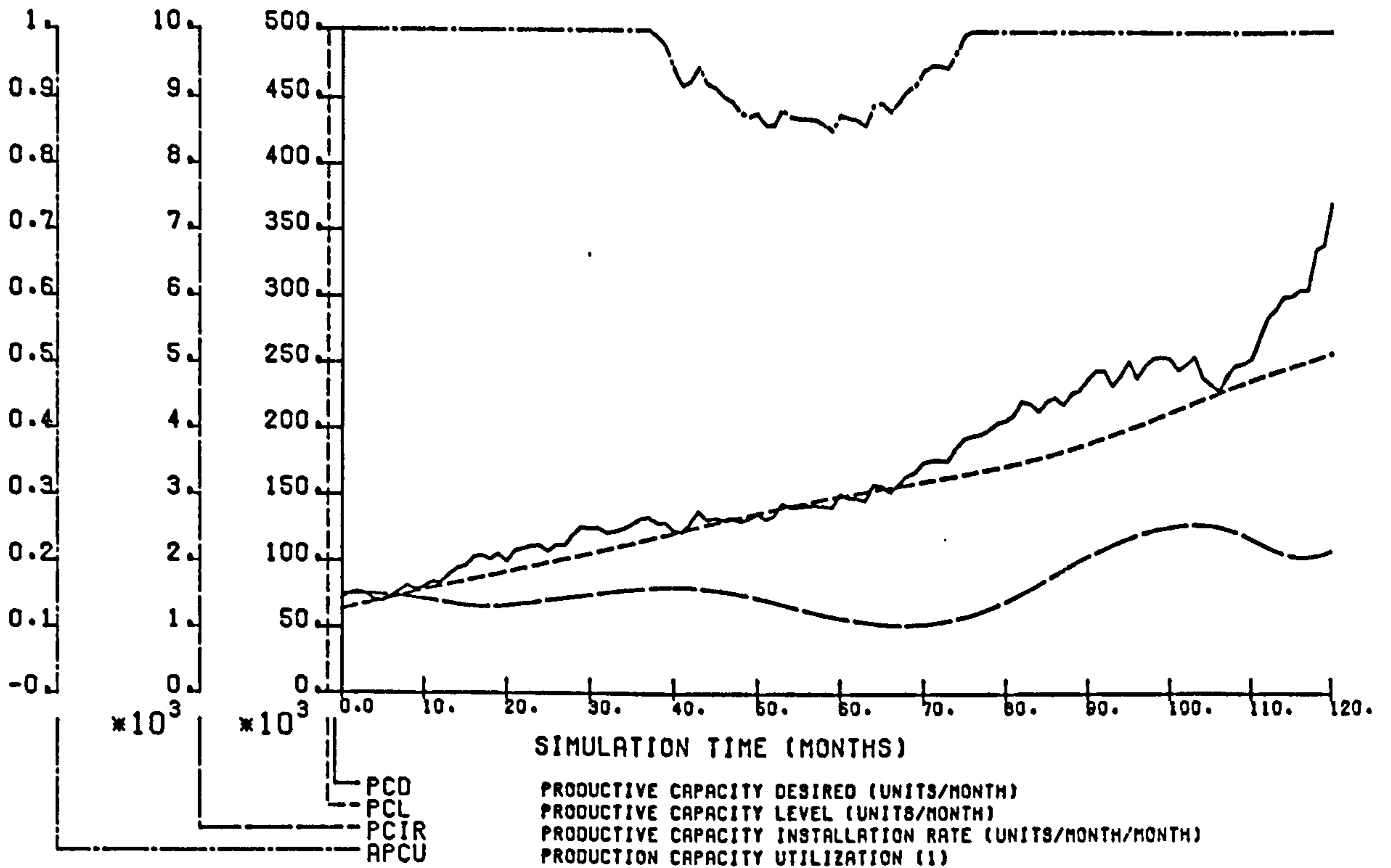


FIG 8.16 NOISE IN DEMAND
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

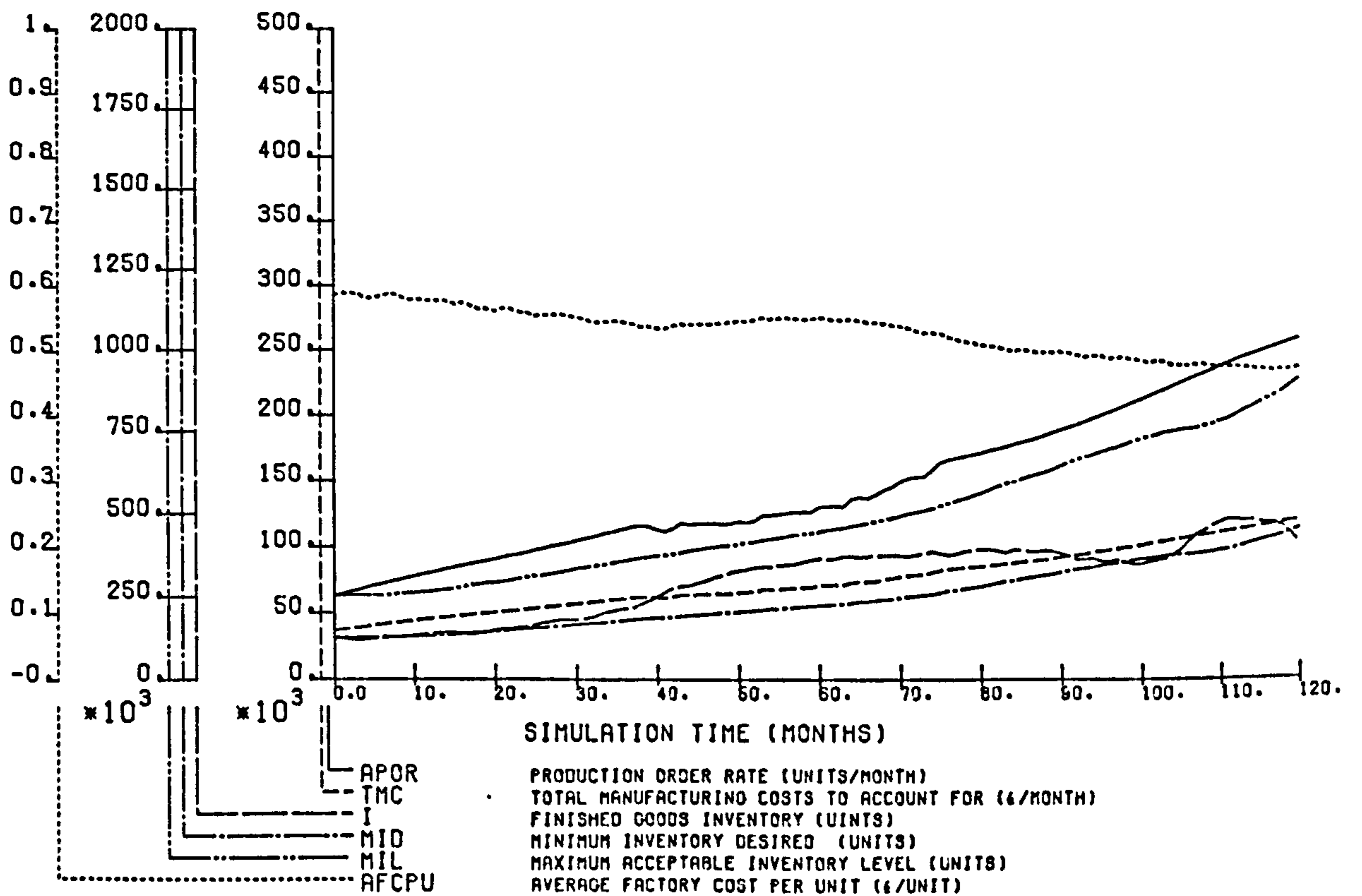


FIG 8.17 NOISE IN DEMAND
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

8.4.2. The Sensitivity Testing:

The model has been tested to see how much its key variables are sensitive to certain parameters changed to values at the extremes of their plausible range. In doing so, we can direct ourselves to changing a great number of the system's parameters, but due to limitations of space, only those parameters thought to be critical for the purpose of this study were changed.

Several runs were made to examine the effects of the errors in the chosen parameters on the system's performance. The results of these runs for the performance measurements namely, accumulated profit (AATP) the performance index (PINX) and its components (SFV, SIP), the variables used to form this index (SSR, PBT, SFMS, APRICE, ROI) and profit margin on sales (CPSR), are presented in Table 8.3.

8.4.2.1. The effect of errors in estimating standby costs (FSBC and ASSBE):

The model was run with 20% over estimation and 20% under estimation respectively after the first year.

The analysis of the results has shown that there are slight changes in the performance measurements than in perfect case (new policy case). The decrease in PINX, in both under and over estimation cases, is mainly due to the fact that the system has become relatively less stable, in particular in the under estimation case. However, there are no changes in the Model's behaviour mode; smooth rapid growth and stable profitability position.

8.4.2.4. The effects of the changes in the values of some delays Components

The model was experimented with the following delays:

- i) Delay in R & D outcome (DORE): bias factor about \pm 25%.
- ii) Delay in perceived market effort by customers (TPME): bias factor about \pm 67%.
- iii) Delay in perceived natural fibre price by customers (TCNFP): bias factor 50%.

It was found that the system was relatively insensitive even to large errors in these parameters: smooth and rapid growth, stable and satisfactory level of profitability.

The improvement in the system's numerical performance caused by shortening DORE indicates the desirability to adopt this change. The insensitivity of the system to the errors in TPME, and the slight effect of substantial errors in TCPNFP suggests that the firm does not need to expend extensive effort to obtain accurate forecasts of these parameters which are difficult if not impossible to be precisely estimated.

8.4.2.5. The effects of the errors in natural fibre price forecast (NFP):

The model was run with an equal weight given to the price indices of cotton and wool instead of heavy weight given to the latter (D = .5 instead of .3).

As can be seen in Table 8.3 the system is sensitive to this change. The improvement in the numerical performance of the system is due to the fact that cotton price is more stable than wool price. The maximum value is approximately 1.57 times of the minimum value in the former, whereas, it is 3.3 in the latter. Therefore, when cotton price index is given the same weight, the system becomes more stable and, at the same time, the pressure to decrease synthetic fibre price becomes lesser. This can be seen in the improvement in the SFV as well as SIP.

The behaviour pattern of the system as a whole, however, is relatively insensitive to such change.

8.4.2.6. The effect of the errors in estimating the relation between price and market share:

To test the sensitivity of the system to the errors in estimating the degree of substitution which a price change would bring about, the Model was run under the assumption that the errors are $\pm 10\%$. This is done by adjusting the TABLE Function PMT.

In the case of 10% "over estimate"

PMT = .935/.88/.825/.748/.66/.50

In the case of 10% "under estimate"

PMT = .76/.72/.675/.612/.54/.50

It was found that the changes in the numerical performance measurements were less than or equal to $\pm 10\%$. Therefore, the system did not amplify these errors but it reduced them for some variables. The behaviour mode of the system was approximately insensitive to these errors.

8.4.3. Conclusions:

From the previous analysis the following conclusions can be drawn:

- a) The behaviour pattern of the system in response to seasonal disturbances is the expected and desirable one.
- b) The system is relatively insensitive to NOISE variations in demand.
- c) The numerical performance of the system to changes in the values of some parameters are relatively sensitive. However, this performance in all cases is still highly satisfactory.
- d) The behaviour mode of the system is insensitive to these changes in the parameters. The system is, therefore, extremely robust with respect to these parameter errors.

Table 8.3: Performance Measurement Values for Various Parameters Tested

Variables Parameter	AATP	PINX	SFV	SIP	SSR	PBT		CPSR %		APRICE		ROI %		SFMS %
						MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	
Perfect estimate:	2650190	145.5	200.48	54.982	299024	76898	18481	31	24	1.10	.85	16	11	47
Standby costs:														
+20% over estimate	2334680	133.68	194.65	60.965	299460	68808	18493	28	20	1.10	.85	16	10	47
-20% under estimate	2962560	137.73	206.33	68.595	298534	84827	18493	35	26	1.10	.85	17	12	47
Capital costs per unit:														
No changes case	2576370	140.23	196.36	56.13	296321	73772	18493	31	24	1.10	.85	16	11	47
Increase case	2501730	132.92	192.29	59.365	293705	70599	18493	30	23	1.10	.85	15	11	46
FME:														
+20% over estimate	2650310	145.47	200.48	55.012	299029	76898	13493	31	25	1.10	.85	16	12	47
-20% under estimate	2451560	126.25	196.99	70.747	294274	73583	18493	30	23	1.10	.84	16	10	46
DORE:														
60 months	2445910	132.10	186.8	54.703	280744	70796	18493	30	29	1.10	.85	17	11	44
36 months	2903670	156.09	216.83	60.738	320888	84792	18493	32	26	1.10	.85	16	12	50
TPME:														
5 months	2619780	145.73	198.97	53.247	297090	76309	18493	31	24	1.10	.85	16	12	47
1 month	2681500	145.25	202.02	56.776	300933	77469	18493	32	25	1.10	.85	16	12	47
TCPNFP:														
18 months	2702720	151.39	201.33	49.94	288973	73479	18493	32	25	1.10	.85	17	12	45
6 months	2575490	128.84	202.86	74.019	316867	85368	18493	31	23	1.10	.85	18	11	50
NFP:														
D = .5	29211680	172	219.9	46.683	2950053	92983	18493	35	25	1.10	.91	19	12	46
PMT:														
+10% bias factor	2955950	152.5	233.34	70.841	334206	88655	18493	32	26	1.10	.85	18	12	52
-10% bias factor	2352760	130.11	177.41	47.295	263340	65831	18493	30	23	1.10	.85	15	11	41

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CHAPTER IX

MODEL EXPERIMENTATIONS

CHAPTER IXMODEL EXPERIMENTATIONS

In this chapter we, firstly, examine the behaviour of the system under different pricing policies, in order to determine which policies are preferred in comparison with the new policy run discussed in Section 8.3, to achieve higher growth and profitability targets. The policies to be examined are direct costing, discount and R & D policies.

We, secondly, investigate the effects of the two developments which occurred in 1973 - energy crisis and the Price Code, on the behaviour of the system.

A brief overview of the results obtained is given in the following pages.

The chapter is therefore outlined as follows:-

- 9.1. Direct costing policy
- 9.2. Discount policy
- 9.3. R & D policy
- 9.4. The Price Code and energy crisis effects
- 9.5. Conclusion

9.1. Direct Costing Policy:

The purpose of this section is to investigate the effects of the adoption of direct costing policy on the growth and profitability of the firm. The simulation results presented in Figs. 9.1, 9.2, 9.3, 9.4 and Table 9.1 (which also includes data on full costing to compare with), show the behaviour of the system under direct costing policy, from which the following observations can be made.

a) The adoption of direct costing policy does not affect the growth rate.

b) The profitability situation is lower than in full costing case.

This is due to the combination of the following:

i) the slight increase in total unit costs, and consequently price, during most of the simulated period which is due to the increase in factory overheads per unit sold resulting from the write-off of these costs in the period that they occurred.

ii) the decrease in pre-tax profit during most of the simulated period and, consequently, accumulated profit due to the immediate charge of these factory overheads against revenue.

It should be noted, however, that the decrease in accumulated profit is less significant than the difference between month-to-month profit figures.

- iii) pre-tax profit margin on sales is lower because sales revenue is approximately the same.
- iv) however, there is no change in return on investment due to the increase in assets turnover resulting from the substantial decrease in the monetary value of work in process and finished goods inventories.

The previous observations can be interpreted in accounting terms as follows:-

In direct costing method fixed factory overheads are regarded as "period" costs and, therefore, they are released as expenses along with the other expenses in the period in which they are incurred. As a result, fixed factory overhead will not be included in the figures of work in process and finished goods inventories carried forward. Since there is a continuous increase in the level of inventory during the simulated period (which means that, in full costing a portion of the fixed factory overhead of the period is charged to inventories and thereby deferred to future periods), the pre-tax profit is lower than in full costing. However, the difference between accumulated profit under two methods is very small (about 4%). This is the expected result in the long-run because production and sales on average tend to become equal over a long period.

Therefore, the differences in profitability, here, are due solely to the difference in accounting for fixed factory overhead rather than to the real changes in the performance of the system.

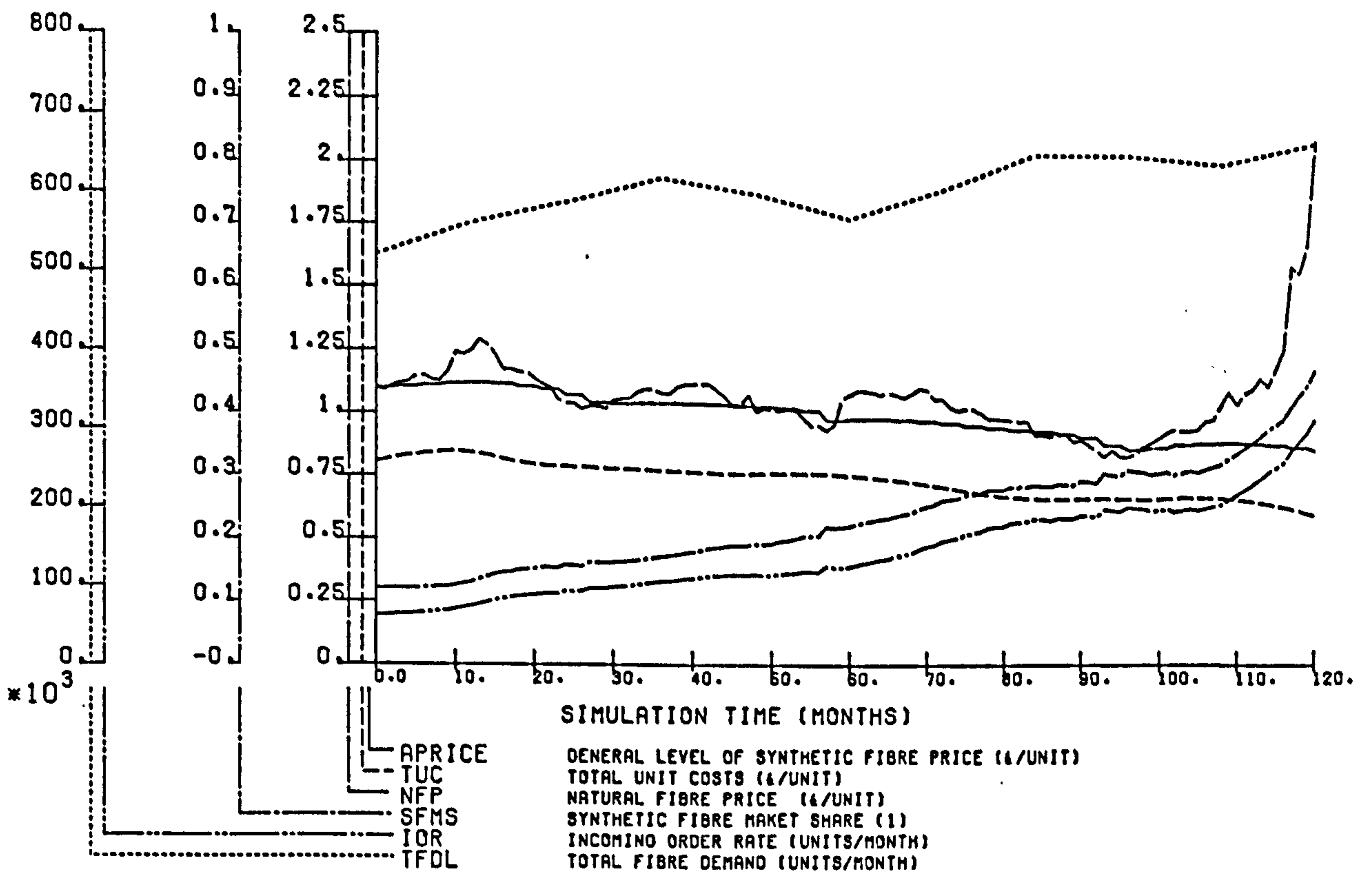


FIG 9-1: THE BEHAVIOUR IN THE DIRECT COSTING CASE THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

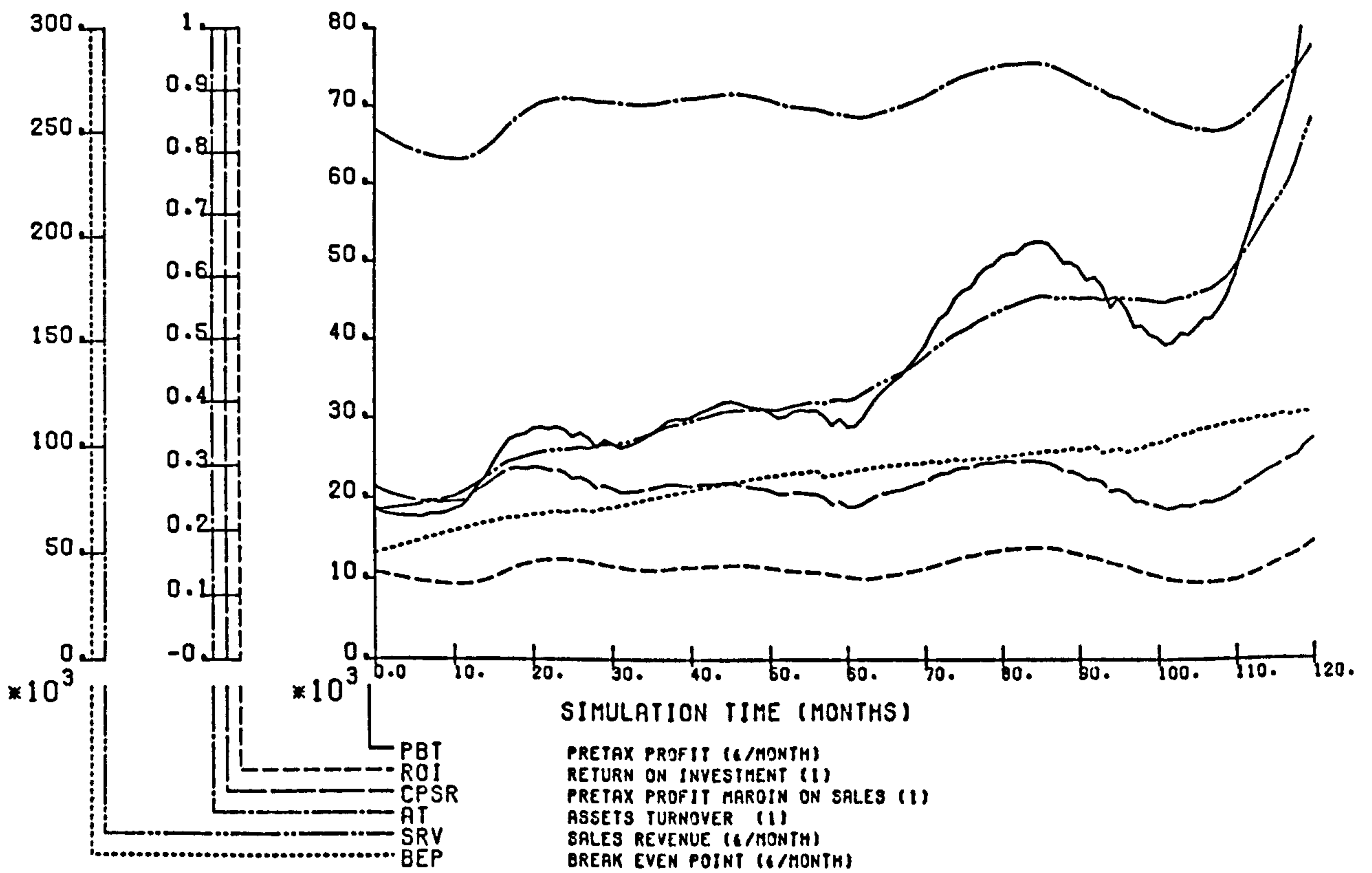


FIG 9-2: THE BEHAVIOUR IN THE DIRECT COSTING CASE THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

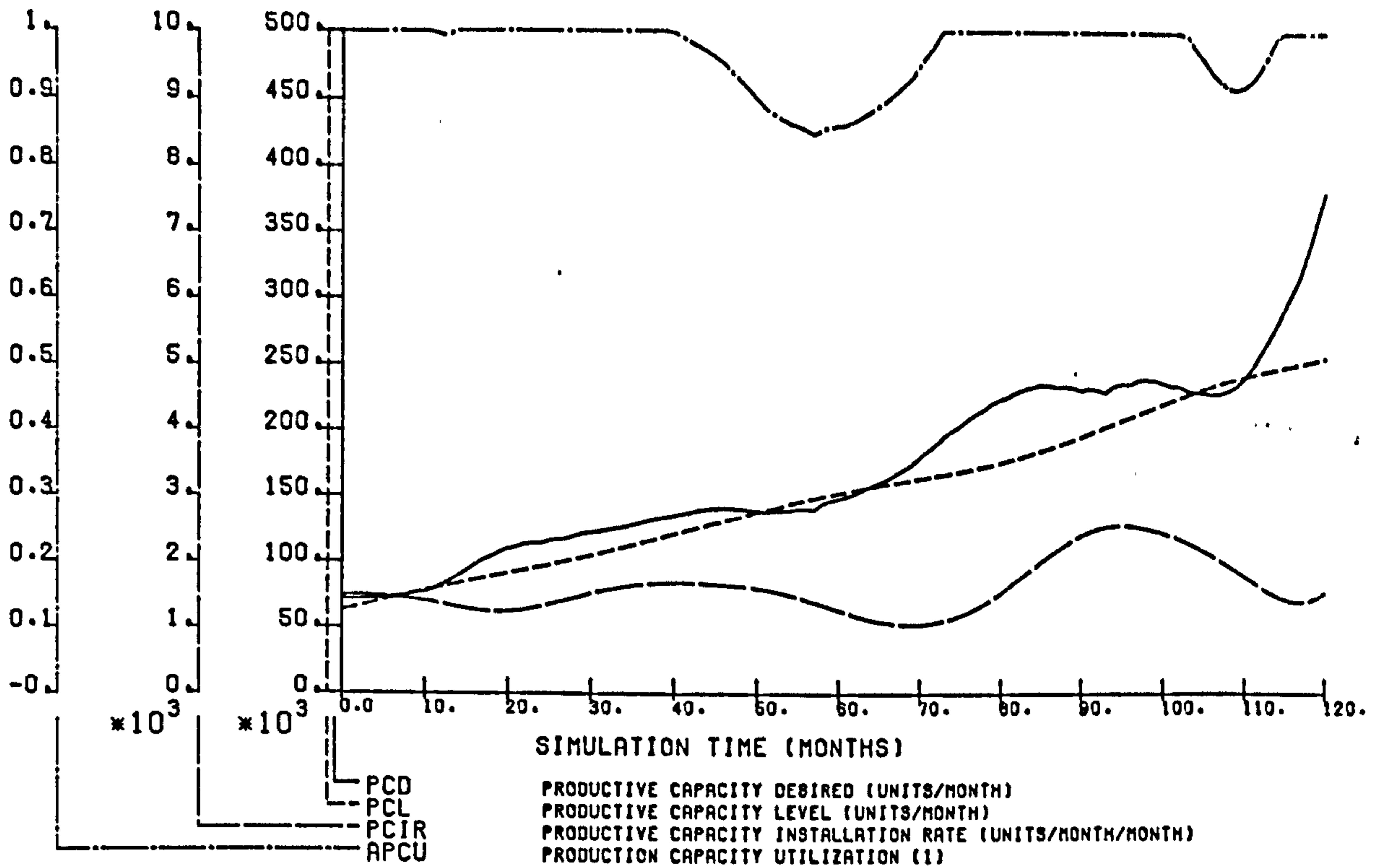


FIG 9.3: THE BEHAVIOUR IN THE DIRECT COSTING CASE THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

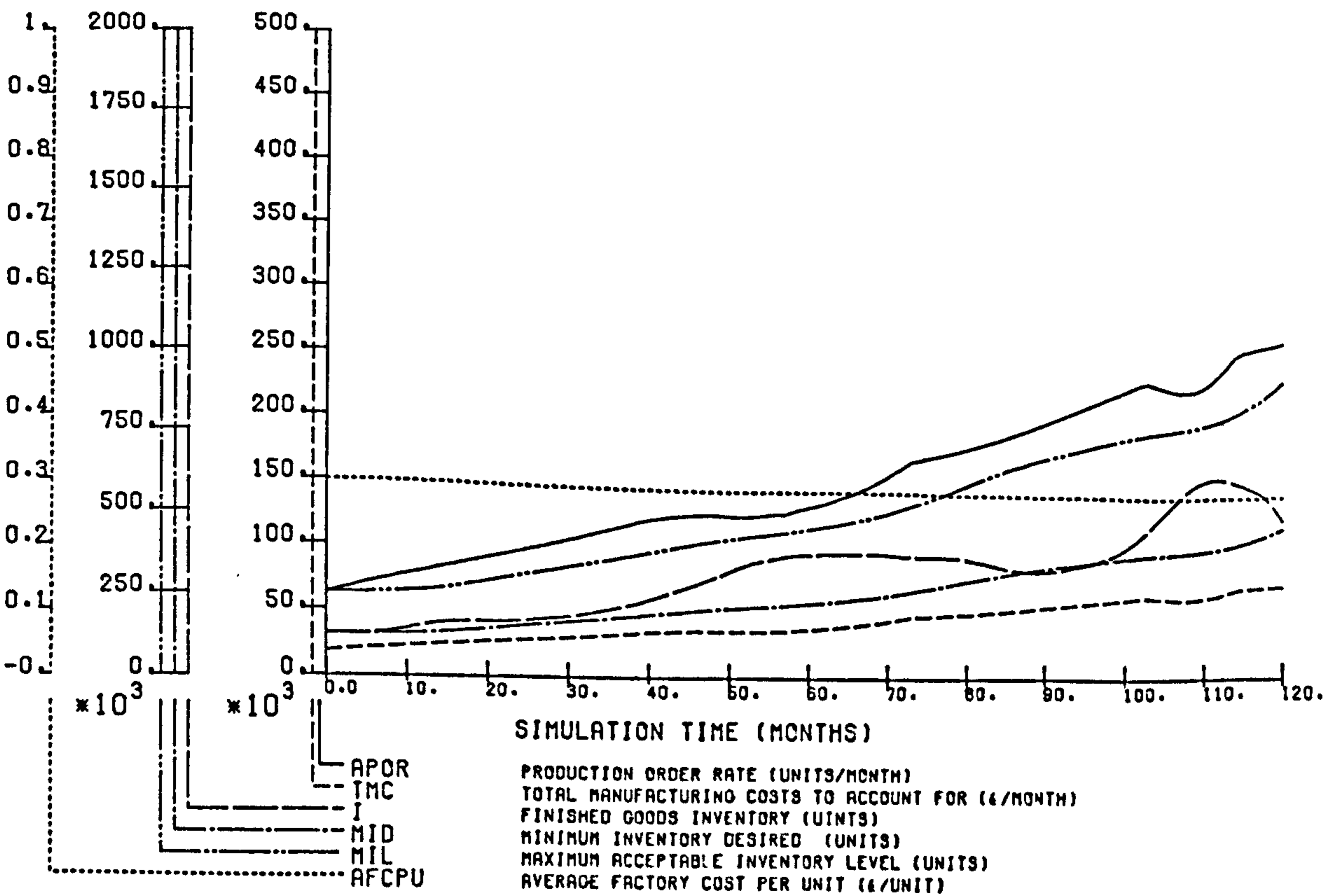


FIG 9.4: THE BEHAVIOUR IN THE DIRECT COSTING CASE THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

Table 9.1: Some Numerical Output Comparisons for
Various Costing Policies

Variable Parameters	Full Costing		Direct Costing	
	MAX	MIN	MAX	MIN
AATP	2650190	-	2561100	-
PINX	145.50	-	125.42	-
SFV	200.48	-	198.31	-
SIP	54.982	-	72.986	-
SSR	299024	63180	295757	63180
PBT	76898	18493	87388	17641
SFMS	47%	12%	47%	12%
APRICE	1.10	.85	1.12	.85
ROI	16%	12%	18%	12%
CPSR	31%	25%	34%	23%
Inventory I	587978	126143	607788	126143
Work in Process WIPI	627165	63180	633122	63180
Monetary Value of I	280626	73957	166644	37738
Monetary Value of WIPI	276556	37023	167973	18891

9.2. Discount Policy:

In this section the effect of a change in the discount (price allowance) policy on the growth and profitability of the firm will be explored. To do so the model has been experimented with under different price discount and maximum inventory cover policies.

Four cases are examined in this section, which are:-

- 1) An aggressive discount policy with an aggressive inventory policy.
- 2) An aggressive discount policy with a conservative inventory policy.
- 3) A conservative discount policy with an aggressive inventory policy.
- 4) A conservative discount policy with a conservative inventory policy.

The impacts on growth and profitability compared with the moderate case (new policy case) are presented in Table 9.2 and examined in the following sub-sections.

Table 9.2: Performance Measurement Comparisons for Various Discount Policies

Variables	Moderate discount Policy		ADP & AIP		ADP & CIP		CDP & AIP		CDP & CIP	
	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	MIN
AATP	2650190	-	2716910	-	2772910	-	2645420	-	2638210	-
PINX	145.5	-	154.25	-	154.04	-	143.78	-	136.82	-
SFV	200.48	-	202.62	-	205.09	-	200.53	-	199.89	-
SIP	54.982	-	48.365	-	51.047	-	56.75	-	63.041	-
SSR	299024	63180	299321	63180	301178	63180	299100	63180	297608	63180
PBT	76898	18481	77787	18481	78778	18278	76728	18481	78086	18481
SFMS	47%	12%	47%	12%	47%	12%	47%	12%	47%	12%
APRICE	1.10	.85	1.10	.85	1.10	.85	1.10	.85	1.11	.85
ROI	16%	12%	16%	12%	17%	12%	16%	12%	17%	12%
CPSR	31%	25%	31%	25%	31%	26%	32%	24%	32%	24%

9.2.1. An aggressive discount policy (ADP) with an aggressive inventory policy (AIP):

It is assumed that the firm has increased price allowance by adjusting the TABLE function TPA to become:

$$\text{TPA} = .45/.325/.215/.115/.08/.05/0$$

In the meantime, it does not change its aggressive inventory policy.

Analysis of the results has shown that:

- a) The growth rate is the same as the moderate case.
- b) The profitability situation is slightly improved as compared with the moderate case: accumulated profit and the maximum pre-tax profit are 2716910£ and 77787 £/M, while they have been 2650190£ and 76898 £/M in the moderate case respectively.
- c) The performance of the system as a whole has improved: the PINX is 154.25 while it has been 145.5 in the moderate case.

9.2.2. ADP with a conservative inventory policy (CIP):

It is assumed, here, that the firm adopts ADP with conservative inventory policy in which the maximum acceptable cover MACOV is equal to the minimum desired one.

Examining the results has shown the following:

- a) There is a slight increase in the growth rate: the maximum shipment sent rate is 30178 U/M compared with 299024 in the moderate case.
- b) The profitability situation has improved: accumulated profit and the maximum pre-tax profit have become 2772910£ and 78778 £/M compared with 2650190£ and 76898£/M in the moderate case, respectively. In the meantime, there are slight improvements in return on investment and pre-tax margin on sales.
- c) The improvement in the performance of the whole system is approximately the same as the previous case.

9.2.3. A conservative discount policy (CDP) with AIP:

It is assumed that the firm has decreased price allowance by adjusting TPA to become:

TAP = .30/.22/.145/.08/.03/0/0

with aggressive inventory policy (AIP)

The analysis of the results has shown that there have been no significant effects on the growth and profitability situations as well as the performance of the system as a whole.

9.2.4. CDP with CIP:

It is assumed that the firm adopts CDP with CIP.

Analysis of the results has shown the following effects:

- a) There is a slight decrease in the growth rate: the maximum shipment sent rate is 297608 compared with 299024 in the moderate case.
- b) The profitability has changed slightly. Accumulated profit has fallen, while the maximum pre-tax profit has risen. The rise in the latter is due to a very slight difference between the value of price at the end of the simulated period (.854 £/U compared with .85 £/U in the moderate case).
- c) The performance of the whole system is less efficient. The decrease in PINX is about 6%.

Due to the limitation of space, only the graphical outputs of the model in the cases ADP with CIP and CDP with CIP are reported in figures 9.5,9.6,9.7,9.8,9.9,9.10,9.11, and 9.12.

The most obvious differences between the behaviour of the system in these cases and the moderate case (new policy case) are:

- (i) The adoption of CDP with CIP which has resulted in a substantial decrease in inventory (i.e. it has been below its minimum desired level from month 5 onwards, but the ability of the system to meet demand is not affected.) Consequently, the periods in which the firm works below its capacity have increased.

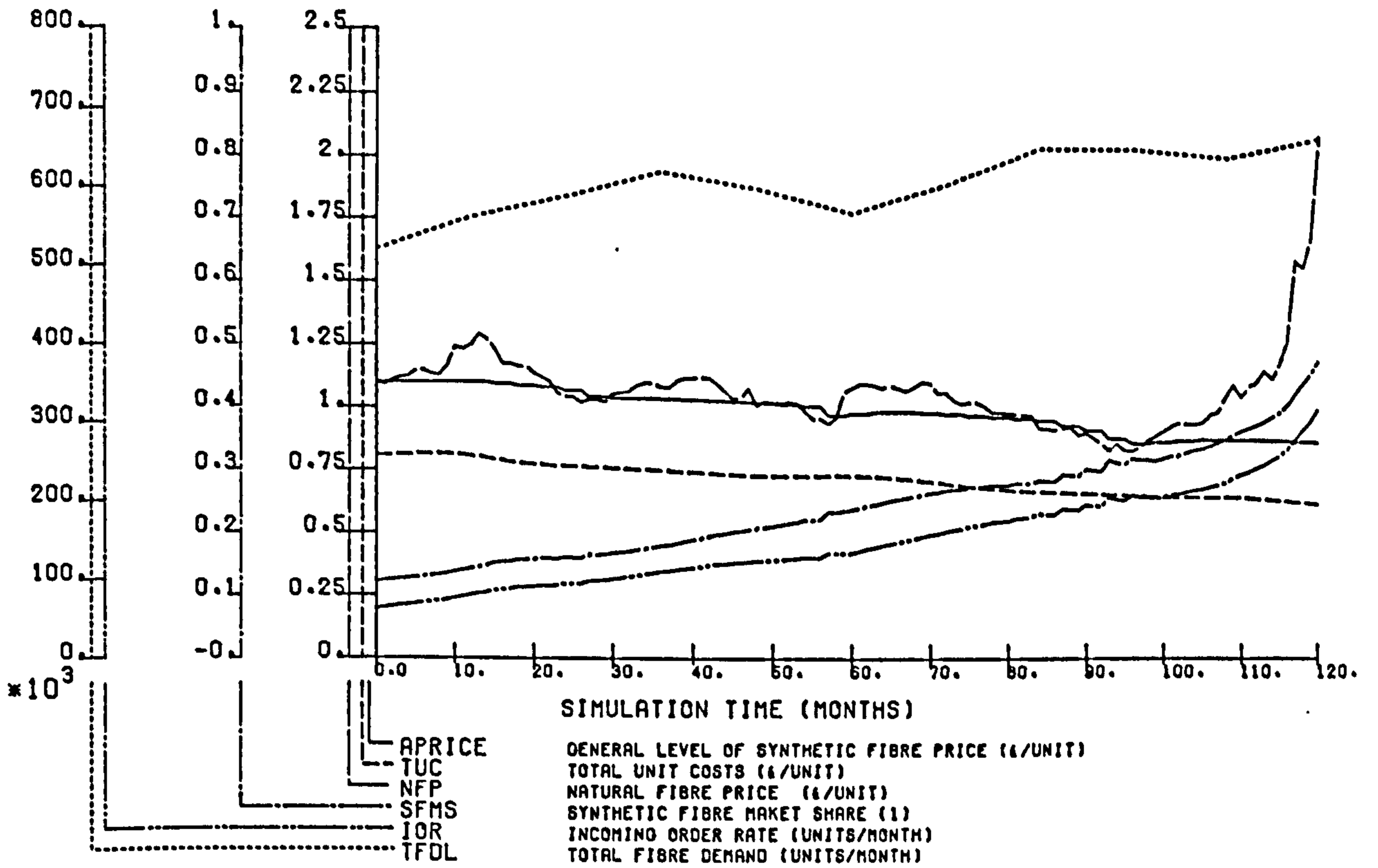


FIG 9.5 ADP&CIP THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

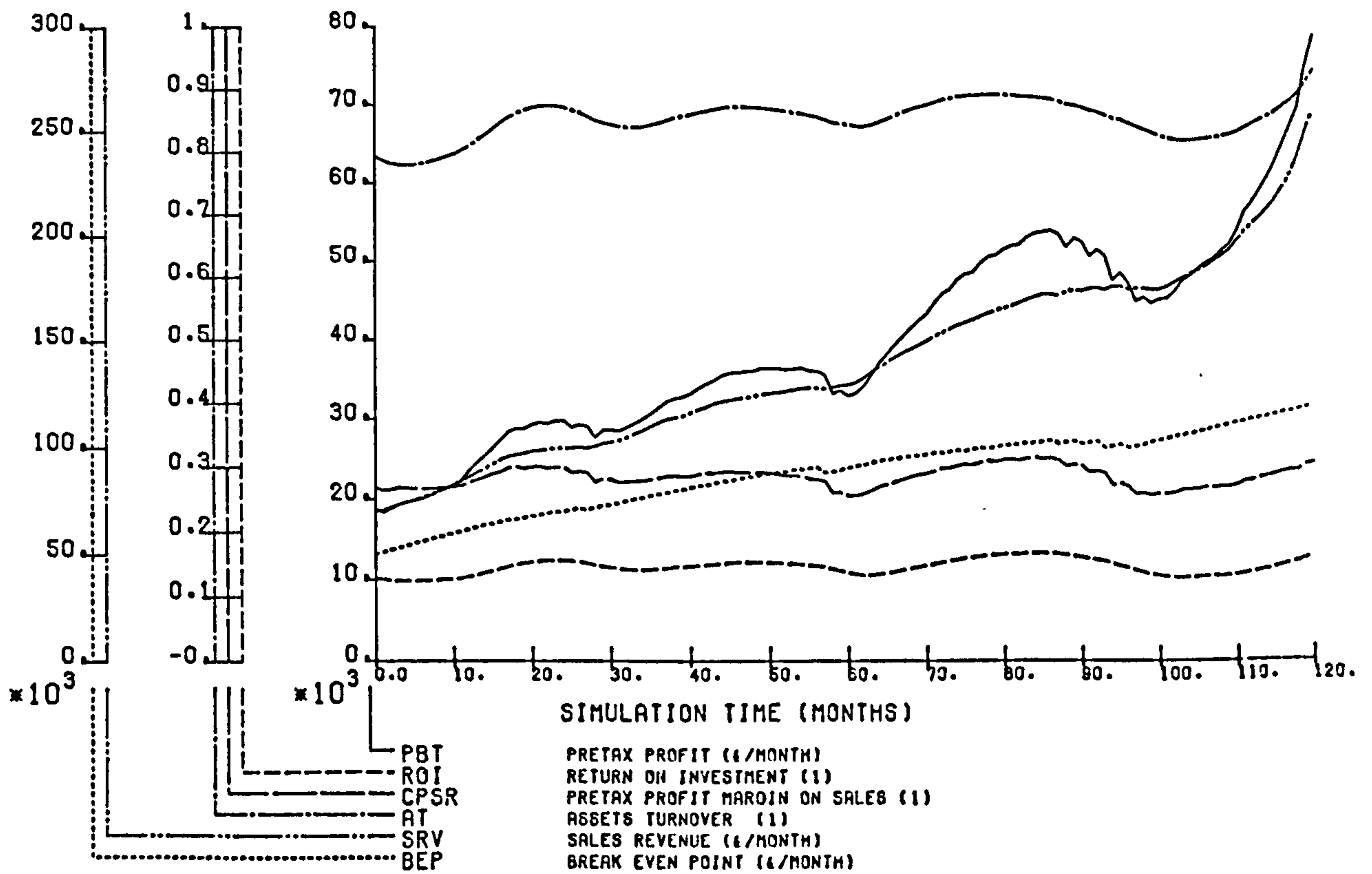


FIG 9.6 ADP&CIP THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

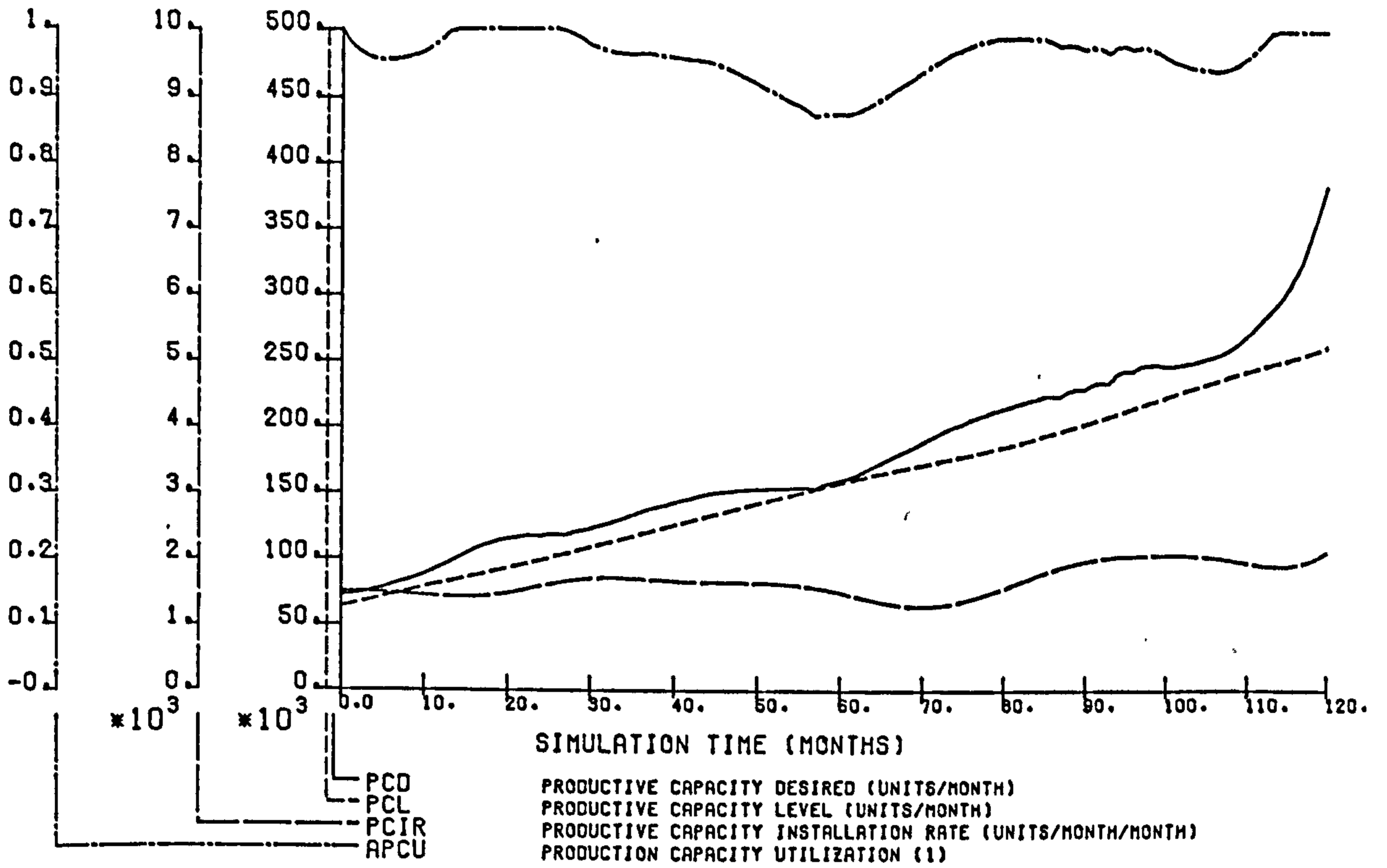


FIG 9.7 ADP&CIP
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

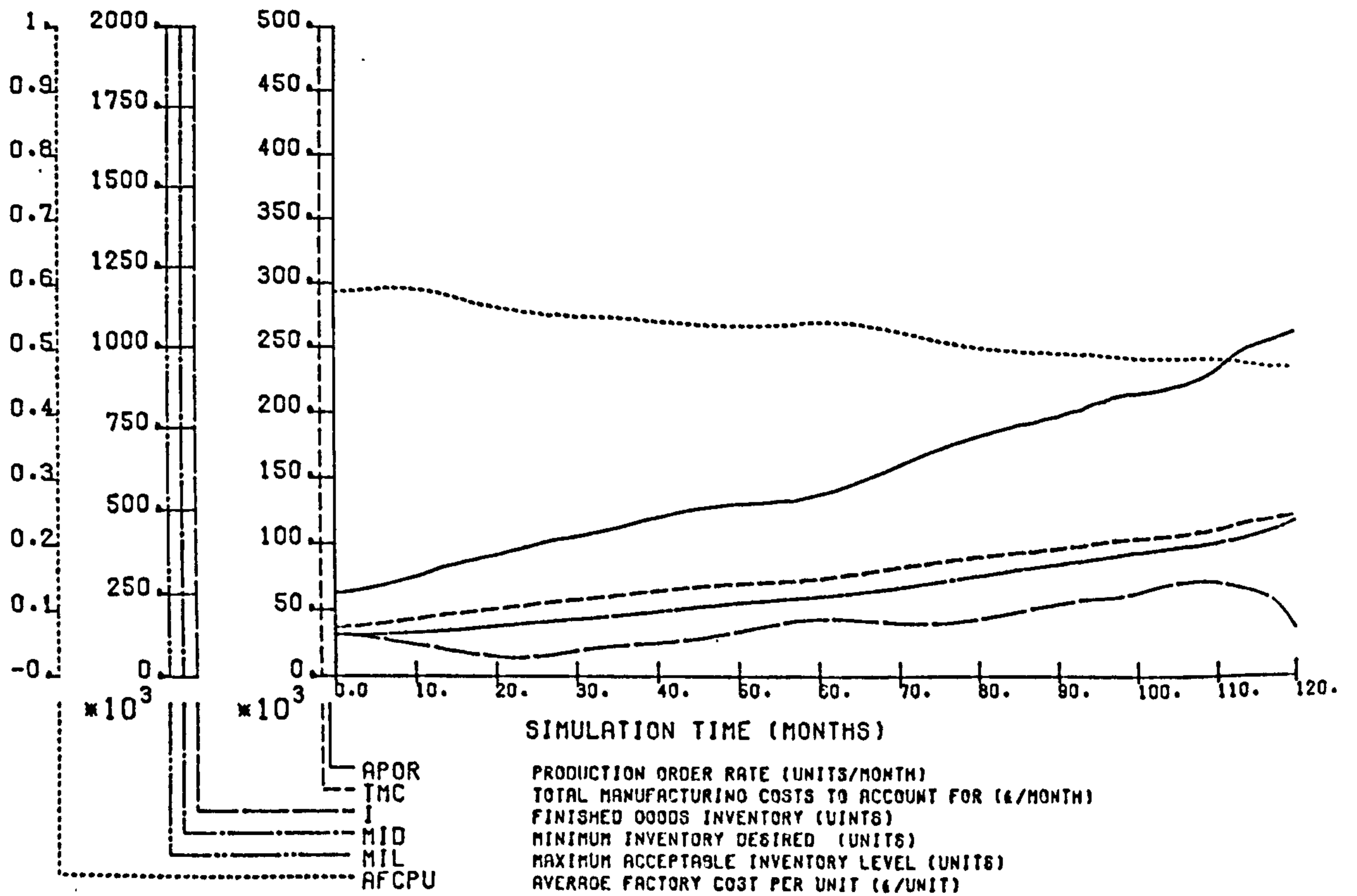


FIG 9.8 ADP&CIP
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

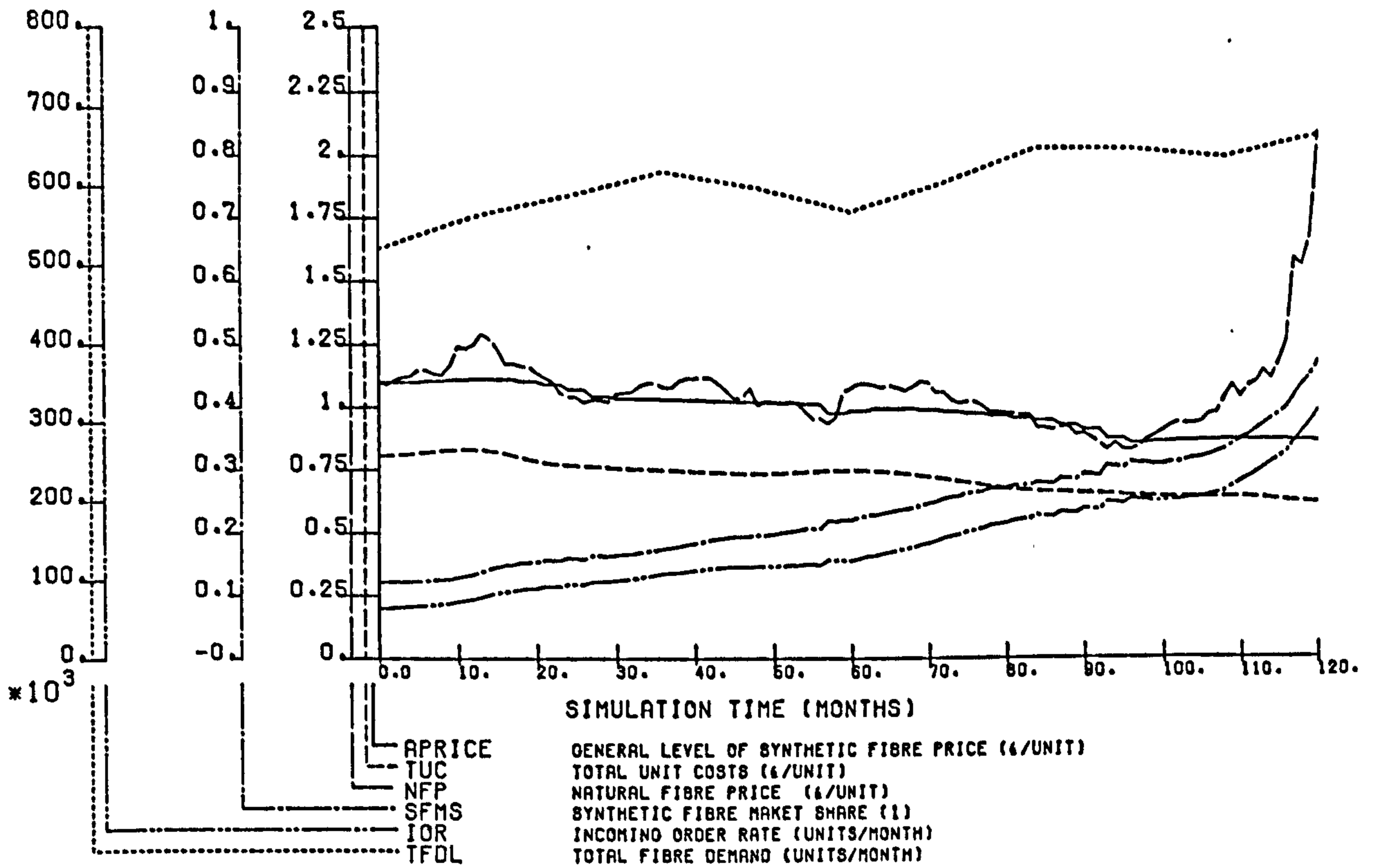


FIG 9.9:CDP&CIP
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

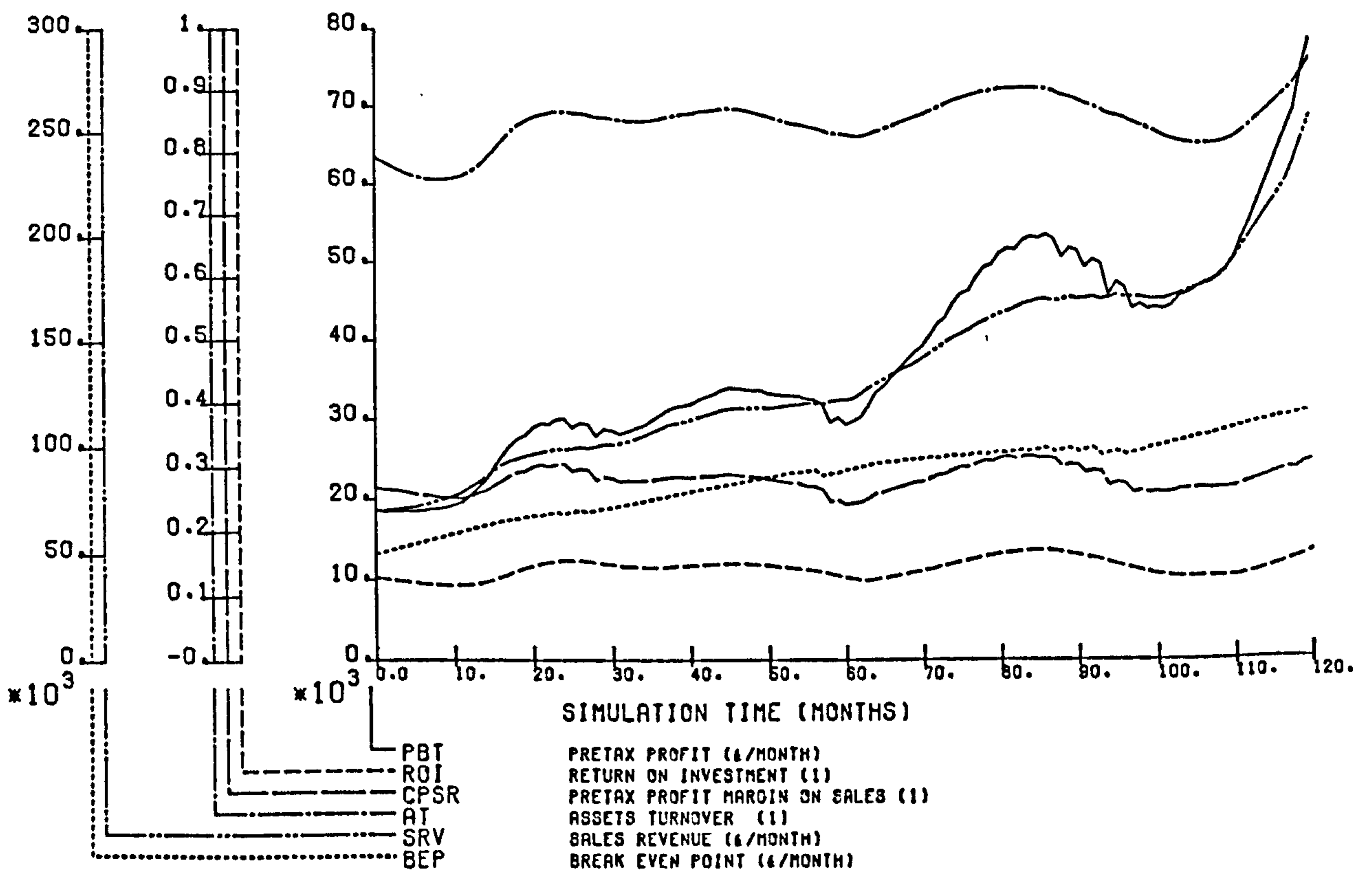


FIG 9.10:CDP&CIP
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

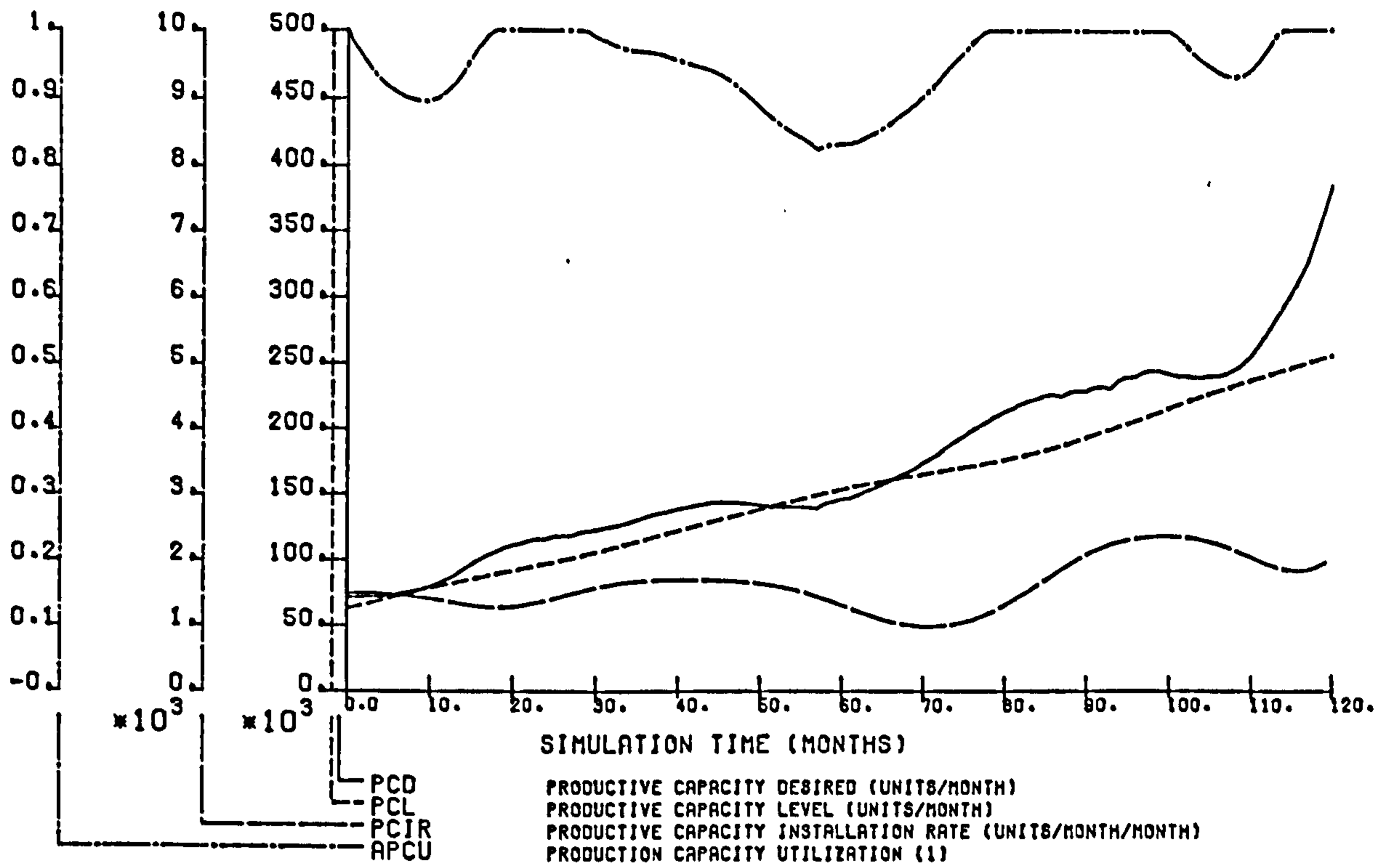


FIG 9.11:CDP&CIP
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

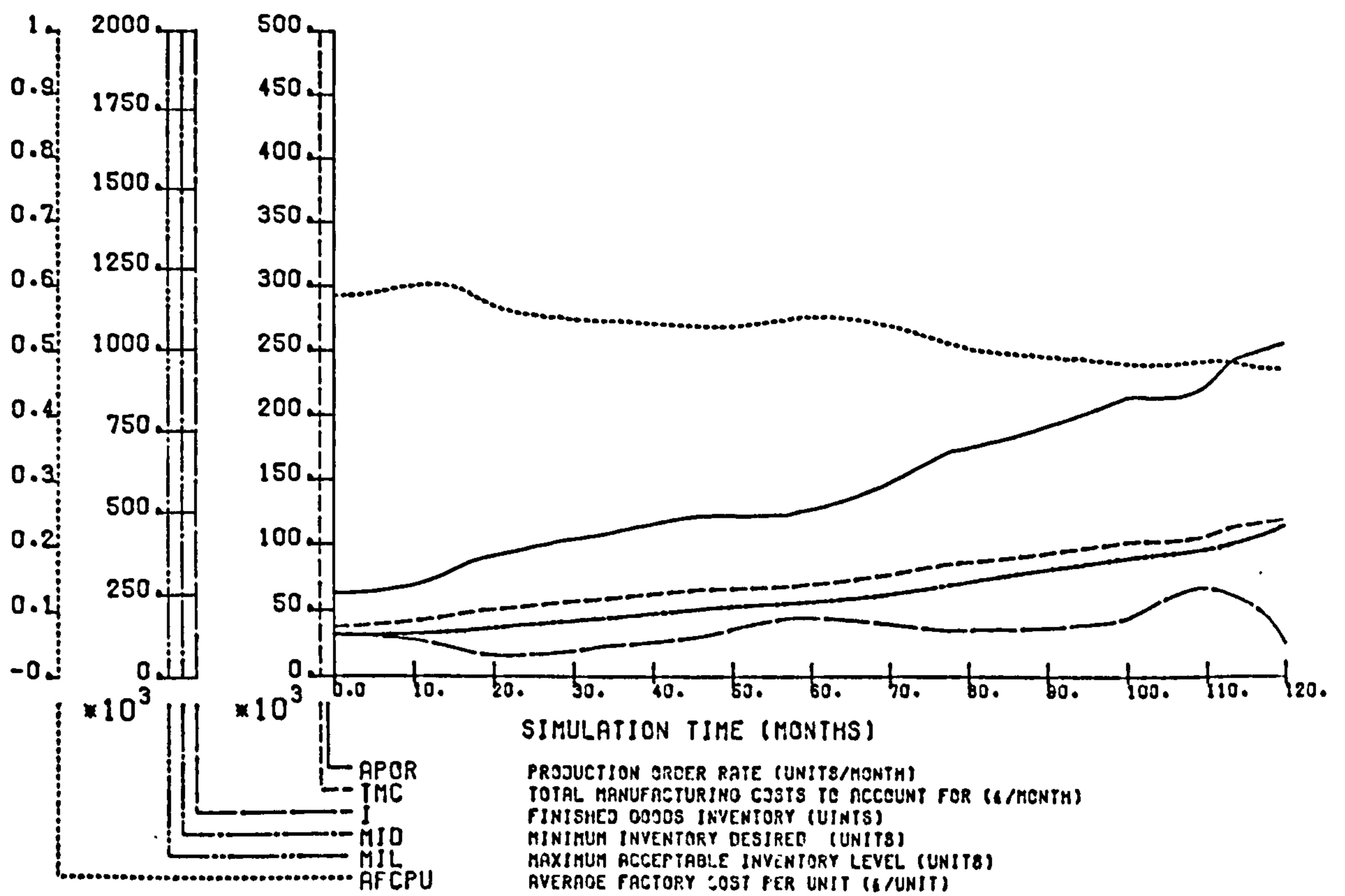


FIG 9.12:CDP&CIP
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

- (ii) The adoption of ADP with CIP which has resulted in no significant changes than the previous one with regard to inventory and capacity utilization. However, the ability of the firm to achieve its growth and profitability targets has increased. Synthetic fibre market share is higher than in the moderate one from month 30 onwards and, consequently, pre-tax profit because of the price, is the same.

9.3. R & D Policy

In this section we will examine the effect on the firm's growth and profitability of allocating different amounts of money to research and development activity. To do so, the model is simulated under two policies:

- 1) An aggressive R & D policy.
- 2) A conservative R & D policy.

The effects on growth and profitability in comparison with the moderate policy (new policy case) are presented in Table 9.3. and analysed in the following sub-sections.

Table 9.3: Performance Measurement Comparison for
Various R & D Policies

Variables Policy	Moderate Case		Aggressive R&D Policy		Conservative R&D Policy	
	MAX	MIN	MAX	MIN	MAX	MIN
AATP	2650190	-	2814330	-	2455410	-
PINX	145.5	-	159.37	-	127.69	-
SFV	200.48	-	218.53	-	179.93	-
SIP	54.982	-	59.154	-	52.233	-
SSR	299024	63180	325827	63180	269021	63180
PBT	76898	18481	85537	17994	68939	18968
SFMS	47%	12%	51%	12%	42%	12%
APRICE	1.10	.85	1.10	.85	1.10	.85
ROI	16%	11%	17%	12%	15%	11%
CPSR	31%	24%	31%	26%	31%	24%

9.3.1. An aggressive R & D policy:

It is assumed that the firm has increased the fraction of sales revenue allocated to R & D FSRVR by 20%.

Analysis of the results has shown that:-

- a) The growth rate has increased substantially as compared with moderate case. The maximum shipment sent rate and synthetic fibre market share have increased from 47% and 299024 U/M to 51% and 325827 U/M, respectively.
- b) There has been a significant improvement in profitability situation. Accumulated profit and maximum pre-tax profit have increased from 2650190£ and 76898 £/M in the moderate case to 2814330 £ and 85537 £/M, respectively.
- c) The performance of the system as a whole is better: the PINX has increased from 145.5 to 159.37.

9.3.2. A conservative R & D policy:

It is assumed, here, that the firm has reduced FSRVR by 20%.

The simulation results have shown that:-

- a) The growth rate has decreased. The maximum shipment sent rate and synthetic fibre market share have decreased from 299024 U/M and 47% in the moderate case to 269021 U/M and 42%, respectively.
- b) The profitability situation has decreased, too. Accumulated profit and pre-tax profit have become 2455410£ and 68939 £/M instead of 2650190£ and 76898 £/M, respectively in the moderate case.

- c) There is a decrease in the performance of the whole system: PINX has become 127.69, while it was 145.5 in the moderate case.

The graphical outputs of the model in the cases of aggressive and conservative R & D policies are shown in Figs. 9.13,9.14,9.15,9.16,9.17,9.18,9.19 and 9.20, which should be compared with the performance in the moderate case (new policy) presented in Chapter 8. The comparison shows that:-

- (i) The adoption of the aggressive R & D policy increases the ability of the firm to achieve higher growth and profitability targets than in the moderate case. Market share (and consequently incoming order rate) is higher from about month 40 onwards. The delay in occurrence of the improvement is due to the delay in the outcome of R & D. This, in turn, results in higher pre-tax profit and return on investment during the same period.
- (ii) The adoption of conservative R & D policy has resulted in the decrease of the ability of the firm to achieve the same growth and profitability targets as in the moderate case. Thus, market share and consequently incoming orders rate, are lower from about month 40 onwards. This, in turn, results in lower pre-tax profit and return on investment during the same period.

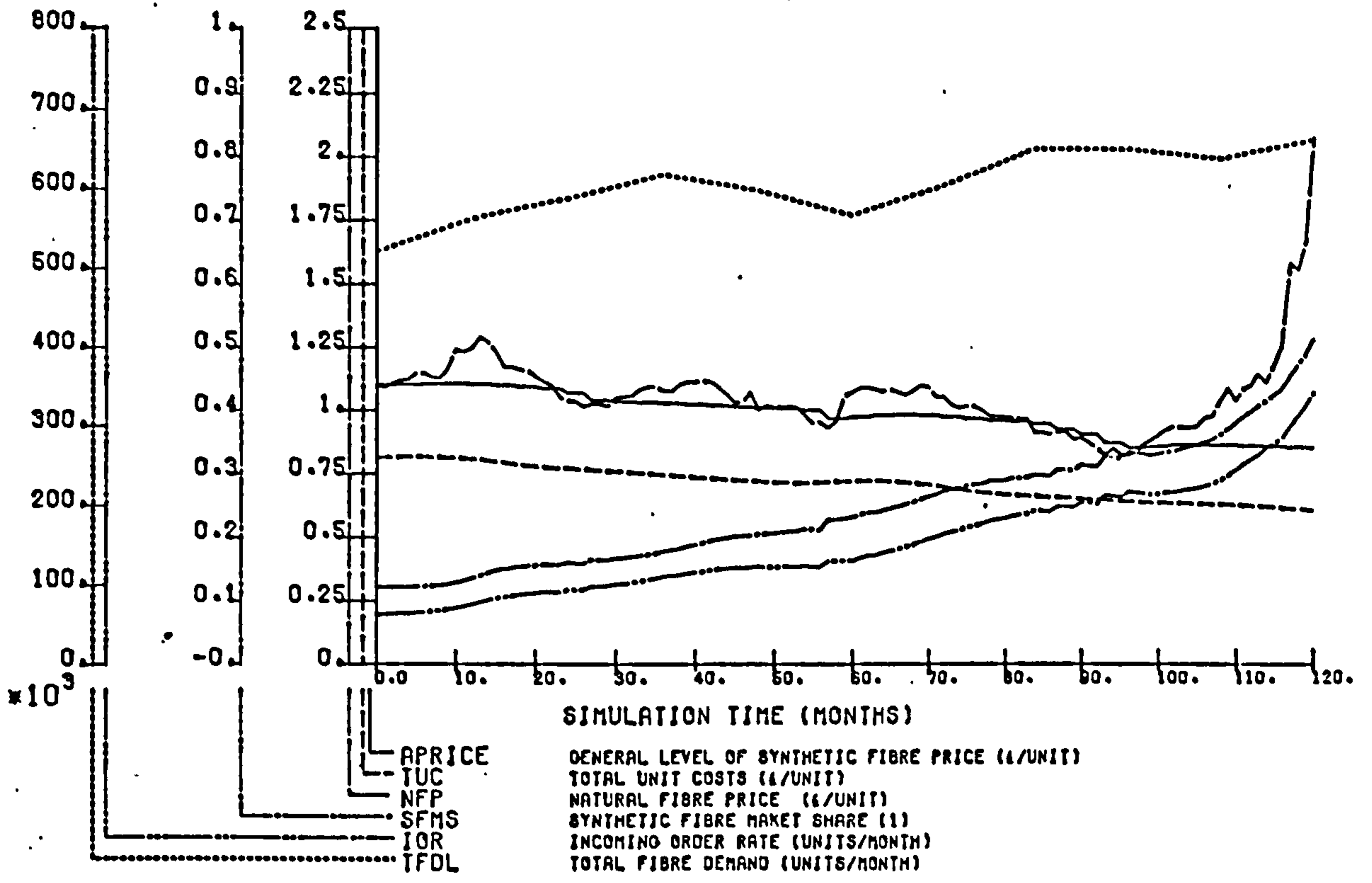


FIG 9.13 AGGRESSIVE R&D POLICY THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

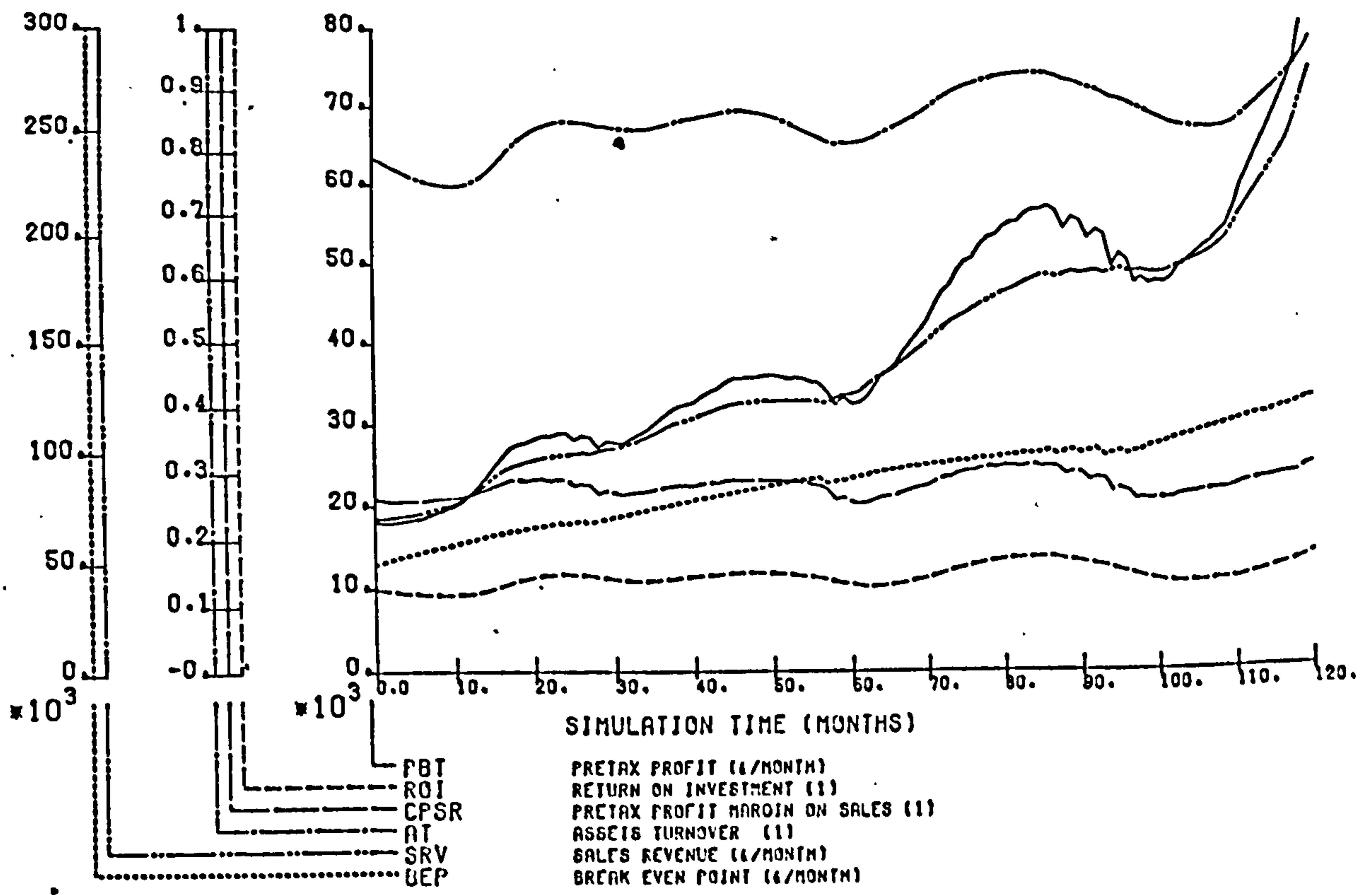


FIG 9.14 AGGRESSIVE R&D POLICY THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

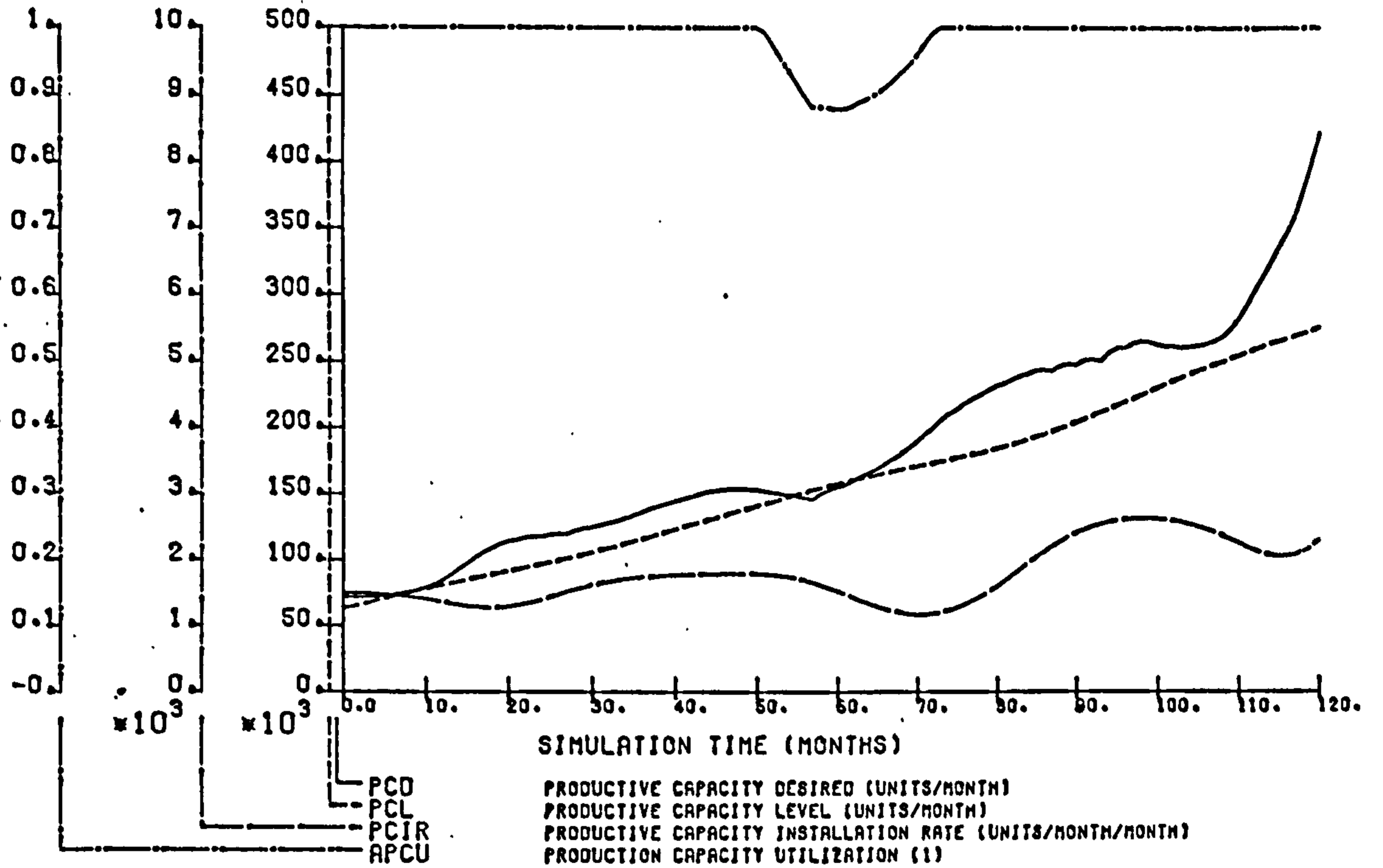


FIG 9.15 AGGRESSIVE R&D POLICY
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

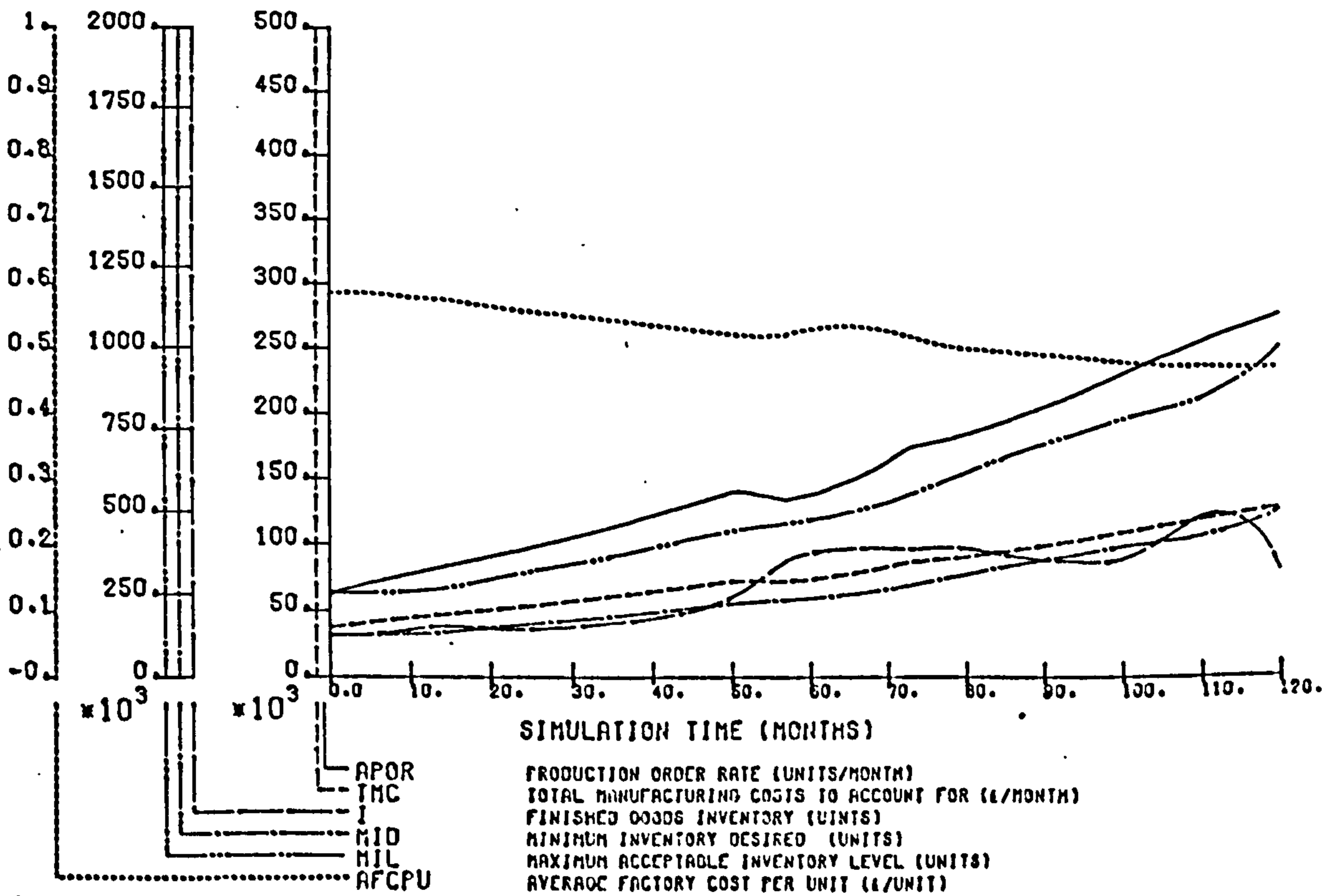


FIG 9.16 AGGRESSIVE R&D POLICY
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

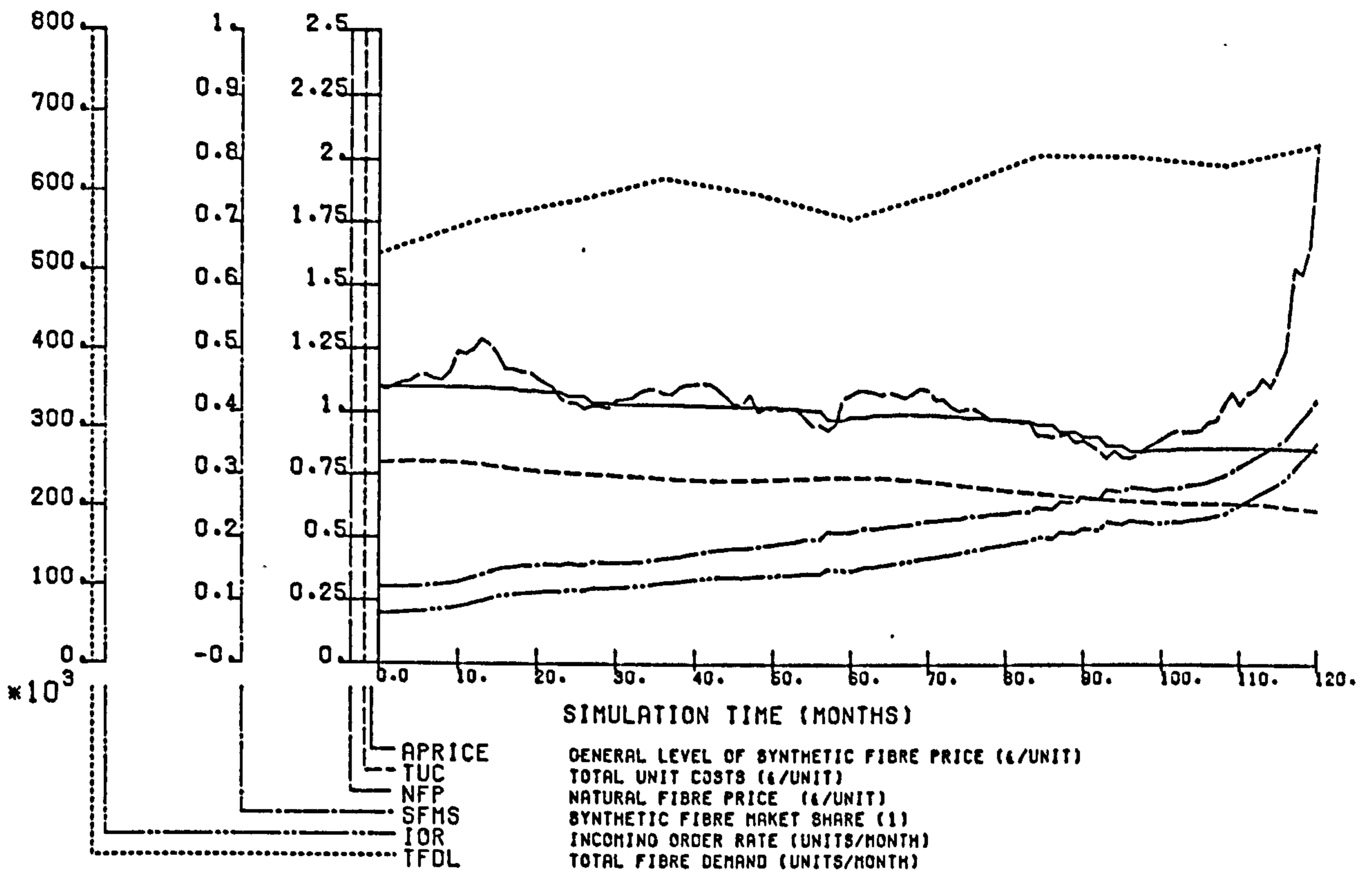


FIG 9-17: CONSERVATIVE R&D POLICY
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

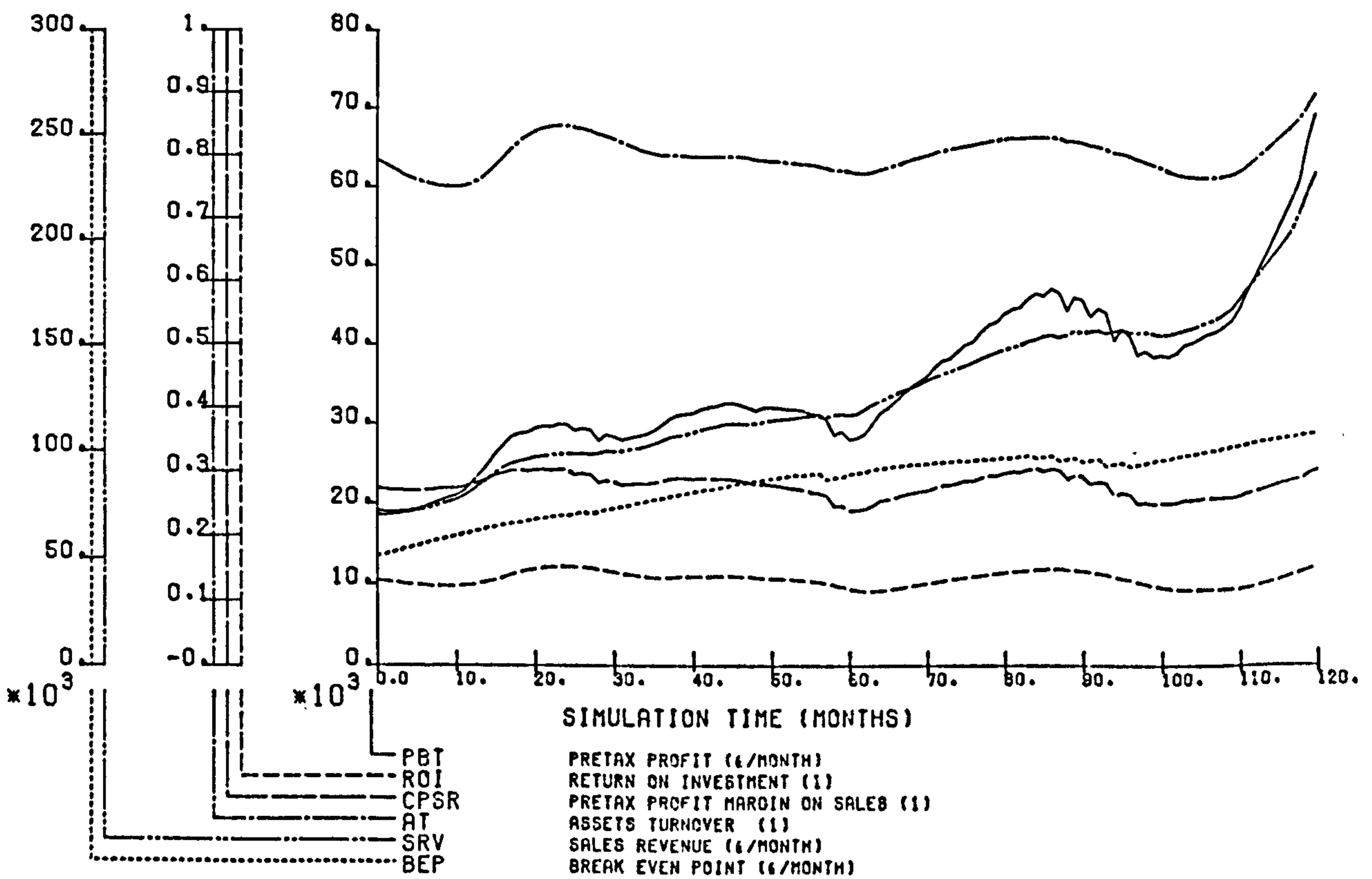


FIG 9-18: CONSERVATIVE R&D POLICY
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

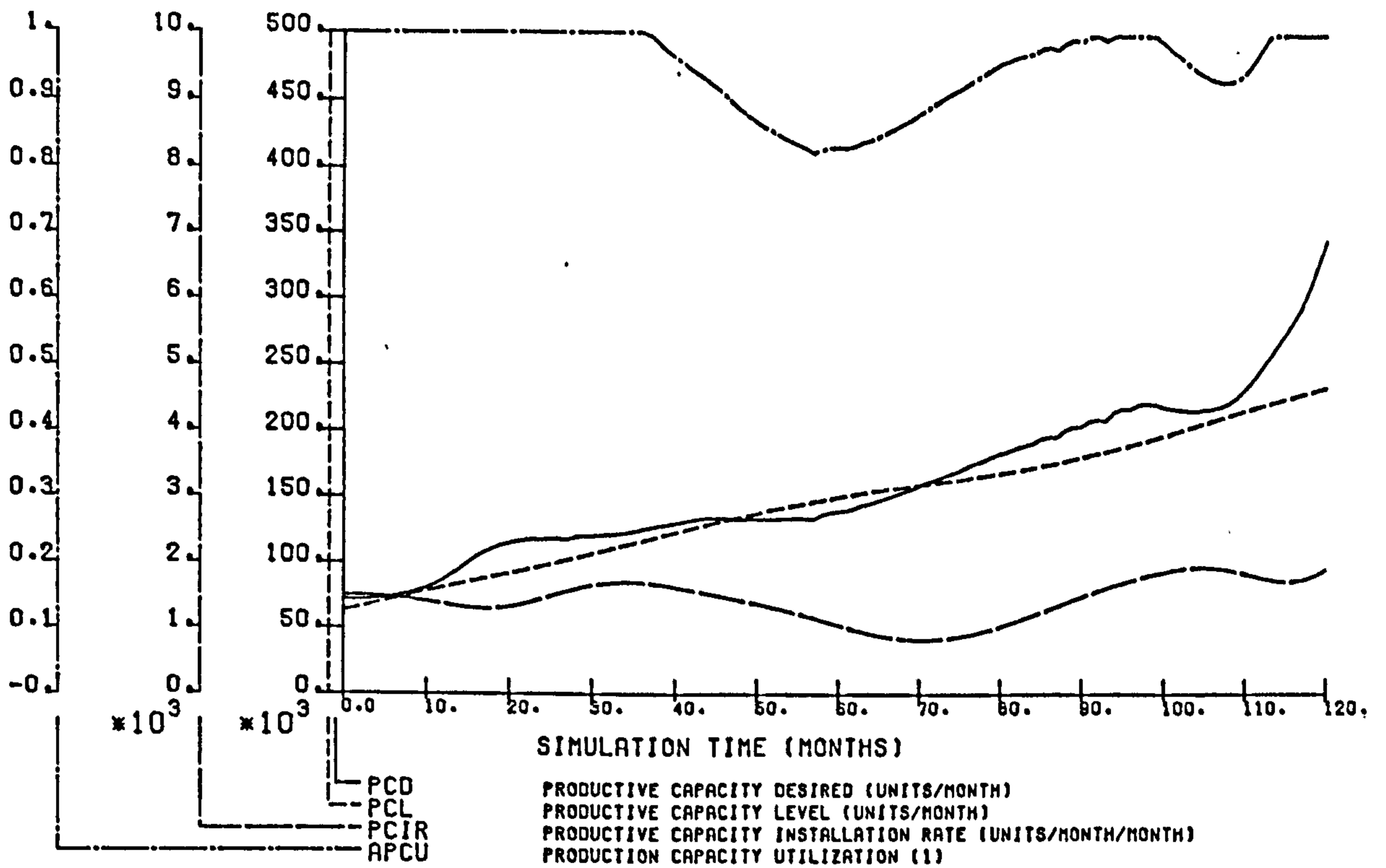


FIG 9.19: CONSERVATIVE R&D POLICY
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

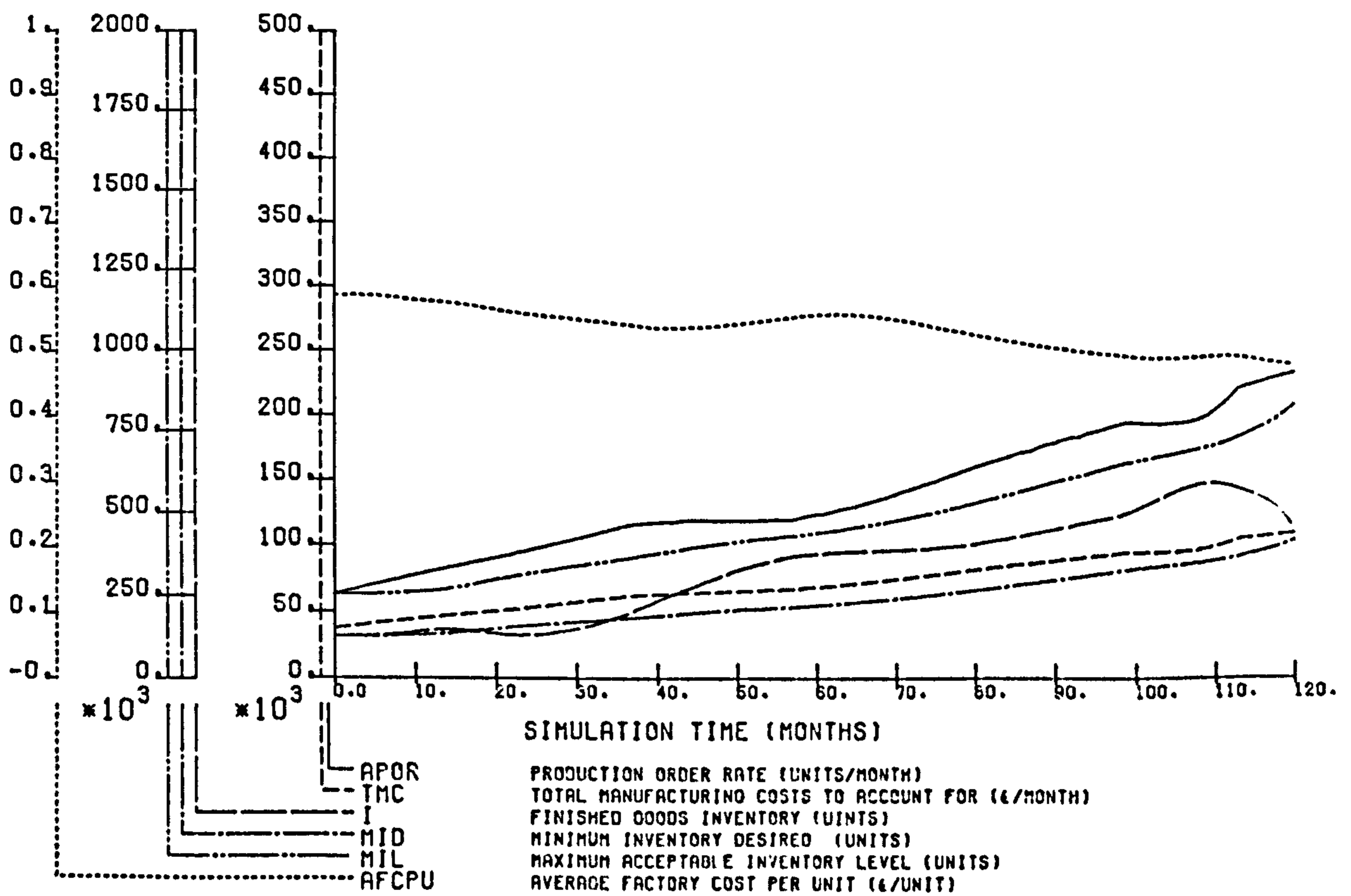


FIG 9.20: CONSERVATIVE R&D POLICY
THE SYNTHETIC FIBRE INDUSTRY PRICING MODEL

9.4. The Price Code and energy crisis effects:

By looking at the situation as it developed in 1973 compared with previous years, it could be noticed that two important changes have occurred. These changes were the introducing of the Price Code and the substantial increase in the prices of the petrochemicals, which form the basis for the manufacture of synthetic fibre, resulting from the energy crises. (The effects of the Price Code on British Industry have received considerable attention: see for example Evely(1976), Cox(1976 and Glynn(1976)).

Because of these changes, it becomes necessary to investigate the following two points which are the purpose of this section:

- a) the impact of raw material price increases on synthetic fibre prices and, consequently, on their competitive situation in the market and
- b) the effect of the Price Code on the firm's profitability

In doing so, the model is adjusted as follows:-

- (i) the simulated period is increased to 13 years (Jan. 1963 to Dec. 1975) to cover a reasonable period during which these changes have come into effect
- (ii) inflation factor in raw material cost during the last three simulated years has been taken into consideration (see Appendix A)
- (iii) inflation factor in labour and capital costs over the simulated period is introduced (see Appendix A)

After such adjustments have been done, the model is simulated under two cases:

- 1) Inflation case in the absence of the Price Code (the firm could increase its prices without the Price Code constraints).
- 2) Inflation case and the Price Code, where the ability of the firm to increase its prices is limited by what is permitted by the Code.

The simulation results are shown in Figs. 9.21,9.22,9.23, 9.21A, 9.22A and 9.23A. The following observations can be made:-

- a) The synthetic fibre price has reversed its downward trend from month 130 onwards for the first time. This upward trend in price is due to the upward trend in the total unit costs over the same period.
- b) The price increase in the second case is lesser than that in the first one due to the effect of the Price Code.
- c) This increase in the price in both cases have not resulted in competitive losses for natural fibres. On the contrary, synthetic fibre market share has continued to increase. It has increased more than 20% from the beginning of 1973 up to the end of 1975. The reason being the big increase in the level of prices of natural fibres in the same period. Although this level has become below its highest value at the beginning of 1973, it is still higher compared with the level of these prices in past years. Owing to the increase in natural fibre price, synthetic fibre has maintained its price advantage in competition with natural fibres.

- d) Pre-tax profit is higher in the first case than that in the second one during the same period (from 1973 to 1975). This is due to the effect of the Price Code.

These results might be summarised as follows:-

- (i) The substantial increase in oil prices forced synthetic fibre prices upward but did not affect their competitive situation in the market.

This result corresponds to what took place in the real system (The Financial Times, 1977).

- (ii) The price level and, consequently, the pre-tax profit under the Price Code were lower than they would have been without the Code. This result suggests that the Price Code has a strong effect on the firm's profitability. It prevents the firm from the normal build up of profitability during the upward phases of the business cycle. There are evidences which support this result in real life (Glynn, 1976).

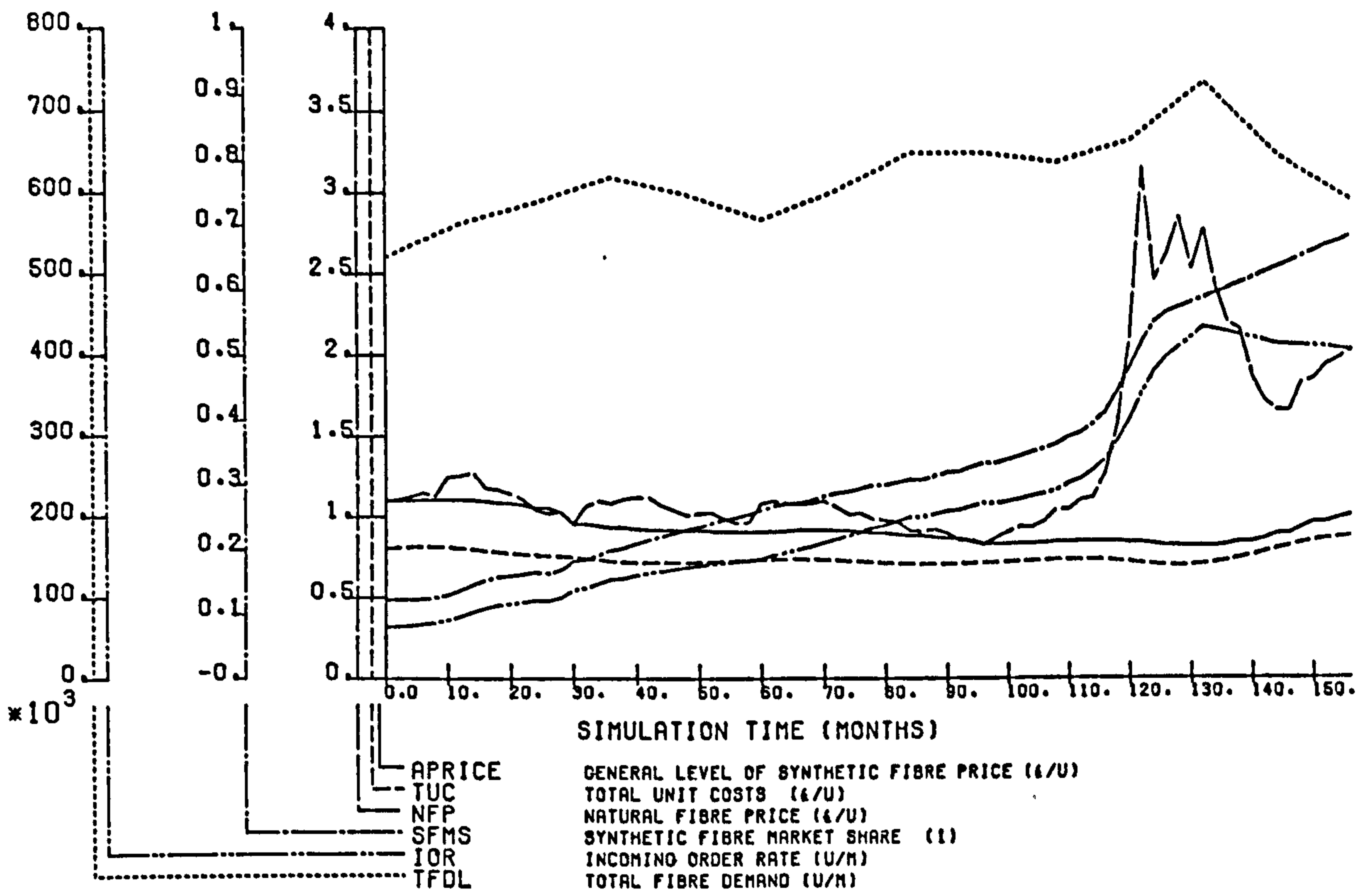


FIG 9.21: BASIC IN INFLATION CASE
THE PRICING MODEL OF SYNTHETIC INDUSTRY

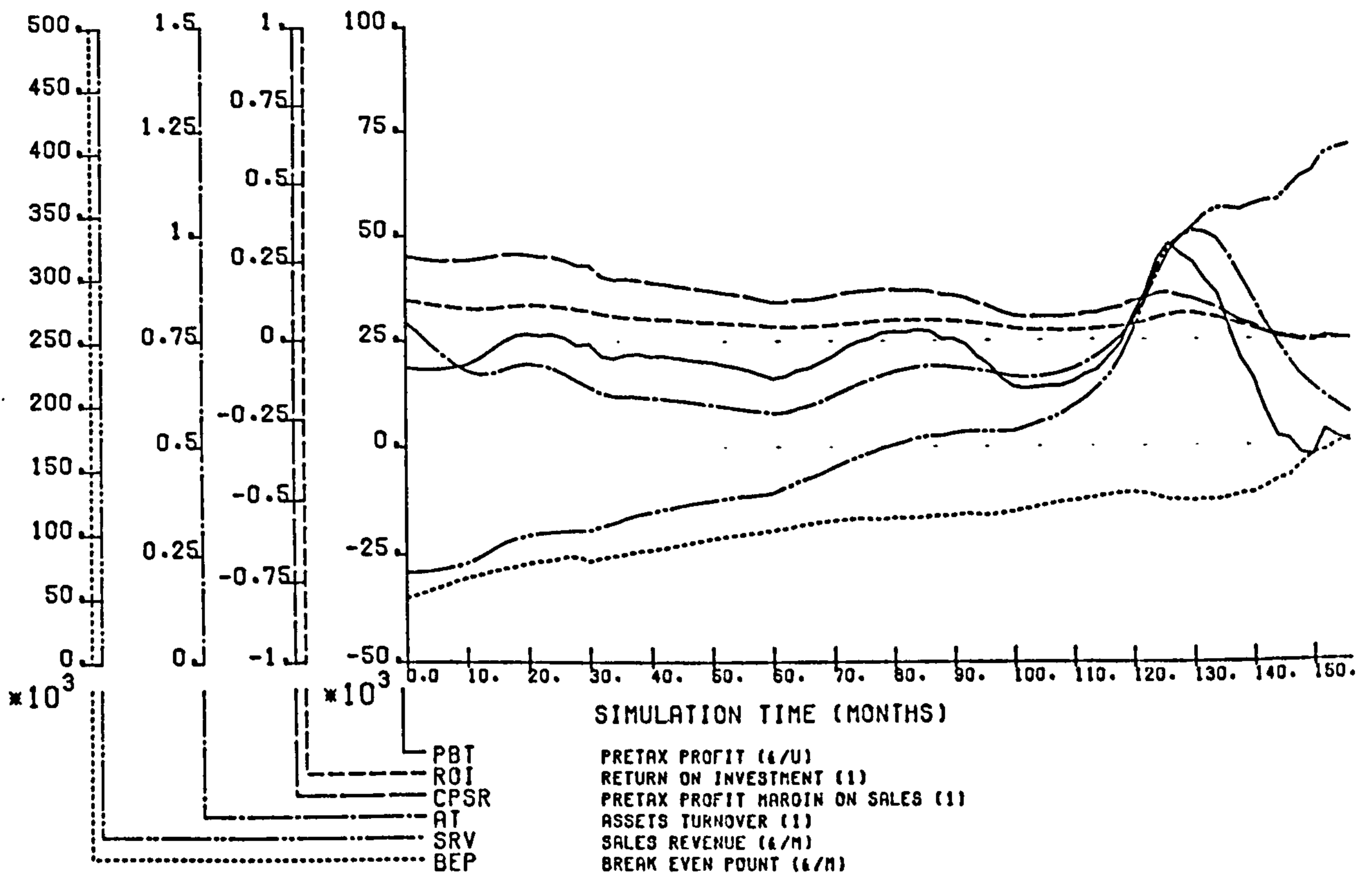


FIG 9.22: BASIC IN INFLATION CASE
THE PRICING MODEL OF SYNTHETIC INDUSTRY

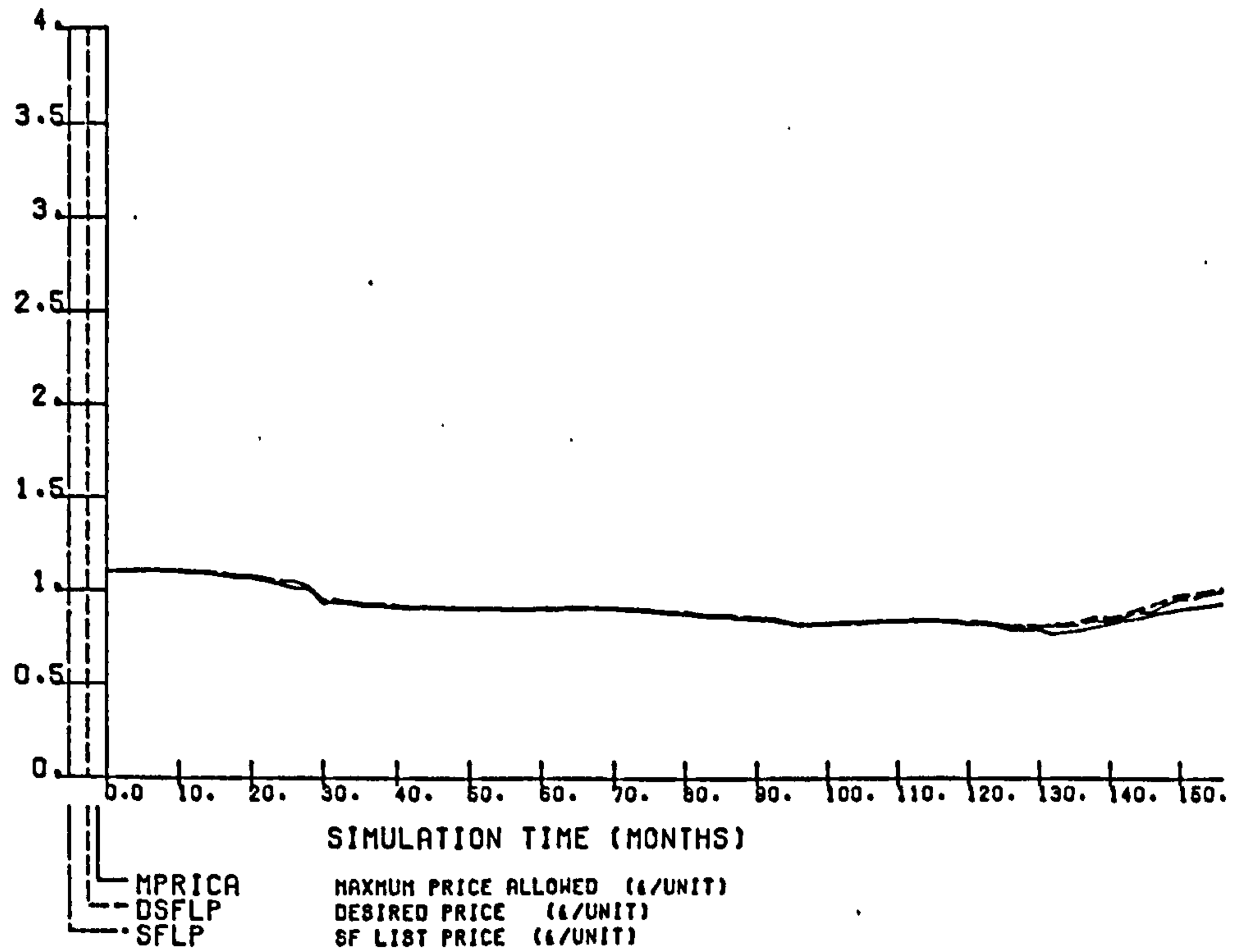


FIG 9.23: BASIC IN INFLATION CASE THE PRICING MODEL OF SYNTHETIC INDUSTRY

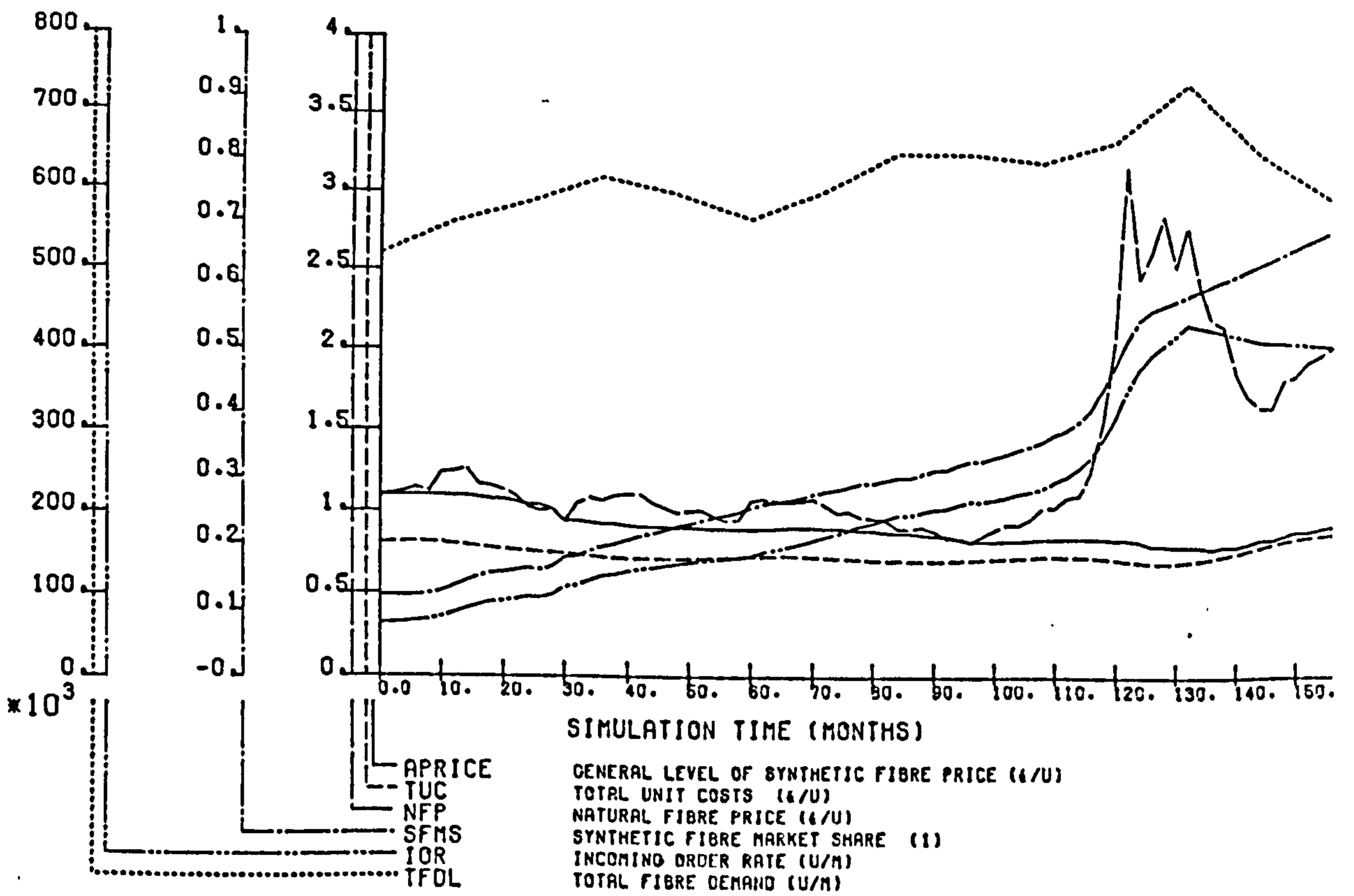


FIG 9.24: BASIC IN INFLATION CASE & PRICE CODE THE PRICING MODEL OF SYNTHETIC INDUSTRY

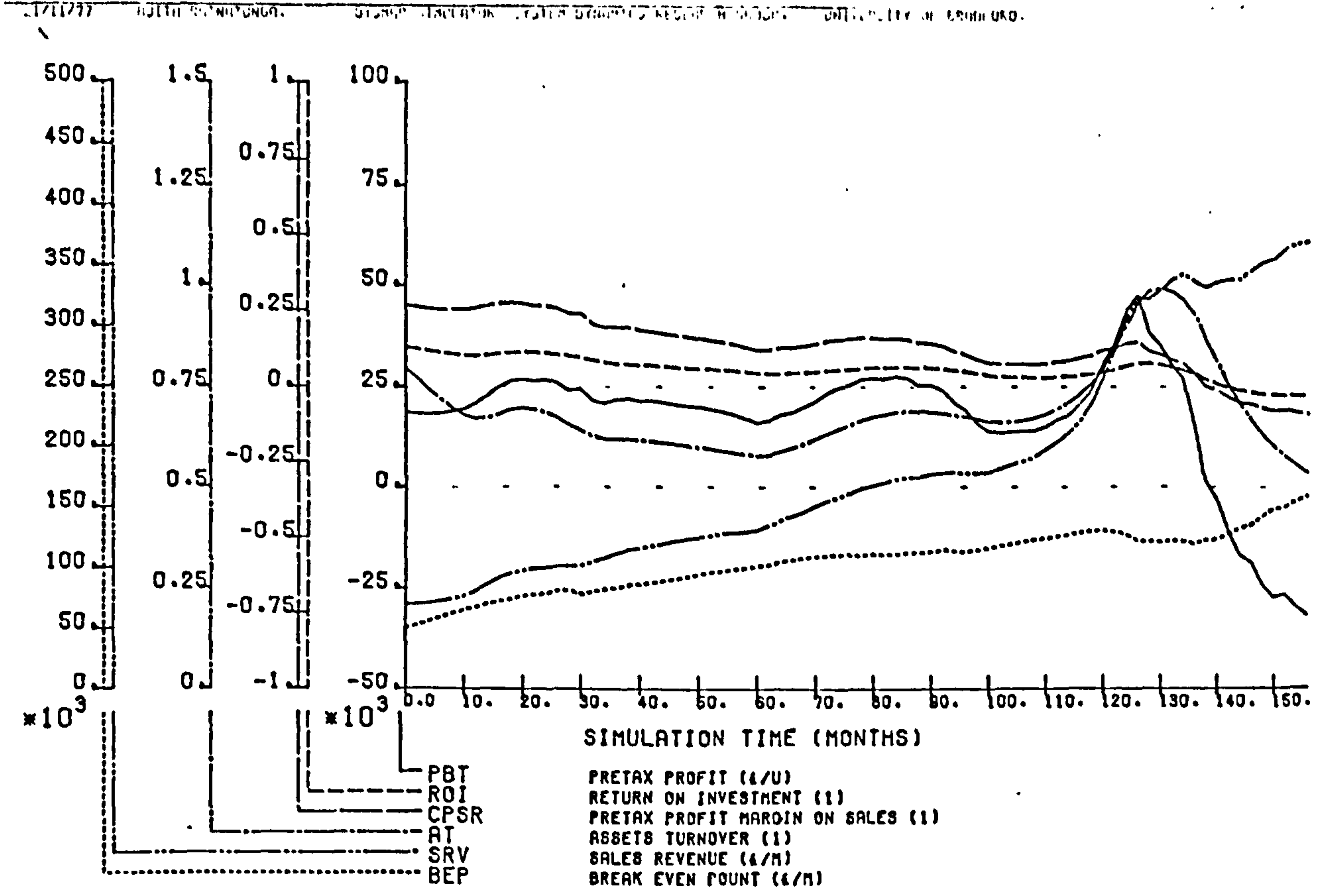


FIG 922A BASIC IN INFLATION CASE & PRICE CODE THE PRICING MODEL OF SYNTHETIC INDUSTRY

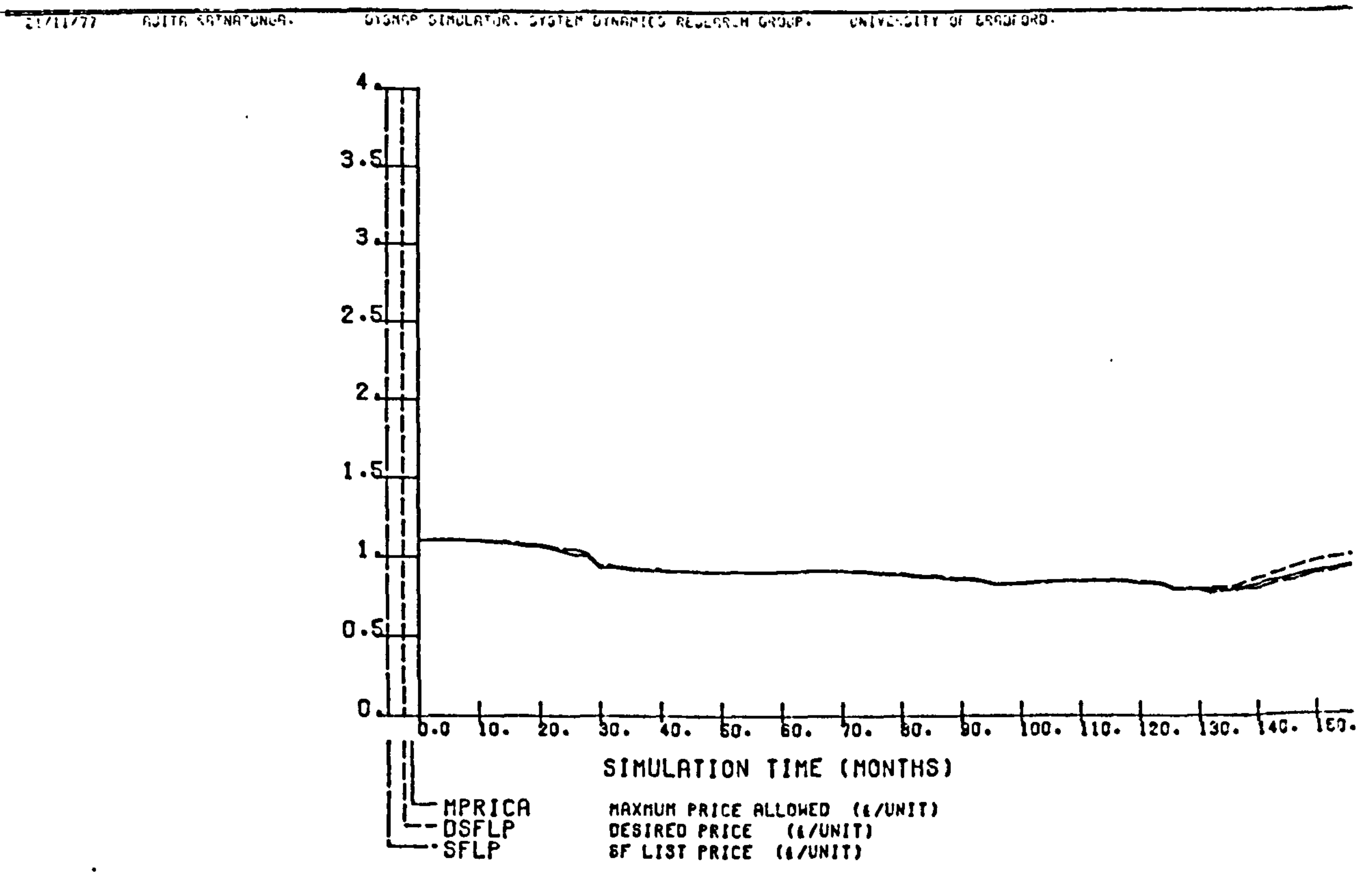


FIG 923A BASIC IN INFLATION CASE & PRICE CODE THE PRICING MODEL OF SYNTHETIC INDUSTRY

Conclusion:

From the results, so far analysed, we may conclude that:-

- 1) The adoption of direct costing policy has led to the same results as the full costing in the long run. In the short run, however, the direct costing approach has distinct advantages over the full costing approach from pricing decision making standpoint. Therefore, the direct costing approach is recommended.
- 2) The adoption of the aggressive discount policy coupled with the conservative inventory policy have increased the ability of the firm to achieve higher growth and profitability targets. Therefore, they are recommended for the firm.
- 3) The Model is highly sensitive to changes in the fraction of sales revenue allocated to R & D. It has been observed that the increase in this fraction has resulted in a considerable improvement in the behaviour of the system. Thus, this course of action is recommended for adoption.
- 4) It is apparent, both in the Model and in the real life, that the rising in oil prices from 1973 onwards has forced synthetic fibre prices upward. However, this rising has not affected the competitive situation of these fibres in the market.
- 5) The simulation has shown that the Price Code has a significant effect on the firm's profitability. This effect has also been observed in the real life. Therefore, we believe that this control over prices should be dropped.

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P A R T T H R E E

SOME ASPECTS OF MODEL APPLICATIONS

CHAPTER X

INPUT AND OUTPUT DATA

CHAPTER XINPUT AND OUTPUT DATA

In this chapter the purposes for which the input data required, type and sources of these data are discussed. This is followed by the examination of the nature and benefits of the output data. This chapter is ended with a brief discussion of the main features and potential uses of the model.

The chapter is outlined as follows:-

- 10.1 Input data required for the model
- 10.2 Outputs of the model
- 10.3 Features of the model
- 10.4 Potential uses of the model

10.1 Input data required for the Model

10.1.1. The need for data

The model considered in this study requires a set of specific data for the following purposes:

- a) Constructing the influence diagram and justifying the causal relationships between the variables which form this diagram. The system dynamicist requires descriptive information on the important factors concerning the problem and how the pricing system works.
- b) Estimating the parameters and determining the initial values of some variables. The system dynamicist needs a set of data from which parameters and initial values can be evaluated.
- c) Testing the validity of the model. Data about the actual system performance over the simulated period are needed to be compared with the simulated results in order to determine whether the results are consistent with the actual system performance, so that a decision can be made to accept and implement or reject the model.
- d) Ongoing tracking during the implementation phase. Once the model becomes in use, the system dynamicist requires up to date information concerning the likely problems that may arise in order to find solutions for them.

10.1.2 Type of input data required

The input data required to achieve the above purposes could be broadly classified into two categories:

- a) Historical data, describing the current state of the system. Plant profile, balance sheet, operating cost structure, sales volume and market shares fall in this category. Such data are usually straightforward to obtain.
- b) Forecast data, describing the expected trends of certain inputs in the future. These data, in turn, can be divided into two sub categories according to the degree of accuracy. Firstly, some of those inputs can be forecast with high accuracy from the statistical analysis of available data. Cost behaviour and productivity fall in this sub category. Secondly, a precise estimation of some of those inputs in particular, the response data, is impossible. It is well recognized that no firm has enough data to forecast the response of customers as well as competitors to changes in marketing control variables such as price, quality and advertising. Furthermore, it is recognized that these data cannot be objectively measured.

At the same time, it is well recognized that managers making decisions concerning these variables are implicitly making judgement about customers response. The system dynamicist, therefore, has to accept the judgements which should be obtained from more than one person. From these personal estimations, a composite forecast is developed by using the Delphi technique or an average of these

estimations is used (see, for more details, Oxfenfeldt, 1975; Little, 1975; Catling, 1972). The system dynamicist should test the sensitivity of the system to errors in the adopted values of these variables and make the system relatively insensitive to these errors.

Two important points concerning historical and forecast data discussed above should be mentioned.

- (i) These data should be provided in a desired form for this model. The model requires average data over the recent years. The system dynamicist needs the required data to be presented in a format compatible with the model (i.e. cost classification). The accounting systems in leading firms such as I.C.I. is capable of producing the required data in the desired form (Owen, 1969).
- (ii) These data should be provided at the right time. In other words, the time factor should be initially weighted over the accuracy. Tests of sensitivity should, however, be carried out to determine the sensitivity of the system to the errors in estimating the values of the parameters so that a list of parameters requiring improvement and which should deserve more attention can be provided.

10.1.3. Data sources

The input data for this model can be obtained from the firm and outsiders.

A - Firm Sources:

By enquiring and research within departments of the firm the following data can be obtained:

- (i) marketing data concerning marketing mix variables and policy such as market share, sale volume, profit margin associated with this sale volume, price, discount, quality and market effort.
- (ii) production and inventory data concerning production, inventory variables and policies such as production requirements, production processes turnover and raw material reordering point.
- (iii) financial and costing data concerning financial and costing variables and policies such as product cost, product price, profit margin, return on capital employed, average delay in paying and collecting bills and accounting methods.
- (iv) data concerning the firm's corporate strategy such as the firm's objectives and policies concerning profitability and growth.

B - External Sources:

The model requires forecast data to describe the future expected changes in the environment (e.g. the growth in total fibre demand, natural fibre price movements) and in the response of the market to changing in marketing mix variables (e.g. price, quality). These forecasts require information more than what the firm has. Therefore, to generate these forecasts the necessary information can be obtained from external sources such as trade journals, members of trade associations, Government and trade sources and distributors.

10.2 Outputs of the Model

The model produces tables and graphs of any number of its variables at successive points in time. These outputs are required for the following purposes:-

- (i) to understand the behaviour of the model so that the causes of unsatisfactory behaviour can be determined and the corrected action(s) suggested.
- (ii) to increase the capability of the accounting and management information systems, from which the model is a part, to provide top management and executives with the information required in the suitable form at the right time.

10.2.1. Graphical outputs

The model has the capability of plotting the dynamics through time of its variables. The model's variables which have been thought to be most important for the purpose of this model are plotted and classified into a set of graphs. These graphs are shown in chapters 8 and 9. Obviously, the graphical form is the most convenient way to present the results for the users who have not enough time to examine the tabular output such as top management and executive managers.

10.2.2. Tabular outputs

The model also has the capability of printing the numerical values of its variables in the form of a set of tables at successive points of time. An example of these tables is shown in Fig. 10.1. This allows the likely user to examine the effects of his decisions on the performance of the system and makes the required changes. They also contain a wide range of physical and financial data which can be used to construct the following operating and financial statements:

1. production, inventory and shipment reports
2. production fixed capacity plan...
3. products cost report
4. marketing performance report (the composition and effects of a marketing mix).
5. profit and loss account
6. profitability ratios statement
7. balance sheet statement
8. expected income statement

10.3. Features of the model:

Little (1970) has pointed out that a model designed to be used by a manager should be understandable, evolutionary (it starts simple and expands later) and easy to use. In this respect, also, there are some writers who have suggested a set of criteria (summarized in Shehata, 1976) for evaluating good models which include modularity, flexibility and reliability.

In this section we will discuss the fundamental features of the proposed model along which the acceptability of it may be evaluated in the light of previous criteria.

1. Simplicity and Flexibility: The model is kept relatively simple although it encompasses the financial, marketing and production activities of the firm. That is because the model deals basically with highly aggregated data.

However, flexibility features make it easy to alter the model's structure to deal with less aggregate data or to represent fundamental changes that occur in the real system. Likewise, the output information unit can easily be detailed or consolidated according to the user's needs. Thus, the model overcomes one of the most common shortcomings, namely unflexibility of corporate models in use (Naylor, 1976).

2. Maintainability: The model is constructed on a modular basis so that its individual sectors can be added or deleted without problems. It is, therefore, a highly reliable model.
3. Understandability: The model, as has been mentioned, requires relatively low mathematical sophistication, so that the average manager can understand it easily. Furthermore, its logic is familiar for managers. We should, therefore, expect that this model will be understood by top management and executive managers and, as a consequence, they will give it their full support.
4. Deterministic: The model is deterministic, assuming that the input variables and the relationships built into the model can be estimated with certainty. This type of model is especially useful in comparing one strategy against another such as pricing policies (Heestand, 1972).
5. Descriptive: It is a descriptive model showing the relationships within the real system and, hence, illustrates the type of behaviour under different assumed conditions. The model can not be used to predict the future values of a set of certain variables.
6. Interactive: It is an interactive model in that the user can directly run it on a terminal and get the output printed at the same terminal very quickly, or receive immediate response (if time-sharing system is used). Thus, he explores rapidly the effects of the possible alternatives and, at the same time, can keep his information confidential.

7. Compatibility: The model serves many purposes. It can be used as a planning tool, calculating and training device. This point will be examined fully in the following section.

We can conclude, from the previous discussion, that the model satisfies most of the criteria of a good one.

10.4. Potential Uses of the Model:

- a) The model mainly can be used as a planning tool in that it enables corporate management to explore all feasible and attractive pricing strategic alternatives under different conditions. It makes possible the examination of all consequences of those alternatives and determination of their long-run net effects on the firm's profitability and growth objectives. Thus, the alternative which best satisfies these objectives would be selected.

The model, in this respect, gives the firm two special capabilities; one of which is the ability to analyse systematically pricing policies on a strategic level. It also enables the executive managers to take top level overall views, thereby enabling them to work in harmony together. Their actions concerning price and related policies would be guided and constrained by the selected pricing strategy.

It should be remembered, however, that the model takes no account of the competition between synthetic fibres themselves for the market (see Chapter 3). Thus, although it is very useful for pricing policies analysis on the firm basis showing what managerial policies need to be

followed to achieve the firm's ultimate objectives, the model in its current form cannot be used for pricing analysis on an individual product basis.

However, the model can be modified by taking into account the competition factor. We expect this process to be fairly easy since each fibre faces pricing problems that are approximately unique.

- b) The model can be used to monitor the actual performance against the planned one. The annual plan would be constructed which is, in some respects, the first year in the long-run plan where the model is concerned. Any discrepancy between planned and actual performance would be analysed and the reasons identified. This analysis may lead to improve and modify the model, both of which effects tend to produce better decision making.
- c) The model can be used as a calculating device. Thus, it increases the capability of the accounting system in preparing the projected operating and financial statements and reports at the right time.
- d) It can be used as a training device for managers to develop a better understandability for the mechanisms of the pricing system.

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CHAPTER XI

CONCLUSIONS AND SUGGESTIONS FOR FURTHER STUDIES

CHAPTER XICONCLUSIONS AND SUGGESTIONS FOR FURTHER STUDIES

In this chapter the most important conclusions reached in this study are summarised and suggestions for further studies are pointed out.

The chapter is outlined as follows:-

11.1. Conclusions

11.2. Suggestions for further studies

11.1. Conclusions

The most important conclusions reached in this study may be summarised as follows:-

1. The pricing systems in an oligopoly market are extremely complex, dynamic, non-linear and interdependent. Many components are not easily measured and controlled. There is a high degree of uncertainty. They interact with the external forces including the environment and competitors. System Dynamics is the appropriate approach to tackle such problems.
2. Therefore, a system dynamic model of the long-run pricing strategy for a leading manufacturing firm in the synthetic fibre industry, which is chosen as an illustrative case, has been developed to provide answers to these questions:
 - (i) Do the pricing policies affect the overall performance of a firm?
 - (ii) Do the managerial pricing control policies have significant effects on the dynamic behaviour of the system?

The developed model has exhibited many of the behavioural characteristics that the synthetic fibre industry exhibits. One is the downward trend of the prices. The other is the continuous increase in the market share. Moreover, the model displays the real system situations of under capacity utilization, excess inventory and low level of profitability.

This performance has remarkably improved by changing inventory control, capacity acquisition and pricing policies through analysing feedback loops which form the system.

3. The tests carried out show that the improved system is:
 - a) insensitive to seasonal and random disturbances in its prime input (total fibre demand level).
 - (b) relatively sensitive to changes in the values of certain parameters. However, the performance in all cases is still highly satisfactory. Moreover, the system is extremely robust with respect to these parameter errors in the sense that it always has much the same behaviour mode regardless of errors.

4. The behaviour of the improved system under pricing control policies: direct costing, discount and R & D policies, are examined to determine which policies are better from the firm's profitability and growth point of view. It is concluded that:-
 - a) the adoption of direct costing policy has led to the same results as the full costing in the long-run. In the short-run however, the direct costing approach has distinct advantages over the full costing approach from pricing decision making standpoint. Therefore, the direct costing approach is recommended to be adopted.

- b) The adoption of the aggressive discount policy coupled with the conservative inventory policy have increased the ability of the firm to achieve higher growth and profitability targets. Therefore, they are recommended for the firm.
 - c) The system is highly sensitive to changes in the fraction of sales revenue allocated to R & D. It has been observed that the increase in this fraction has resulted in a considerable improvement in the behaviour of the system. Thus, this course of action is recommended for adoption.
5. The effects on the behaviour of the system of the two important changes, namely; the introducing of the Price Code and the substantial increase in oil prices, which have occurred in 1973, have been examined. It is concluded that:-
- a) It is apparent both in the model and the real system, that the rising oil prices from 1973 onwards has forced synthetic fibre prices upward. However, this rising has not affected the competitive situation of those fibres in the market.
 - b) The simulation has shown that the price code has a significant effect on the firm's profitability. This effect has also been observed in real life. Therefore, we do believe that this control over prices should be dropped.

6. The potential uses of the model:-

- a) the principal use of the model is as a planning tool. In its current form the model can be used to assist corporate management to explore all feasible and attractive pricing strategic alternatives under different conditions. It makes possible the examination of all consequences of these alternatives and the determination of their long-run effects on the firm's profitability and growth objectives. Thus, the alternative which best satisfies these objectives would be selected. The selected strategy will guide and constrain the actions of those responsible for the company's pricing policies.

Moreover, the model, after some modifications to take into account the competition between synthetic fibre types themselves, can be used for pricing policies analysis on a basis of an individual product.

- b) the model can be used to monitor the actual performance against planned performance. The annual plan would be constructed which is, in some respects, the first year in the long-run where the model is concerned. Any discrepancy between planned and actual performance would be analysed and the reasons identified. This analysis may call to improve and modify the model, both of which effects tend to produce better decision making.

11.2. Suggestions for Further Studies

Starting from the developed model the following studies would seem to be worth while.

1. Further work in the developed model:

Studies could be directed to the following points:-

- a) Expanding this model to cover other pricing control policies such as credit and cost reduction policies.

It is desirable also in this inflationary economy to investigate the effects of accounting methods to calculate product costs on pricing and profitability of the firm, i.e. studying the behaviour of the system if the firm bases its product costs on "Current Cost" rather than "Historical Cost".

- b) Testing the effect of changes in the prime input. In Chapter 9 it has been shown how a combination of discount, inventory, costing and R & D policies affect the behaviour of the system in the case of observed business cycle. The magnitude and length of this cycle might differ in the future. Also the growth rate in fibre demand might be lesser or higher than the observed one. Therefore, further simulation runs of the model must be made to test the effect of these policies on the behaviour of the system under different possible shapes of business cycle and with different rates of growth in fibre demand.

- c) Testing the sensitivity of the system to errors in certain untested parameters such as price decision period, time for management to perceive off-list selling to basic demand ratio, and time to average total unit costs.

2. Implementation of the Developed Model

It is well known that leader firms are willing to apply any project that has potential payoff. Therefore, it is desirable to study the practical aspects of implementation of the developed model only or with the other three slightly modified versions for the three main synthetic fibres, namely polyester, nylon and acrylic.

The work could be directed, after approaching a price leader firm and arousing the interest of top management and executive managers in the project, to bring the developed model into agreement with the real system.

3. Pricing Policies of an Aggressive Follower Firm

Presumably, all firms in the industry wait for the price leader to initiate a list price change and they usually follow it shortly after.

However, there is a possibility that one of those follower firms may decide to take over that price leadership position. It is, therefore, desirable to develop an effective pricing strategy which enables this price follower to become the price leader.

APPENDIX A

SOME NOTES ON MODEL DATA

APPENDIX ASOME NOTES ON MODEL DATA

THE INPUT:

The actual U.K. fibre consumption index was calculated from Table A-1. This table has been constructed from data reported in Monthly Digest of Statistics (HMSO), Quarterly Statistical Review (Textile Statistics Bureau) and Textile Organon with some approximation. In the absence of consumption figures for any fibre type, the consumption is found by adding to production the import and subtracting export figures.

TABLE A-1 : FIBRE CONSUMPTION

Year	Man-Made Fibre				Cotton		Wool		Total Consumption Million Pounds	U.K. Consumption Index
	Synthetic Million Pounds	%	Cellulosic Million Pounds	%	Million Pounds	%	Million Pounds	%		
1962	171	12	363	25.5	421	29.5	471	33	1426	100
1963	213	13.8	424	27.5	421	27.3	484	31.4	1542	108
1964	254	15.8	456	28.3	448	27.9	451	28.0	1606	113
1965	307	18.1	460	27.1	498	29.3	435	25.6	1700	119
1966	346	21.1	416	25.3	461	28.1	419	25.5	1642	115
1967	465	29.8	321	20.6	390	25	385	24.6	1561	109
1968	520	31.4	346	20.9	385	23.2	405	25.5	1656	116
1969	553	31.1	435	24.4	379	21.3	414	23.2	1781	125
1970	610	34.3	438	24.6	370	20.8	362	20.3	1780	125
1971	662	37.6	446	25.4	314	17.8	338	19.2	1760	123
1972	703	38.5	467	25.5	289	15.8	370	20.2	1829	128

The second driving force for the model is natural fibre prices. The price indices of wool and cotton up to 1968 were taken from Monthly Digest of Statistics (HMSO). From 1968 onwards, due to unavailability of monthly indices, the prices of Merino 64's and U.S. Orleans/Texas M₁ reported in United Nation/ Monthly Bulletin of Statistics were used to calculate wool and cotton price indices respectively.

THE MARKETING SECTOR:

Initial values of prices and the starting values of quality and market effort have been chosen to produce synthetic fibre market share equal to the actual one which is equal to around 12%.

Synthetic fibre quality table was found by repeated simulation, since no historical data about the relation between the level of R & D expenditure and quality were available.

Fraction of sales revenue allocated to R & D was chosen equal to 3.5%. This was guided by the estimation of this fraction, from data in annual reports of European Chemical Companies, which was 3-5% (Jarvis, P.E.J., et al., A Company Model for Research and Development, R & D Management, 1976).

MANUFACTURING SECTOR:

The cost estimation in Table A-2 provided a guide to choose starting values of cost components which are:

Raw Material	.215 (£/U)
Variable Overheads	.010 (£/U)
Direct Labour Costs	.084 (£/U)
Indirect Labour Costs	.042 (£/U)
Depreciation	.100 (£/U)
Factory Standby Costs	.135 (£/U)
Administrative and Selling Standby Costs	.100 (£/U)
Variable selling Expenses	.050 (£/U)

VARIABLE	POLYESTER £/kg	NYLON 6 £/kg
Raw Material	.223	.290
Conversion	.127	.127
Depreciation	.08	.08
Overhead	.135	.135
Sale expenses	.10	.10
Packing	.05	.05

TABLE A-2: THE ESTIMATED COST OF STAPLE FIBRES

Source: Hirsh, B.W. and Ellis, P.,
 "An Introduction to Textile Economics"
 The Trade Press, Manchester, England, 1972.

The decrease in direct and indirect labour costs over simulation period is generated by using learning curve concept.

The long-run average cost curve of an L-shaped discussed in economic textbooks was used as a guide to estimate the level of factory and administrative and selling standby costs in relation to the size of productive capacity. The decreasing rate of these standby costs as productive capacity increases and the minimum scale point on the curve are selected on a purely arbitrary basis.

FINANCIAL SECTOR:

Average investment required per unit of input (AIRPU) was estimated to be decreased over time. It is assumed that AIRPU will be 50% from its initial value, at the end of the simulated period.

This was guided by the available data about the continuous decrease in the incremental capital-output ratio in the chemical industry due to increasing plant scale and technological improvement. This ratio (at 1970 price) fell from 2:1 in the early 1950's to 1.4:1 in the late 1960's and estimated to be about 1.1 : 1.0 in 1973 (NEDO, Industrial Review to 1977; Chemicals, 1973).

TO ADJUST THE MODEL TO ACCOUNT FOR INFLATION FACTOR:

- a) The U.K. actual fibre consumption index was extended up to the end of 1975 based on the fibre consumption data reported in Textile Trends 1966-75, NEDO, 1976.

- b) Inflation factor in raw materials was guided by data presented in Table A-3. The index used in the model is:

Year	1972	1973	1974	1975
Raw Material Price Index	100	130	178	200

	U.S. Cent per kg	
	End of 1972	End of 1974
Polymer	45.2	76.2
Nylon Salt	70.5	112.6
Acrylonitrile	28.5	51.1

TABLE A-3: COSTS OF SELECTED CHEMICAL DERIVATIVES AT THE END OF 1972 AND ESTIMATED FOR THE END OF 1974

Source: O.E.C.D.,

"Impact of changes in the Availability and Prices of Energy and Textile Raw Materials on the Future Activities of the Textile and Clothing Industry", 1976

- c) Inflation factor in labour cost is calculated, based on data in Table A-4 with assumptions that inflation factor before 1966 was zero.

Year	Earnings in Man-Made Fibre	Index
1966	20.22	100
1967	22.03	110
1968	23.47	117
1969	27.00	139
1970	30.32	152
1971	33.54	168
1972	37.83	189
1973	42.90	214
1974	50.31	251
1975	64.20	267

TABLE A-4: AVERAGE WEEKLY EARNINGS OF FULL-TIME MANUAL MEN
(21 YEARS AND OVER)

Source: NEDO

Textile trends 1966-75.

"An Economic Profile of U.K. Textile and Clothing
Industry", 1976

- d) To account for inflation factor in capital costs, price index for capital expenditure on plant and machinery was used. (Central Statistical Office, Price Index Number of Current Cost Accounting, HMSO, No. 2, August, 1976).

TO VALIDATE THE MODEL:

Synthetic fibre market share in Table A-1 and prices of representative synthetic fibres in Table A-5 are used.

Year	Polyester (Staple 3 Denier) £ per pound	Nylon (Staple 3 Denier) £ per pound
1961	1.2	1.18
1962	1.1	1.08
1963	1.0	1.08
1964	0.92	1.05
1965	0.84	0.93
1966	0.75	0.93

TABLE A-5: SYNTHETIC FIBRE PRICES IN U.K.

Source: Industrial Fibre, Commonwealth Secretariat, 1970.

APPENDIX B

LIST OF COMPUTER PROGRAMME OF THE SYSTEM

APPENDIX BLIST OF COMPUTER PROGRAMME OF THE SYSTEMTHE PRICING MODEL OF SYNTHETIC FIBRE INDUSTRY

1 NOTE
2 DOC
3 NOTE THE INPUT
4 NOTE
5 NOTE
6 NOTE
7 NOTE
8 NOTE
9 A $TFDL.K = 510000 * (AUKCI.K / 100)$
10 A $AUKCI.K = TABHL(AFCIT, TIME.K, 0, 120, 12)$
11 T $AFCIT = 100 / 108 / 113 / 119 / 115 / 109 / 116 / 125 / 125 / 123 / 128$
12 NOTE
13 NOTE
14 NOTE MARKETING SECTOR
15 NOTE
16 NOTE
17 NOTE
18 NOTE DEMAND AND MARKET SHARE SUB-SECTOR
19 NOTE
20 NOTE
21 NOTE
22 A $FMBOFS.K = FFMBOS.K * TFDL.K$
23 A $FFMBOS.K = SFQ.K / NFQR$
24 C $NFQR = 1$
25 A $SFQ.K = TABHL(SFQT, CERE.K, 0, 125E3, 75E3)$
26 T $SFQT = .27 / .31 / .47 / .55 / 62 / .68 / .74 / .80 / .86 / .92 / 97 / 1$
27 A $SFMSL.K = PM.K * FFMC.K$
28 A $FFMC.K = PME.K / RMES.K$
29 A $RMES.K = TABHL(RMEST, FFMBOS.K, 0, 1, .1)$
30 T $RMEST = 600 / 1200 / 1750.1 / 2283.6 / 2450 / 2600 / 2750 / 2880 / 3000 /$
31 X1 $3100 / 3150$
32 A $PM.K = TABHL(PMT, PR.K, .5, 1, .1)$
33 T $PMT = 0.85 / 0.75 / 0.68 / 0.60 / 0.50$
34 A $PR.K = SFLP.K / NFPPC.K$
35 L $NFPPC.K = NFPPC.J + DT / TCPNFP * (NFP.J - NFPPC.J)$
36 N $NFPPC = INFP$
37 C $TCPNFP = 12$
38 A $SFBD.K = SFMSL.K * FMBOFS.K$
39 A $SFMSN.K = NRPM.K * FFMC.K$
40 A $NRPM.K = TABHL(PMT, NRNPR.K, .50, 1, .10)$
41 A $NRNPR.K = NRP.K / NFPPC.K$
42 A $OLS.K = (SFMSN.K - SFMSL.K) * FMBOFS.K$
43 R $IOR.KL = SFBD.K + OLS.K$
44 A $SFMS.K = (SFBD.K + OLS.K) / TFDL.K$

45 NOTE
46 NOTE PROMOTION AND QUALITY SUB-SECTOR
47 NOTE
48 NOTE
49 NOTE
50 NOTE MARKET EFFORT EQUATIONS
51 NOTE
52 NOTE
53 A $ME.K = \min(FME * ASRV.K, RMES.K)$
54 C $FME = .0275$
55 L $ASRV.K = ASRV.J + DT / TASN * (SRV.JK - ASRV.J)$
56 N $ASRV = ASSR * ISFLP$
57 C $TASN = 3$
58 L $AME.K = AME.J + (DT / DAME) * (ME.J - AME.J)$
59 N $AME = ASRV * FME$
60 L $PME.K = PME.J + DT / TPME * (AME.J - PME.J)$
61 N $PME = AME$
62 C $DAME = 1$
63 C $TPME = 3$
64 NOTE
65 NOTE RESEARCH EQUATIONS
66 NOTE
67 A $FFMUSF.K = 1 - FFMBOS.K$
68 A $RRE.K = \text{TABHL}(RRET, FFMUSF.K, 0, .8, .1)$
69 T $RRET = 0 / 3000 / 5600 / 8000 / 10300 / 12500 / 14500 / 16200 / 17350$
70 A $PRE.K = FSRVR * ASRV.K$
71 C $FSRVR = .035$
72 R $RSR.KL = \min(RRE.K, PRE.K)$
73 L $ARE.K = ARE.J + (DT / TARB) * (RSR.JK - ARE.J)$
74 N $ARE = FSRVR * ASRV$
75 C $TARB = 1$
76 R $RSBE.KL = ((\text{PULSE}((RP.K / DT), DORE, DORE)) * (1 - DM)) + ((\text{DELAY3}(RSBE7.JK,$
77 X1 $DORE / 8)) * DM)$
78 C $DM = 1$
79 L $RP.K = RP.J + DT * (RSR.JK - RSBE.JK)$
80 N $RP = RSR$
81 N $RSR = FSRVR * ASRV$
82 R $RSBE1.KL = \text{DELAY3}(RSR.JK, DORE / 8)$
83 R $RSBE2.KL = \text{DELAY3}(RSBE1.JK, DORE / 8)$
84 R $RSBE3.KL = \text{DELAY3}(RSBE2.JK, DORE / 8)$
85 R $RSBE4.KL = \text{DELAY3}(RSBE3.JK, DORE / 8)$
86 R $RSBE5.KL = \text{DELAY3}(RSBE4.JK, DORE / 8)$
87 R $RSBE6.KL = \text{DELAY3}(RSBE5.JK, DORE / 8)$
88 R $RSBE7.KL = \text{DELAY3}(RSBE6.JK, DORE / 8)$
89 N $RSBE1 = RSR * .99$
90 N $RSBE2 = RSR * .95$
91 N $RSBE3 = RSR * .75$
92 N $RSBE4 = RSR * .45$
93 N $RSBE5 = RSR * .10$
94 N $RSBE6 = RSR * .01$
95 N $RSBE7 = 0$
96 L $CERE.K = CERE.J + DT * RSBE.JK$
97 N $CERE = 0$
98 C $DORE = 48$

99 NOTE
100 NOTE PRICING AND DISCOUNT SUB-SECTOR
101 NOTE
102 NOTE
103 NOTE
104 A $SFLP.K = \text{SAMPLE}(SPSLP.K, PERD, ISFLP)$
105 C $ISFLP = 1.1$
106 C $PERD = 3$
107 L $SPSLP.K = SPSLP.J + DT/TPPL * (PSFLP.J - SPSLP.J)$
108 C $TPPL = 1$
109 N $SPSLP = ISFLP$
110 A $PSFLP.K = \text{MIN}((SFLP.K * PMD.K * PMC.K * PMB.K) - EDTUC.K + EITUC.K), NFP.K)$
111 A $EITUC.K = \text{MAX}(TUC.K - ATUC.K, 0)$
112 A $EDTUC.K = \text{MAX}(ATUC.K - TUC.K, 0)$
113 NOTE
114 A $PMB.K = \text{TABHL}(PMBT, BRP.K, .5, 3, .5)$
115 T $PMBT = 1/1/1/1.2/1.4/1.5$
116 L $BRP.K = BRP.J + (DT/TPBR) * (BR.J - BRP.J)$
117 N $BRP = 1$
118 A $BR.K = B.K / NB.K$
119 C $TPBR = 3$
120 NOTE
121 L $ANFP.K = ANFP.J + (DT/TANFP) * (NFP.J - ANFP.J)$
122 N $ANFP = INFP$
123 C $TANFP = 1$
124 A $NFP.K = INFP * ((WPI.K * (1 - D)) + (CPI.K * D))$
125 C $INFP = 1.1$
126 A $WPI.K = \text{TABHL}(WPIT, TIME.K, 0, 120, 12) / 100^*$
127 T $WPIT = 100/99/88/96/85/90/86/76/72/119/228$
128 A $CPI.K = \text{TABHL}(CPIT, TIME.K, 0, 120, 12) / 100^*$
129 T $CPIT = 100/99/99/96/98/113/104/108/122/126/220$
130 C $D = .3$
131 A $CANPR.K = NFP.K / ANFP.K$
132 L $CANPP.K = CANPP.J + (DT/TPCANPR) * (CANPR.J - CANPP.J)$
133 N $CANPP = 1$
134 C $TPCANPR = 12$
135 A $PMC.K = \text{TABHL}(PMCT, CANPP.K, .4, 2, .2)$
136 T $PMCT = .4/.6/.8/1/1/1/1/1/1$
137 NOTE
138 A $DV1.K = (\text{MAX}(NSFLPR.K, 1)) * (1 - DV3.K)$
139 A $DV2.K = (\text{MIN}(NSFLPR.K, 1)) * DV3.K$
140 A $DV3.K = \text{CLIP}(1, 0, PLSBDR.K, .5)$
141 A $PMD.K = DV1.K + DV2.K$
142 A $NSFLPR.K = NRP.K / SFLP.K$
143 A $NRP.K = (\text{MAX}((SFLP.K * (1 - PA.K)), FPR.K))$
144 A $FPR.K = AFCPU.K * (1 + \text{MARGIN})$
145 C $\text{MARGIN} = .30$
146 A $OLSBDR.K = OLS.K / SFBD.K$
147 L $PLSBDR.K = PLSBDR.J + (DT/TPLSBD) * (OLSBDR.J - PLSBDR.J)$
148 N $PLSBDR = 0$
149 C $TPLSBD = 3$
150 A $PA.K = \text{TABHL}(TPA, APCU.K, .4, 1, .1)$
151 T $TPA = .45/.325/.215/.115/.05/0/0$

* Monthly indices are used in the final version of the model

152 NOTE
153 A $APRICE.K = ((SFBD.K * SFLP.K) + (OLS.K * NRP.K)) / (SFBD.K + OLS.K)$
154 NOTE
155 NOTE
156 NOTE SHIPPING EQUATIONS
157 NOTE
158 NOTE
159 L $B.K = B.J + DT * (IOR.JK - SSR.JK)$
160 N $B = AOR$
161 A $NB.K = AOR.K * MDSB$
162 A $SSRD.K = K / MDSB$
163 R $SSR.KL = MIN(SSRD.K, I.K / DT)$
164 A $DD.K = B.K / VSSR.K$
165 L $VSSR.K = VSSR.J + DT / CTTS * (SSR.JK - VSSR.J)$
166 N $VSSR = ASSR$
167 C $CTTS = .250$
168 L $ASSR.K = ASSR.J + DT / TAS * (SSR.JK - ASSR.J)$
169 N $ASSR = AOR$
170 C $TAS = 12$
171 C $MDSB = 1$
172 NOTE
173 NOTE
174 NOTE MANUFACTURING SECTOR
175 NOTE
176 NOTE
177 NOTE
178 NOTE PRODUCTION AND INVENTORY SUB-SECTOR
179 NOTE
180 NOTE
181 NOTE
182 NOTE CAPACITY ACQUISITION EQUATIONS
183 NOTE
184 NOTE
185 L $PCL.K = PCL.J + DT * (PCIR.JK)$
186 N $PCL = 63180$
187 R $PD.KL = (PCL.K * WOR) / 12$
188 L $APD.K = APD.J + DT * PD.JK$
189 N $APD = 0$
190 R $PCIR.KL = DELAY3(PCOR.JK, DRPC)$
191 N $PCOR = 2500$
192 C $DRPC = 24$
193 L $PCOO.K = PCOO.J + DT * (PCOR.JK - PCIR.JK)$
194 N $PCOO = PCOR$
195 R $PCOR.KL = DPC.K / TOPC * CLIP(PMLT.K, 1, DVR, 1)$
196 C $DVR = 0$
197 A $PMLT.K = TABHL(PMLTT, RECPM.K, 0, 2, 0.5)$
198 A $RECPM.K = EPSR.K / CPSR.K$
199 T $PMLTT = 2 / 1.5 / 1 / .8 / .5$
200 C $TOPC = 4$
201 A $DPC.K = MAX(0, (PCD.K - PCOO.K - PCL.K))$
202 A $PCD.K = EOR.K + (B.K - NB.K) / TDBA$
203 C $TDBA = 12$

204 NOTE
 205 NOTE
 206 NOTE
 207 NOTE
 208 A $NPOR.K = AOR.K + (MID.K - I.K) / TAI$
 209 A $MID.K = ASSR.K * MICOV$
 210 C $MICOV = 2$
 211 A $EPCU.K = NPOR.K / PCL.K$
 212 A $MPOR.K = AOR.K + (MIL.K - I.K) / TAI$
 213 A $MIL.K = ASSR.K * MACOV$
 214 C $MACOV = 6$
 215 A $DVP.K = CLIP(1, 0, EPCU.K, 1)$
 216 A $PPOR.K = (NPOR.K * DVP.K) + (MPOR.K * (1 - DVP.K))$
 217 A $APOR.K = MIN(PCL.K, PPOR.K)$
 218 A $APCU.K = APOR.K / PCL.K$
 219 C $TAI = 3$
 220 R $PSR.KL = APOR.K$
 221 R $PCR.KL = DELAY3(PSR.JK, PPD)$
 222 N $PSR = AOR$
 223 C $PPD = 3$
 224 L $AAPOR.K = AAPOR.J + DT / PPD * (PSR.JK - AAPOR.J)$
 225 N $AAPOR = AOR$
 226 NOTE
 227 NOTE
 228 NOTE
 229 NOTE
 230 L $ARUP.K = ARUP.J + DT / TARUP * (RUP.J - ARUP.J)$
 231 N $ARUP = AOR * MRUPU$
 232 C $TARUP = 3$
 233 A $DV.K = ARUP.K + (DRI.K - RI.K) / TARI$
 234 R $ROR.KL = DV.K$
 235 C $TARI = 3$
 236 R $RRS.KL = DELAY3(ROR.JK, SD)$
 237 N $ROR = ARUP$
 238 C $SD = 2$
 239 A $DRI.K = (D1 * (AOR.K * MRUPU) + (1 - D1) * ARUP.K) * RCOV$
 240 C $D1 = 1$
 241 C $RCOV = 2$
 242 A $RUP.K = APOR.K * MRUPU$
 243 C $MRUPU = 1.075$
 244 L $RI.K = RI.J + DT * (RRS.JK - RUP.J)$
 245 N $RI = AOR * MRUPU * RCOV$
 246 L $WIPI.K = WIPI.J + DT * (PSR.JK - PCR.JK)$
 247 N $WIPI = PSR * DCV$
 248 C $DCV = 1$
 249 L $I.K = I.J + DT * (PCR.JK - SSR.JK)$
 250 N $I = AOR * MICOV$

251 NOTE
 252 NOTE MANUFACTURING COSTS SUB-SECTOR
 253 NOTE
 254 NOTE
 255 NOTE
 256 R RIMB.KL=DV.K*RMP
 257 C RMP=.20
 258 R CRRS.KL=DELAY3(RIMB.JK,SD)
 259 N RIMB=ROR*RMP
 260 L VMIDP.K=VMIDP.J+DT*(RIMB.JK-CRRS.JK)
 261 N VMIDP=RIMB
 262 A CRUP.K=(MVRI.K/RI.K)*RUP.K
 263 A DLH.K=APOR.K*LHPU.K
 264 A LMPU.K=ILHPU*((IPOR/AAPOR.K)**A)
 265 C ILHPU=.168
 266 C A=.3
 267 N IPOR=AOR
 268 A DLC.K=DLH.K*AWPH
 269 C AWPH=.50
 270 A ILC.K=MILC+(DLC.K*.5)
 271 C MILC=134.3
 272 A VOVH.K=VOHPU*APOR.K
 273 C VOHPU=.01
 274 A FSBC.K=TABHL(FSBCT,PCL.K,63180,315900,21060)
 275 T FSBCT=8395/10200/11600/12600/13700/14500/15400/16200/17100
 276 X1 /18500/20000/21500/23000
 277 A DE.K=(MVPCL.K*WOR)/12)
 278 C WOR=.10
 279 A FOH.K=ILC.K+VOVH.K+FSBC.K+DE.K
 280 R TMC.KL=CRUP.K+DLC.K+(FOH.K*SW)
 281 R TCT.KL=DELAY3(TMC.JK,PPD)
 282 N TMC=WIFI*(.299+OHPU)
 283 C OHPU=.287
 284 A AFCPU.K=MVI.K/I.K
 285 C SW=1
 286 NOTE
 287 NOTE ADMINISTRATION AND SELLING EXPENSES
 288 NOTE
 289 NOTE
 290 NOTE
 291 A ASSBE.K=TABHL(ASSBT,PCL.K,63180,315900,21060)
 292 T ASSBT=6318/7600/8600/9500/10200/10800/11400/12000/
 293 X1 12700/13600/14800/15900/17000
 294 A VSE.K=VSEPU*ASSR.K
 295 C VSEPU=.05

296 NOTE
 297 NOTE
 298 NOTE FORECASTING SECTOR
 299 NOTE
 300 NOTE
 301 NOTE
 302 NOTE
 303 NOTE DEMAND FORECAST
 304 NOTE
 305 NOTE
 306 NOTE
 307 L $AOR.K = AOR.J + (DT/TAOR) * (IOR.JK - AOR.J)$
 308 N $AOR = 63180$
 309 C $TAOR = 3$
 310 A $EOR.K = AOR.K + ECOR.K$
 311 A $ECOR.K = ((AOR.K - PAOR.K) / DAOF) * (FT + TAOR)$
 312 L $PAOR.K = PAOR.J + DT / DAOF * (AOR.J - PAOR.J)$
 313 C $DAOF = 18$
 314 N $PAOR = 57180$
 315 N $FT = DRPC$
 316 NOTE
 317 NOTE COSTING FORECAST
 318 NOTE
 319 NOTE
 320 NOTE
 321 L $ATUC.K = ATUC.J + DT / TATUC * (TUC.J - ATUC.J)$
 322 N $ATUC = .80475$
 323 N $TATUC = TAOR$
 324 A $TUC.K = AFCPU.K + VSEPU + ((FOH.K * (1 - SW)) + ASSBE.K + AME.K + ARE.K) / AOR.K$
 325 L $PATUC.K = PATUC.J + DT / DATUCF * (ATUC.J - PATUC.J)$
 326 A $ECTUC.K = ((ATUC.K - PATUC.K) / DATUCF) * (FT + TATUC)$
 327 A $ETUC.K = ATUC.K + ECTUC.K$
 328 N $PATUC = ATUC$
 329 N $DATUCF = DAOF$
 330 NOTE
 331 NOTE PRICING FORECAST
 332 NOTE
 333 NOTE
 334 NOTE
 335 L $AAPRI.K = AAPRI.J + (DT / TASFP) * (APRICE.J - AAPRI.J)$
 336 N $AAPRI = ISFLP$
 337 N $TASFP = TATUC$
 338 L $PAAPRI.K = PAAPRI.J + (DT / DAASFP) * (AAPRI.J - PAAPRI.J)$
 339 N $PAAPRI = AAPRI$
 340 N $DAASFP = DATUCF$
 341 A $ECASFP.K = ((AAPRI.K - PAAPRI.K) / DAASFP) * (FT + TASFP)$
 342 A $ESFPR.K = AAPRI.K + ECASFP.K$

343 NOTE
344 NOTE PROFITABILITY FORECAST
345 NOTE
346 NOTE
347 NOTE
348 A $ESRV.K = EOR.K * ESFPR.K$
349 A $EPBT.K = ESRV.K - (EOR.K * ETUC.K)$
350 A $EPSR.K = EPBT.K / ESRV.K$
351 NOTE
352 NOTE FINANCIAL SECTOR
353 NOTE
354 NOTE
355 NOTE
356 NOTE PROFIT EQUATIONS
357 NOTE
358 NOTE
359 L $MVB.K = MVB.J + DT * (MVOR.JK - SRV.JK)$
360 N $MVB = B * ISFLP$
361 R $MVOR.KL = (SFBD.K * SFLP.K) + (OLS.K * NRP.K)$
362 R $SRV.KL = DELAY3(MVOR.JK, DD.K)$
363 N $MVOR = MVB / MDSB$
364 A $ACOUS.K = (MVI.K / I.K) * VSSR.K$
365 A $PBT.K = VSRV.K - (ACOUS.K + AME.K + ASSBE.K + VSE.K + IOD.K +$
366 X1 $ARE.K) - (FOH.K * (1 - SW))$
367 L $APL.K = APL.J + DT / TAPR * (PBT.J - APL.J)$
368 N $APL = ASSR * (ISFLP - ATUC)$
369 C $TAPR = 3$
370 A $PAT.K = (1 - TAX.K) * APL.K$
371 A $TAX.K = .40$
372 R $RE.KL = PAT.K - DIV.K$
373 L $VSRV.K = VSRV.J + DT / CTTS * (SRV.JK - VSRV.J)$
374 N $VSRV = ASRV$
375 L $ABTP.K = ABTP.J + DT / TABTP * (PBT.J - ABTP.J)$
376 N $ABTP = APL$
377 C $TABTP = 12$
378 NOTE
379 NOTE CASH FLOW EQUATIONS
380 NOTE
381 NOTE
382 L $CASHB.K = CASHB.J + DT * ((CRD.JK + RALTD.JK) - (SRMO.JK + SRASO.JK + CPRM.JK +$
383 X1 $TAXP.J + PCP.JK + DIV.J + IOD.J + RRLTD.JK))$
384 R $SRMO.KL = (FOH.K - DE.K) + DLC.K$
385 R $SRASO.KL = ASSBE.K + VSE.K + AME.K + ARE.K$
386 N $CASHB = DCPU * ASSR$
387 A $TAXP.K = TAX.K * APL.K$
388 A $DIV.K = .40 * PAT.K$
389 R $AIR.KL = (DPC.K / TOPC) * AIRPU.K$
390 A $AIRPU.K = IAIRPU * CPTIM.K$

391 C IAIRPU=12
 392 A CPTIM.K=TABHL(CPTIMT,TIME.K,0,120,12)
 393 T CPTIMT=1/.92/.85/.78/.72/.66/.61/.56/.52/.51/.50
 394 R PCP.KL=DELAY3(AIR.JK,DRPC)
 395 N AIR=PCOR*IAIRPU
 396 R CPRM.KL=DELAY3(CRRS.JK,DPAP)
 397 N CRRS=RIMB
 398 C DPAP=2
 399 R CRD.KL=DELAY3(SRV.JK,DCAR)
 400 N SRV=ASRV
 401 C DCAR=1.5
 402 A IOD.K=(AI*LTDL.K)/12
 403 C AI=.10
 404 R RALTD.KL=(MAX(CDIS.K,0))/TACD
 405 C TACD=1
 406 A CDIS.K=CASHD.K-CASHB.K
 407 A CASHD.K=DCPU*ASSR.K
 408 C DCPU=.80
 409 R RRLTD.KL=LTDL.K/DRLTD
 410 C DRLTD=60
 411 NOTE
 412 NOTE BALANCE SHEET EQUATIONS
 413 NOTE
 414 NOTE
 415 L MVRI.K=MVRI.J+DT*(CRRS.JK-CRUP.J)
 416 N MVRI=RI*RMP
 417 L MVWIPI.K=MVWIPI.J+DT*(TMC.JK-TCT.JK)
 418 N MVWIPI=TMC*DCV
 419 L MVI.K=MVI.J+DT*(TCT.JK-ACOUS.J)
 420 N MVI=TMC*MICOV
 421 L ACR.K=ACR.J+DT*(SRV.JK-CRD.JK)
 422 N ACR=DCAR*ASRV
 423 L MVPCL.K=MVPCL.J+DT*(PCP.JK)
 424 L ADE.K=ADE.J+DT*(DE.J)
 425 N ADE=0
 426 N MVPCL=PCL*IAIRPU
 427 L EAREL.K=EAREL.J+DT*RE.JK
 428 N EAREL=MVI+MVWIPI+CASHB+ACR+MVPCL-ACP-LTDL-ADE
 429 L LTDL.K=LTDL.J+DT*(RALTD.JK-RRLTD.JK)
 430 N LTDL=0
 431 L ACP.K=ACP.J+DT*(CRRS.JK-CPRM.JK)
 432 N ACP=RIMB*DPAP

433	NOTE	
434	NOTE	FINANCIAL AND COSTING RATIOS
435	NOTE	
436	NOTE	
437	NOTE	RETURN ON CAPITAL EMPLOYED RATIO. IT REFLECTS THE
438	NOTE	OVERALL EFFICIENCY OF THE BUSINESS
439	NOTE	
440	A	$AST.K = MVRI.K + MVI.K + MVWIPI.K + ACR.K + CASHB.K + (MVPCL.K - ADE.K)$
441	A	$PMG.K = PAT.K / ASRV.K$
442	A	$AT.K = (ASRV.K * 12) / AST.K$
443	A	$ROI.K = PMG.K * AT.K$
444	A	$CPSR.K = PBT.K / VSRV.K$
445	NOTE	
446	A	$CAS.K = ACR.K + MVRI.K + MVWIPI.K + MVI.K + CASHB.K$
447	A	$WCR.K = CAS.K / ACP.K$
448	NOTE	
449	NOTE	BREAK EVEN AND PROFIT ANALYSIS
450	NOTE	
451	A	$BEP.K = TSBC.K / VCPR.K$
452	A	$TSBC.K = FSBC.K + MILC + DE.K + ASSBE.K$
453	A	$VCPU.K = (MRUPU * RMP) + (LMPU.K * AWP) + ((ILC.K - MILC) / APOR.K) + (AME.K / AOR.K)$
454	X1	$+ (ARE.K / AOR.K) + VOHPU + VSEPU$
455	A	$VCPR.K = VCPU.K / APRICE.K$
456	A	$MOS.K = VSRV.K - BEP.K$
457	A	$MOSP.K = MOS.K / VSRV.K$
458	A	$CSR.K = (VCPU.K * VSSR.K) / VSRV.K$
459	NOTE	
460	NOTE	COSTING RATIOS TO SHOW THE TREND OF COSTS AND THE RELATIVE
461	NOTE	SIZE OF EACH PRINCIPAL TYPE OF COST IN RELATION TO SALES
462	NOTE	
463	A	$FOSR.K = FOH.K / ASRV.K$
464	A	$ASSSR.K = ASSBE.K / ASRV.K$
465	A	$MESR.K = ME.K / ASRV.K$
466	NOTE	
467	NOTE	PERFORMANCE INDEX
468	NOTE	
469	NOTE	
470	NOTE	
471	A	$SFV.K = ASSR.K * W1 + ASFMS.K * W2 + ABTP.K * W3$
472	A	$SIP.K = IPPRIC.K * W4 + IPROI.K * W5$
473	A	$PINX.K = SFV.K - SIP.K$
474	C	$W1 = 3.19E-4$
475	C	$W2 = 2.0385E2$
476	C	$W3 = 9.4E-4$
477	C	$W4 = 81.7354$
478	C	$W5 = 37.08854$
479	L	$ASFMS.K = ASFMS.J + DT / TAMS * (SFMS.J - ASFMS.J)$
480	N	$ASFMS = .1215$

481 C TAMS=12
 482 C STIM=24
 483 L $IPPRIC.K=IPPRIC.J+DT*((APRICE.J-PRTD.J)/PRTD.J)$
 484 X1 $**INT(2))$
 485 N IPPRIC=0
 486 L $PRTD.K=PRTD.J+DT/STIM*(APRICE.J-PRTD.J)$
 487 N PRTD=ISFLP
 488 L $IROI.K=IROI.J+DT*((ROI.J-ROITD.J)/ROITD.J)**INT(2))$
 489 N IROI=0
 490 L $ROITD.K=ROITD.J+DT/STIM*(ROI.J-ROITD.J)$
 491 N ROITD=.1277

492 NOTE

493 NOTE

494 NOTE

DOC CARDS

495 NOTE

496 D A=(1) IT IS A CONSTANT ITS VALUE EQUAL TO OR GREATER THAN
 .3 AND EQUAL TO OR LESS THAN .5. IT GENERATES A
 DECLINE IN LHPU FALL BETWEEN 20 AND 30% EVERY TIME
 AAPOR IS DOUBLED

497	D	AAPOR = (U/M)	AVERAGE PRODUCTION ORDER RATE
498	D	AAPRI = (£/U)	AVERAGE SYNTHETIC FIBRE PRICE
499	D	AATP = (£)	ACCUMULATED PAT.
500	D	ABTP = (£/M)	AVERAGE BEFORE TAX PROFIT
501	D	ACOUS = (£/M)	AVERAGE COSTS OF UNITS SOLD
502	D	ACP = (£)	ACCOUNTS PAYABLE
503	D	ACR = (£)	ACCOUNTS RECEIVABLE
504	D	ADE = (£)	ACCUMULATED DEPRECIATION
505	D	AFCIT = (1)	ACTUAL FIBRE CONSUMPTION INDEX TABLE
506	D	AFCPU = (£/U)	AVERAGE FACTORY COSTS PER UNIT SOLD
507	D	AI = (1/YEAR)	ANNUAL RATE OF INTEREST
508	D	AIR = (£/M)	ACTUAL INVESTMENT ORDER RATE
509	D	AIRPU = (£/(U/M))	ACTUAL CAPITAL COST REQUIRED PER UNIT OF PRODU
510	D	AME = (£/M)	ACTUAL MARKET EFFORTS
511	D	ANFP = (£/U)	AVERAGE NATURAL FIBRE PRICE
512	D	AOR = (U/M)	AVERAGE ORDER RATE
513	D	APCU = (1)	ACTUAL PRODUCTION CAPACITY UTILIZATION
514	D	APD = (U/M)	ACCUMULATED PHYSICAL DEPRECIATION
515	D	APL = (£/M)	AVERAGE PROFIT LEVEL
516	D	APOR = (U/M)	ACTUAL PRODUCTION ORDER RATE
517	D	APRICE= (£/U)	GENERAL LEVEL OF SYNTHETIC FIBRE PRICE
518	D	ARE = (£/M)	ACTUAL RESEARCH EXPENSES
519	D	ARUP = (RU/M)	AVERAGE RAW MATERIAL USED IN PRODUCTION
520	D	ASFMS = (1)	AVERAGE SYNTHETIC FIBRE MARKET SHARE
521	D	ASRV = (£/M)	AVERAGE SALES REVENUE
522	D	ASSBE = (£/M)	ADMINISTRATIVE & SELLING STANDBY EXPENSES
523	D	ASSBT = (£/M)	TABLE OF ADMINISTRATIVE & SELLING STANDBY EXPENSES
524	D	ASSR = (U/M)	AVERAGE SHIPMENT SENT RATE
525	D	ASSSR = (1)	ADMINISTRATIVE AND SELLING STANDBY EXPENDITURE/ AVERAGE SALES REVENUE RATIO

526	D	AST = (£)	TOTAL ASSETS
527	D	AT = (1)	ASSETS TURNOVER
528	D	ATUC = (£/U)	AVERAGE TOTAL UNIT COST
529	D	AUKCI=(1)	ACTUAL U.K. FIBRE CONSUMPTION INDEX
530	D	AWPH=(£/M)	AVERAGE WAGES PER HOUR
531	D	B = (U)	BACKLOG
532	D	BEP = (£/M)	BREAK EVEN POINT
533	D	BR = (1)	BACKLOG-NORMAL BACKLOG RATIO
534	D	BRP = (1)	BACKLOG RATIO PERCEIVED BY MANAGEMENT
535	D	CANPP=(1)	CURRENT-AVERAGE NATURAL FIBRE PRICE RATIO PERCEIVED BY MANAGEMENT
536	D	CANPR=(1)	CURRENT TO AVERAGE NATURAL FIBRE PRICE RATIO
537	D	CAS = (£)	CURRENT ASSETS
538	D	CASHB = (£)	CASH BALANCE
539	D	CASHD = (£)	CASH DESIRED
540	D	CDIS = (£)	CASH DISCREPANCY
541	D	CERE = (£)	CUMULATIVE EFFECTIVE RESEARCH EXPENSES
542	D	CPI = (1)	COTTON PRICE INDEX
543	D	CPIT = (1)	COTTON PRICE INDEX TABLE
544	D	CPRM = (£/M)	CASH PAYMENT FOR RAW MATERIALS
545	D	CPSR = (1)	CURRENT PROFIT-AVERAGE SALES REVENUE RATIO
546	D	CPTIM = (1)	CHANGE IN CAPITAL COST PER UNIT OF OUTPUT DUE TO TECHNOLOGICAL IMPROVEMENT IN NEW PRODUCTION FACILITIES OVER TIME MULTIPLIER
547	D	CPTIMT = (1)	CPTIM TABLE
548	D	CRD = (£/M)	CASH RECEIVED FROM DEBTORS
549	D	CRRS = (£/M)	BILLS OF RAW MATERIALS RECEIVED
550	D	CRUP = (£/M)	COST OF RAW MATERIALS USED IN PRODUCTION
551	D	CSR = (1)	CONTRIBUTION-SALES REVENUE RATIO
552	D	CTTS = (M)	TIME TO AVERAGE SHIPMENT SENT (VSSR)
553	D	D = (1)	DUMMY TO TRANSFER FROM INDEX TO ANOTHER
554	D	D1 = (1)	DUMMY TO TRANSFER BETWEEN THE DRI POLICIES
555	D	DAASFP= (M)	DELAY IN AVERAGE SF PRICE FOR FORECASTS
556	D	DAME = (M)	DELAY IN ALLOCATE AND PRODUCE MARKET EFFORTS
557	D	DAOF = (M)	DELAY IN AOR FOR FORECASTS
558	D	DATUCF=(M)	DELAY IN AVERAGE TOTAL UNIT COSTS FOR FORECAST
559	D	DCAR=(M)	DELAY IN COLECT ACCOUNTS RECEIVABLE
560	D	DCPU=(£/U/M)	DESIRED CASH PER UNIT OF UNITS SHIPPED
561	D	DCV = (M)	DESIRED COVER IN WORK IN PROCESS INVENTORY
562	D	DD = (M)	DELIVERY DELAY
563	D	DE = (£/M)	DEPRECIATION EXPENSES
564	D	DIV = (£/M)	DIVIDEND
565	D	DLC = (£/M)	DIRECT LABOUR COST
566	D	DLH = (H/M)	DIRECT LABOUR HOURS,
567	D	DM = (1)	DUMMY TO TRANSFER FROM CONTINUOUS TO DISCRETE RESEARCH OUTCOME
568	D	DORE = (M)	DELAY IN OUTCOME OF RESEARCH EXPENSES
569	D	DPAP = (M)	DELAY IN PAY ACCOUNTS PAYABLE

570	D	DPC = (U/M)	DEFICIT IN PRODUCTION CAPACITY
571	D	DRI = (RU)	DESIRED RAW MATERIAL INVENTORY
572	D	DRLTD = (M)	DELAY IN REPAYMENT LONG-TERM DEBT
573	D	DRPC = (M)	DELAY IN RECEIVE AND INSTALLATION PR CAPACITY
574	D	DT = (M)	SOLUTION TIME INTERVAL
575	D	DV = (RU/M)	DUMMY TO CALCULATE RAW MATERIAL ORDER RATE
576	D	DV1 = (1)	DUMMY VARIABLE TO DETERMINE THE DECISION DEPEND UPON NET REALIZED TO LIST PRICE RATIO
577	D	DV2 = (1)	DUMMY VARIABLE TO DETERMINE THE DECISION DEPEND UPON NET REALIZED TO LIST PRICE RATIO
578	D	DV3 = (1)	DV TO CONTROL THE CHOICE BETWEEN DV1 AND DV2
579	D	DVP = (1)	DUMMY VARIABLE TO CONTROL PLANNED PRD ORDER
580	D	DVR = (1)	DUMMY VARIABLE TO TRANSFER FROM ONE PRODUCTION CAPACITY ORDERING POLICY TO ANOTHER
581	D	EAREL = (£)	EQUITY AND RETAINED EARNING
582	D	ECASFP = (£/U)	EXPECTED CHANGE IN SYNTHETIC FIBRE PRICE
583	D	ECOR = (U/M)	EXPECTED CHANGE IN INCOMING ORDER RATE
584	D	ECTUC = (£/U)	EXPECTED CHANGE IN TOTAL UNIT COSTS
585	D	EDTUC = (£/U)	ACTUAL DECREASE IN TOTAL UNIT COSTS
586	D	EITUC = (£/U)	ACTUAL INCREASE IN TOTAL UNIT COSTS
587	D	EOR = (U/M)	EXPECTED INCOMING ORDER RATE
588	D	EPBT = (£/M)	EXPECTED PRE-TAX PROFIT
589	D	EPCU = (1)	EXPECTED PRODUCTION CAPACITY UTILIZATION
590	D	EPSR = (1)	EXPECTED PROFIT-SALES REVENUE RATIO
591	D	ESFPR = (£/U)	EXPECTED SYNTHETIC FIBRE PRICE
592	D	ESRV = (£/M)	EXPECTED SALES REVENUE
593	D	ETUC = (£/U)	EXPECTED TOTAL UNIT COST
594	D	FFMBOS = (1)	FRACTION OF FIBRE MARKET BECOME OPEN TO SF
595	D	FFMC = (1)	FRACTION OF FIBRE MARKET COMMUNICATED
596	D	FFMUSF = (1)	FRACTION OF FIBRE MARKET UNOPEN TO SYNTHETIC F
597	D	FMBOSF = (U/M)	FIBRE MARKET BECOMING OPEN TO SYNTHETIC FIBRE
598	D	FME = (1)	PERCENT FROM AVERAGE SALES REVENUE TO ME
599	D	FOH = (£/M)	FACTORY OVERHEADS
600	D	FOSR = (1)	FACTORY OVERHEADS TO SALES REVENUE RATIO
601	D	FPR = (£/U)	FLOOR (MINIMUM ACCEPTABLE) PRICE
602	D	FSBC = (£/M)	FACTORY STANDBY COSTS (FIXED FOR GIVEN PCL)
603	D	FSBCT = (£/M)	FACTORY STANDBY COSTS TABLE
604	D	FSRVR = (1)	FRACTION FROM ASRV FOR RESEARCH
605	D	FT = (M)	FORECASTING TIME
606	D	I = (U)	FINISHED GOODS INVENTORY
607	D	IAIRPU = (£/(U/M))	INITIAL CAPITAL COST PER UNIT OF OUTPUT
608	D	ILC = (£/M)	INDIRECT LABOUR COST
609	D	ILHPU = (H/U)	INITIAL LABOUR HOURS PER UNIT
610	D	INFP = (£/U)	INITIAL NATURAL FIBRE PRICE

611	D	IOD = (£/M)	INTEREST ON LONG-TERM DEBT
612	D	IOR = (U/M)	INCOMING ORDER RATE
613	D	IPOR = (U/M)	INITIAL PRODUCTION ORDER RATE
614	D	IPPRIC=(1)	INSTABILITY PENALTY TO BE ASSOCIATED WITH VARIATION IN PRICE
615	D	IPROI = (1)	INSTABILITY PENALTY TO BE ASSOCIATED WITH VARIATION IN ROI
616	D	ISFLP=(£/U)	INITIAL SYNTHETIC FIBRE PRICE
617	D	LENGTH = (M)	SIMULATED PERIOD
618	D	LHPU = (H/U)	LABOUR HOURS PER UNIT
619	D	LTDL = (£)	LONG-TERM DEBT LEVEL
620	D	MACOV = (M)	MAXIMUM COVER
621	D	MARGIN = (1)	MARGIN OVER AVERAGE FACTORY COSTS PER UNIT REQUIRED TO COVER THE OTHER COSTS AND PROFIT
622	D	MDSB = (M)	MONTHS DESIRED IN BACKLOG
623	D	ME = (£/M)	ALLOCATED FUND TO MARKET EFFORT
624	D	MESR = (1)	MARKET EFFORT TO SALES REVENUE RATIO
625	D	MICOV = (M)	MINIMUM COVER
626	D	MID = (U)	MINIMUM FINISHED GOOD INVENTORY DESIRED
627	D	MIL = (U)	MAXIMUM FINISHED GOOD INVENTORY LEVEL
628	D	MILC = (£/M)	MINIMUM INDIRECT LABOUR COSTS WHATEVER APOR
629	D	MOS = (£/M)	MARGIN OF SAFETY
630	D	MOSP = (1)	MOS AS PERCENTAGE OF SALES
631	D	MPOR = (U/M)	MAXIMUM PRODUCTION ORDER RATE
632	D	MRUPU = (RU/U)	MINIMUM RAW MATERIAL PER UNIT
633	D	MVB = (£)	MONETARY VALUE OF BACKLOG
634	D	MVI = (£)	MONETARY VALUE OF I
635	D	MVOR = (£/M)	MONETARY VALUE OF INCOMING ORDER RATE
636	D	MVPCL = (£)	MONETARY VALUE OF PCL
637	D	MVRI = (£)	MONETARY VALUE OF RI
638	D	MVWIPI = (£)	MONETARY VALUE OF WIPI
639	D	NB = (U)	NORMAL BACKLOG
640	D	NFP = (£/U)	NATURAL FIBRE PRICE
641	D	NFPPC = (£/U)	NATURAL FIBRE PERCEIVED BY CUSTOMERS
642	D	NFQR = (1)	NATURAL FIBRE QUALITY REFERENCE
643	D	NPOR = (U/M)	MINIMUM PRODUCTION ORDER RATE
644	D	NRNPR = (1)	NET REALIZED-NATURAL FIBRE PRICE PERCEIVED BY CUSTOMERS RATIO
645	D	NRP = (£/U)	NET REALIZED PRICE
646	D	NRPM = (1)	PRICE MULTIPLIER DEPEND ON NET REALIZED PRICE TO NATURAL FIBRE PRICE PERCEIVED RATIO
647	D	NSFLPR = (1)	NET REALIZED-SYNTHETIC FIBRE LIST PRICE RATIO
648	D	OHPU = (£/U)	FOH PER UNIT AT THE BEGINNING OF SIMULATION
649	D	OLS = (U/M)	OFF-LIST SELLING
650	D	OLSBDR = (1)	OFF-LIST SELLING TO BASIC DEMAND RATIO

651	D	PA = (1)	PRICE ALLOWANCE
652	D	PAAPRI = (£/U)	PAST AVERAGE PRICE
653	D	PAOR = (U/M)	PAST AOR
654	D	PAT = (£/M)	PROFIT AFTER TAX
655	D	PATUC = (£/U)	PAST AVERAGE TOTAL UNIT COSTS
656	D	PBT = (£/M)	PRE-TAX PROFIT
657	D	PCD = (U/M)	PRODUCTION CAPACITY DESIRED
658	D	PCIR = (U/M/M)	PRODUCTION CAPACITY INSTALLATION RATE
659	D	PCL = (U/M)	PRODUCTION CAPACITY LEVEL
660	D	PCOO = (U/M)	PRODUCTION CAPACITY ON ORDER
661	D	PCOR = (U/M/M)	PRODUCTION CAPACITY ORDER RATE
662	D	PCP = (£/M)	PAYMENT FOR RECEIVED PRODUCTION CAPACITY
663	D	PCR = (U/M)	PRODUCTION COMPLETION RATE
664	D	PD = (U/M/M)	PHYSICAL DEPRECIATION
665	D	PERD = (M)	PRICE DECISION PERIOD
666	D	PINX = (1)	PERFORMANCE INDEX
667	D	PLSBDR = (1)	PERCEIVED OFF-LIST SELLING TO BASIC DEMAND RATE
668	D	PLTPER = (M)	PLOTTING INTERVAL IN OUTPUT
669	D	PM = (1)	PRICE MULTIPLIER WHICH REPRESENTS THE CHANGE IN THE FRACTION DEMAND SYNTHETIC FIBRES AS A RESULT TO THE CHANGE IN THE RELATION BETWEEN SYNTHETIC FIBRE PRICE AND NATURAL FIBRE PRICE
670	D	PMB = (1)	PRICE MULTIPLIER DUE TO BACKLOG
671	D	PMBT = (1)	PRICE MULTIPLIER DUE TO BACKLOG TABLE
672	D	PMC = (1)	PRICE MULTIPLIER DUE TO NATURAL FIBRE COMPETITION
673	D	PMCT = (1)	TABLE OF PRICE MULT DUE TO NATURAL FIBRE COMP.
674	D	PMD = (1)	PRICE MULTIPLIER DUE TO PERCEIVED OFF-LIST SELLING TO BASIC DEMAND RATIO
675	D	PME = (£/M)	MARKET EFFORTS PERCEIVED BY CUSTOMERS
676	D	PMG = (1)	PROFIT MARGIN
677	D	PMLT = (1)	PROFITABILITY MULTIPLIER
678	D	PMLTT = (1)	PROFITABILITY MULTIPLIER TABLE
679	D	PMT = (1)	PM & NRPM TABLE
680	D	PPD = (M)	PRODUCTION PROCESS DELAY
681	D	PPOR = (U/M)	PLANNED PRODUCTION ORDER RATE
682	D	PR = (1)	LIST PRICE TO PERCEIVED NATURAL FIBRE PRICE RA
683	D	PRE = (£/M)	PLANNED RESEARCH EXPENSES
684	D	PRTD = (£/U)	SYNTHETIC FIBRE PRICE TREND VALUE
685	D	PRTPER = (M)	PRINTING INTERVAL IN OUTPUT
686	D	PSFLP = (£/U)	PROPOSED SYNTHETIC FIBRE LIST PRICE
687	D	PSR = (U/M)	PRODUCTION START RATE
688	D	RALTD = (£/M)	RATE OF ADDING TO LONG-TERM DEBT
689	D	RCOV = (M)	DESIRED RAW MATERIAL COVER
690	D	RE = (£/M)	RETAINED EARNING
691	D	RECPM = (1)	RATIO OF EXPECTED TO CURRENT PRETAX PROFIT MARGIN ON SALES
692	D	RI = (RU)	RAW MATERIAL INVENTORY
693	D	RIMB = (£/M)	RATE OF INCREASE IN RM BILLS
694	D	RMES = (£/M)	REQUIRED MARKET EFFORT FOR SATURATION
695	D	RMEST = (£/M)	REQUIRED MARKET EFFORT FOR SATURATION TABLE

696	D	RMP = (£/RU)	RM PRICE PER UNIT
697	D	ROI = (1)	RETURN ON INVESTMENT
698	D	ROITD = (%)	RETURN ON INVESTMENT TREND VALUE
699	D	ROR = (RU/M)	RAW MATERIAL ORDER RATE
700	D	RP = (£)	RESEARCH POOL
701	D	RRE = (£/M)	REQUIRED RESEARCH EXPENSES
702	D	RRET = (£/M)	REQUIRED RESEARCH EXPENSES TABLE
703	D	RRLTD = (£/M)	RATE OF PAYMENT LONG-TERM DEBT
704	D	RRS = (RU/M)	RAW MATERIAL RECEIVED FROM SUPPLIERS
705	D	RSBE = (£/M)	RESEARCH SPENDING BEFORE EFFECTIVE
706	D	RSBE1 = (£/M)	INTERNAL RATE TO CALCULATE RSBE
707	D	RSBE2 = (£/M)	INTERNAL RATE TO CALCULATE RSBE
708	D	RSBE3 = (£/M)	INTERNAL RATE TO CALCULATE RSBE
709	D	RSBE4 = (£/M)	INTERNAL RATE TO CALCULATE RSBE
710	D	RSBE5 = (£/M)	INTERNAL RATE TO CALCULATE RSBE
711	D	RSBE6 = (£/M)	INTERNAL RATE TO CALCULATE RSBE
712	D	RSBE7 = (£/M)	INTERNAL RATE TO CALCULATE RSBE
713	D	RSR = (£/M)	RESEARCH SPENDING RATE
714	D	RUP = (RU/M)	RAW MATERIAL USED IN PRODUCTION
715	D	SD = (M)	DELAY AT SUPPLIERS
716	D	SFBD = (U/M)	SYNTHETIC FIBRE BASIC DEMAND
717	D	SFLP = (£/U)	SYNTHETIC FIBRE LIST PRICE
718	D	SFMS = (1)	SYNTHETIC FIBRE MARKET SHARE
719	D	SFMSL = (1)	SYNTHETIC FIBRE MARKET SHARE IF THE QUOTED PRICE EQUAL LIST PRICE
720	D	SFMSN = (1)	SYNTHETIC FIBRE MARKET SHARE IF THE QUOTED PRICE EQUAL NET REALIZED PRICE
721	D	SFQ = (1)	SYNTHETIC FIBRE QUALITY PERCEIVED BY MARKET
722	D	SFQT = (1)	SYNTHETIC FIBRE QUALITY TABLE
723	D	SFV = (1)	SUM OF FINAL VALUE
724	D	SIP = (1)	SUM OF INSTABILITY PENALTIES
725	D	SPSLP = (£/U)	SMOOTHED PROPOSED SYNTHETIC FIBRE LIST PRICE
726	D	SRASO = (£/M)	SPENDING RATE ON ADMINISTRATIVE AND SELLING OP
727	D	SRMO = (£/M)	SPENDING RATE ON MANUFACTURING OPERATIONS
728	D	SRV = (£/M)	SALES REVENUE
729	D	SSR = (U/M)	SHIPMENT SENT RATE
730	D	SSRD = (U/M)	SHIPMENT SENT DESIRED
731	D	STIM = (M)	SMOOTH TIME
732	D	SW = (1)	DUMMY TO SWITCH FROM FULL TO DIRECT COSTING
733	D	TABTP = (M)	TIME TO AVERAGE BEFORE TAX PROFIT
734	D	TACD = (M)	TIME TO ADJUST CDIS
735	D	TAI = (M)	TIME TO ADJUST INVENTORY
736	D	TAMS = (M)	TIME TO SMOOTH MARKET SHARE
737	D	TANFP = (M)	TIME TO AVERAGE NATURAL FIBRE PRICE
738	D	TAOR = (M)	TIME TO AVERAGE ORDER RATE
739	D	TAPR = (M)	TIME TO AVERAGE PBT
740	D	TARB = (M)	TIME TO ALLOCATE RESEARCH BUDGET

741	D	TARI = (M)	TIME TO ADJUST RAW MATERIAL INVENTORY
742	D	TARUP = (M)	TIME TO AVERAGE RAW MATERIAL USED IN PROD
743	D	TAS = (M)	TIME TO AVERAGE SSR
744	D	TASFP = (M)	TIME TO AVERAGE ACTUAL SYNTHETIC FIBRE PRICE
745	D	TASR = (M)	TIME TO AVERAGE SRV
746	D	TATUC = (M)	TIME TO AVERAGE TOTAL UNIT COST
747	D	TAX = (1)	TAX RATE
748	D	TAXP = (£/M)	TAX PAYMENT
749	D	TCPNFP = (M)	TIME FOR CUSTOMERS TO PERCEIVE NATURAL FIBRE
750	D	TCT = (£/M)	TOTAL MANUFACTURING COSTS OF UNITS FINISHED IN THE CURRENT MONTH
751	D	TDBA = (M)	TIME FOR DESIRED BACKLOG
752	D	TFDL = (U/M)	TOTAL FIBRE DEMAND LEVEL
753	D	TIME = (M)	BUILT-IN VARIABLE FOR PASSAGE OF TIME
754	D	TMC = (£/M)	TOTAL MANUFACTURING COSTS TO ACCOUNT FOR
755	D	TOPC = (M)	TIME FOR ORDER PRODUCTIVE CAPACITY
756	D	TPA = (1)	TABLE OF PRICE ALLOWANCE
757	D	TPBR = (M)	TIME FOR MANAGEMENT TO PERCEIVE BACKLOG RATIO
758	D	TPCANPR = (M)	TIME FOR MANAGEMENT TO PERCEIVE CURRENT TO AVERAGE NATURAL FIBRE PRICE RATIO
759	D	TPLSBD = (M)	TIME FOR MANAGEMENT TO PERCEIVE OFF-LIST SELLING TO BASIC DEMAND RATIO
760	D	TPME = (M)	TIME FOR CUSTOMERS TO PERCEIVE MARKET EFFORTS
761	D	TPPL = (M)	TIME FOR MANAGEMENT TO PERCEIVE PSFLP
762	D	TSBC = (£/M)	TOTAL STANDBY COSTS
763	D	TUC = (£/U)	TOTAL UNIT COST
764	D	VCPR = (1)	VARIABLE COSTS-PRICE RATIO
765	D	VCPU = (£/U)	VARIABLE COSTS PER UNIT
766	D	VMIDP = (£)	VALUE OF RM IN DELIVERY PIPELINE
767	D	VOHPU = (£/U)	VARIABLE OVERHEAD PER UNIT
768	D	VOVH = (£/M)	VARIABLE OVERHEADS
769	D	VSE = (£/M)	VARIABLE SALES EXPENSES (SHIPPING, BACKING)
770	D	VSEPU = (£/U)	VARIABLE SALES EXPENSES PER UNIT
771	D	VSRV = (£/M)	VERY SHORT-TERM AVERAGE SALES REVENUE
772	D	VSSR = (U/M)	VERY SHORT-TERM AVERAGE SHIPMENT SENT
773	D	W1 = (1/(U/M))	WEIGHT GIVEN TO ASSR
774	D	W2 = (1)	WEIGHT GIVEN TO ASFMS
775	D	W3 = (1/(£/M))	WEIGHT GIVEN TO ABTP
776	D	W4 = (1)	WEIGHT GIVEN TO IPPRIC
777	D	W5 = (1)	WEIGHT GIVEN TO IPROI
778	D	WCR = (1)	WORKING CAPITAL RATIO
779	D	WIPI = (U)	WORK IN PROCESS INVENTORY
780	D	WOR = (1/Y)	ANNUAL WRITE OFF RATE
781	D	WPI = (1)	WOOL PRICE INDEX
782	D	WPIT = (1)	WOOL PRICE INDEX TABLE

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783  NOTE
784  NOTE          OUTPUT  SECTOR
785  NOTE
786  NOTE
787  NOTE
788  NOTE
789  PRINT  1)TFDL, IOR, SFBD, OLS, PPOR, APOR, PCR, SSR, SSRD, B
790  PRINT  2)PCOR, PCIR, PCD, DPC, PCL, APD, EPCU, APCU, MVPCL, ADE
791  PRINT  3)ROR, RUP, DLH, CRUP, DLC, FOH, AFCPU, TUC, EDTUC, EITUC
792  PRINT  4)SFLP, NRP, APRICE, FPR, PA, PM, NRPM, SFMSN, SFMSL, SFMS
793  PRINT  5)FFMBOS, FFMUSF, SFQ, RRE, RSR, RSBE, CERE, AME, ASSBE, VSE
794  PRINT  6)SRV, PBT, PAT, AATP, EAREL, AT, PMG, CPSR, ROI, PINX
795  PRINT  7)RI, I, WIPI, MVRI, MVI, MVWIPI, ACR, CASHB, ACP, LTDL
796  PRINT  8)AOR, PAOR, EOR, ESFPR, ETUC, EPSR
797  PLOT   APRICE=A, TUC=C, NFP=F(0,2.2)/SFMS=M(0.1)/IOR=R,
798  X1     TFDL=L(0,8E5)
799  PLOT   PBT=P(0,8E4)/ROI=R, CPSR=S, AT=T(0,1)/SRV=V, BEP=B(0,3E5)
800  PLOT   PCD=D, PCL=L(0,5E5)/PCIR=I(0,1E4)/APCU=U(0,1)
801  PLOT   APOR=0, TMC=M(0,5E5)/I=G, MID=D, MIL=L(0,17E5)/AFCPU=C(0,1)
802  C      DT=0.125
803  C      LENGTH=120
804  C      PLTPER=2
805  A      PRTPER.K=1+STEP(11,13)
806  RUN    BASIC CASE

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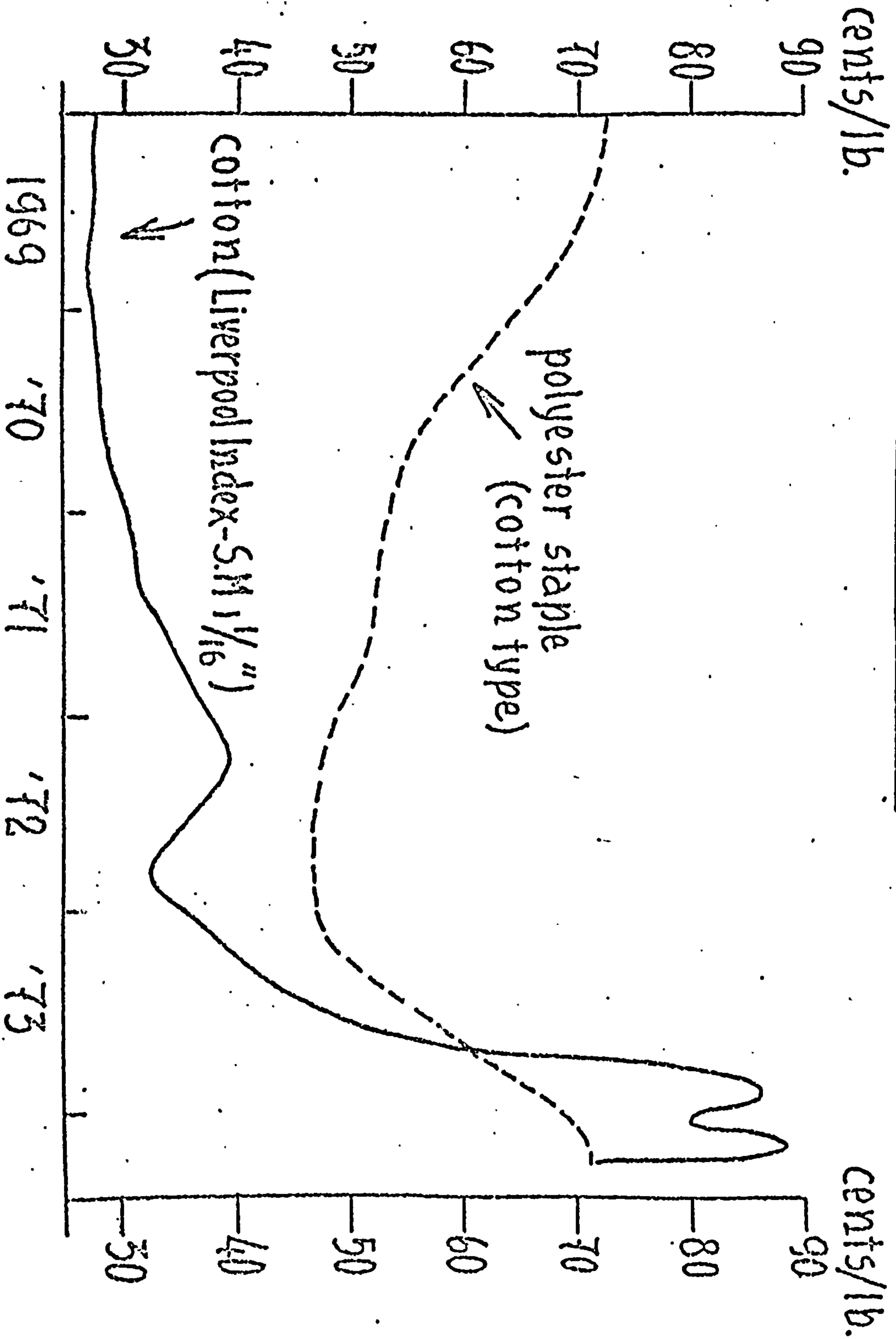
APPENDIX C

THE RECENT HISTORY OF FIBRE PRICES

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THE RECENT HISTORY OF FIBRE PRICES

FIBRE PRICES



Source: Drs. Hans E. Koadam, "Current Aspects of Inter-Fibre Competition and the Effect of the Energy Crisis"