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Marketing Logistics Systems Analysis: The Development of Heuristic Guidelines to Aid Decision Making in the Pharmaceutical Manufacturing Industry.

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ABSTRACT

This thesis describes the development of heuristic guidelines to aid logistics management in manufacturing industry, in this case pharmaceutical manufacturers, to make decisions when faced with the appraisal of alternative methods of operation. A number of research suppositions are proposed which suggest that a more formalised approach to decision making than is current practice can be implemented in assessing the total logistics costs and customer service implications of operations.

A study is made of existing research in logistics and related areas, the pharmaceutical industry in general, and in particular the logistics activities of pharmaceutical manufacturers and the service requirements of their customers. A research programme is devised whose primary purpose is to enable a comparison to be made between the implications of the research suppositions and the empirical data obtained by administering questionnaires to manufacturers and samples of customers.

A model of the decision making process is presented around the framework of a cost-effectiveness analysis. A systems approach is used to analyse a manufacturer's logistics operation, highlighting as it does the interactive effects between logistics activities. The research suppositions provide heuristic guidelines which relate an activity's position on a manufacturer's material flow path to that of the proposed change, and which assign service priorities in terms of lead time to customer types. These guidelines serve to decrease the number of considered interactions and, subsequently, to reduce the complexity of the analysis.

A number of implications of the findings for manufacturing industry in general, for pharmaceutical manufacturers in particular, and for logistics research, are presented. Suggestions are also made to aid any company wishing to apply its own logistics systems analysis along the lines pursued in this study.

CONTENTS

FIGURES

Page

TABLES

Chapter 1

Introduction to the Research

1. Terms of Reference

Whilst the author was working in industry it became apparent to him that there was a pronounced tendency for decisions, taken by managers at all levels, to be directed primarily at furthering the progress of particular departments towards their own goals, rather than towards company goals.

Within the production area, where the author was working, decisions made, or actions taken, concerning the progress of materials usually perceived other departments' requirements as a secondary consideration, and then only on an informal, and often uninformed, basis. The outcomes of many such decisions were suspected of producing sub-optimal conditions with respect to the company's overall profitability.

It appeared that this company was unexceptional in its parochial attitude towards decision-making; the same accusation could be levelled at numerous other companies, at least at an operational level.

Although a large body of literature exists, aimed at the optimisation of specific activities in various industrial situations, few attempts have been made to solve operational problems in the sense of the company as a whole.

The work that has been carried out in viewing a company as a cross-section of departments has tended to be mostly conceptual in its approach.

In military applications, more solid research information is available but this has been mostly concerned with the evaluation of new weapons systems. As a method of cost accounting, the "Planning, Programming, Budgeting System" (PPBS) was originally developed by the United States Department of Defense. It is the reverse of traditional accounting techniques: departmental budgets are determined by the demands of the missions which they serve. As such the evaluation of alternative systems becomes one of balancing costs against resulting benefits.

In an industrial environment, one study that does go some way towards evaluating the interactions between departments is that conducted by Dicer (56). His investigation exposes a very large number of departmental activity interactions, but is restricted in its capability to select only those that are significant in a particular decision-making situation.

For the purpose of this study it was decided to examine the interactions within the manufacturers' organisations of one industry. By doing so, it should be possible to investigate in depth the effects of decisions both in terms of costs and benefits to the whole company. Hopefully the results obtained could be extended to apply to other industrial situations.

Because of the author's previous experience, the pharmaceutical industry was selected for the study. This industry was considered appropriate in being represented by manufacturing companies who produce pharmaceuticals from raw materials through a series of production stages, involving repeated storage and handling operations.

The term used by many authors and people working in industry to cover the movement of materials through each of the production and distribution activities of a firm is logistics. The scope and definition of logistics must now be discussed.

2. Introduction to Logistics

A company organisation is traditionally divided into functions, such as manufacturing, finance, transport, warehousing, marketing, etc. The operations of each of these functions require specialised skills in their fulfillment.

The achievement of overall company objectives within a functional organisation will depend, to a large extent, on decisions taken by managers of individual departments. For operational, or day-to-day, decision making, the success of a departmental organisation implicitly requires that each department manager consider the needs and aims of other departments when taking decisions that could have a widespread effect through the company (108).

At the same time, however, certain evaluative techniques practised by senior management do not facilitate a high level of such cooperation. 'Management by Objectives' is an example of a technique, prevalent in industry, where the emphasis is placed on increasing the efficiency of each individual department's operations. In this way the departments might be encouraged to control and reduce their operating costs, for example. Parker (140) suggests that cost reduction then becomes the primary means whereby each department calls attention to itself.

If each department were to so optimise its own operations, then the company could be operating under a condition termed sub-optimisation.

This is a condition of apparent efficiency in the various departments, but less than optimum efficiency in the operation of the integrated whole (i.e., the company) (140).

Kotler (103) suggests that departmental conflicts are universal enough to render most company operations to be highly sub-optimal. As an illustration of this he lists a summary of organisational conflicts between other departments and marketing (102), reproduced as Table 1.1.

OTHER DEPARTMENTS	THEIR EMPHASIS	MARKETING'S EMPHASIS
ENGINEERING	Long design lead time Functional features Few models with standard components	Short design lead time Sales features Many models with custom components
PURCHASING	Standard parts Price of material Economic lot sizes Purchasing at infrequent intervals	Non-standard parts Quality of material Large lot sizes to avoid stock-outs Immediate purchasing for customer needs
PRODUCTION	Long order lead times and inflexible production schedules Long runs with few models No model changes Standard orders Ease of fabrication Average quality control	Short order lead times and flexible scheduling to meet emergency orders Short runs with many models Frequent model changes Custom orders Aesthetic appearance Tight quality control
INVENTORY MANAGEMENT	Fast moving items, narrow product line Economic levels of stock	Broad product line Large levels of stock
FINANCE	Strict rationales for spending Hard and fast budgets Pricing to cover costs	Intuitive arguments for spending Flexible budgets to meet changing needs Pricing to further market development
ACCOUNTING	Standard transactions Few reports	Special terms and discounts Many reports
CREDIT	Full financial disclosures by customers Low credit risks Tough credit terms Tough collection procedures	Minimum credit examination of customers Medium credit risks Easy credit terms Easy collection procedures

Table 1.1: Summary of Organisational Conflicts Between Other Departments and Marketing

(Source: Kotler (102))

It is reasonable to suppose that the list presented in Table 1.1 can be expanded to include conflicts amongst the departments themselves. Dicer's research (56) exposes the existence of conflicts among each of eight departments within the distribution function (Traffic, Warehousing, Inventory Control, Plant Location, Packaging, Documentation, Materials Handling and Production Planning), between each of these and the other departments of the larger company organisation (including Marketing), and also with the environment external to the company.

Kotler's observation would therefore seem to be justifiable:

> "While departments are an efficient means for carrying out and controlling specific types of business activities, they are less defensible as a source of policy on issues that have inter-departmental significance ....."
>
> (Reference: Kotler (103))

In many companies, the organisation is structured into departments which fall under the domain of either the Production Director, the Marketing Director or the Finance Director. Table 1.2 lists a typical array of such departments and the type of director to whom they may have to report.

In a company organisation, such as that represented by Table 1.2, it is unreasonable to assume that the Managing Director will have either the time, or the available information, to resolve operational, or day-to-day, conflicts. However many production and financial activities involve highly complicated decision issues whose resolution makes an impact upon marketing strategy. In turn marketing decisions can have a very pronounced effect on production and financial activities. There is thus a necessity for coordinating the decision-making process within the three areas if overall company profits are to be maximised. However Kotler (103) notes that, in spite of the desirability of joint interdepartmental decision making for many types of company decisions, there is a strong departmental bias in practice.

Production Director	Marketing Director	Finance Director
Production	Inventory Control	Accounting
Production Control	Quality Control	Credit Control
Storage and Warehousing	Customer Service Policies	Order Processing
Transport	Customer Complaints	Invoicing
Packaging		Documentation
Materials Handling		
Purchasing		
Facilities Location		
Order Preparation		

Table 1.2: Typical Departmental Responsibilities of the Production, Marketing and Finance Directors

One type of decision is that concerned with the supply of materials and information between each of the departments. Such decisions do not only require the meeting of internal company cost requirements but also require that the needs of customers are met. In this respect, the divisions of production, marketing and finance are all directly involved. A customer's order would be received by the company's order processing department (finance division), his material requirements supplied by the transport department (production division), and any complaints he might have received by the customer complaints section (marketing division).

This particular decision area concerned with the supply of materials and information is a very wide one covering many department activities. It is given the name of logistics, materials management or physical distribution management. A number of definitions should serve to distinguish between each of these terms and to define the area of interest more closely.

Definitions:

La Londe et al (106) present a schematic of the company's (the manufacturer's) operations and its links with its distributor and customers, in order to illustrate the scope of the terms: business logistics, materials management and physical distribution management. This is reproduced below as Figure 1.1.

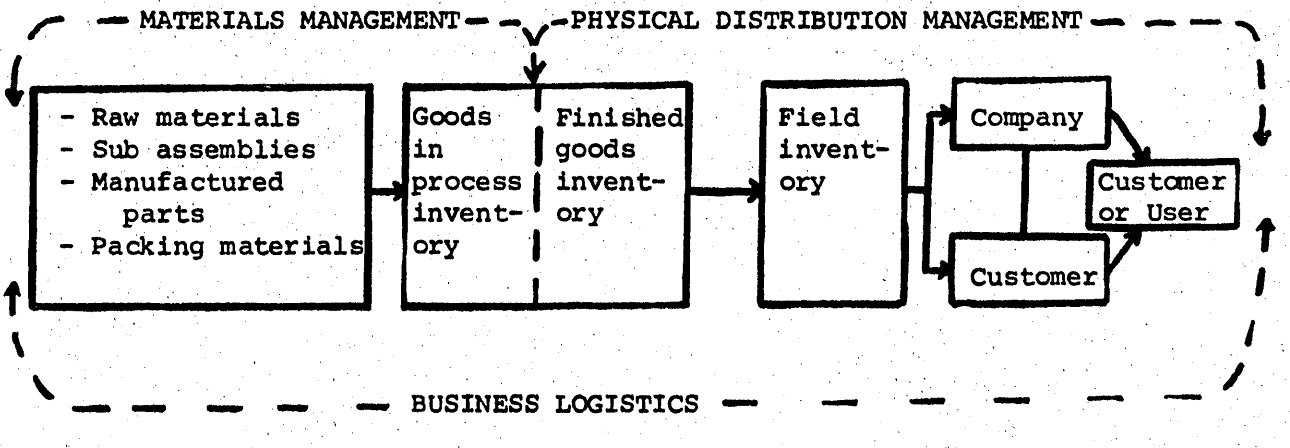

Figure 1.1: Schematic Illustrating Distinction Between Business Logistics, Materials Management and Physical Distribution Management

(Source: La Londe et al (106))

Bowersox et al (19) define materials management as:

> "..... that aspect of industrial management concerned with the activities involved in the acquisition and use of all materials employed in the production of the finished product. These activities may include production and inventory control, purchasing, traffic, materials handling and receiving".

(Reference: Bowersox et al (19))

Bowersox (16) defines physical distribution management as a:

> "..... term employed in manufacturing and commerce to describe the broad range of activities concerned with the efficient movement of finished products from the end of the production line to the consumer, and in some cases includes the movement of raw materials from the source of supply to the beginning of the production line. These activities include freight transportation, warehousing, materials handling, protective packaging, inventory control, plant and warehouse site selection, order processing, market forecasting and customer service".

(Reference: Bowersox (16))

Logistics is defined as:

> "..... the art and science of management, engineering and technical activities concerned with requirements, design and supplying and maintaining resources to support objectives, plans and operations. It is a broad field of endeavour consisting of many inter-disciplinary activities".

(Reference: Henn (81))

The logistics concept stems from its application in the science of military tactics and warfare (156). Its extension to use in business can be summed up by referring to La Londe et al (106) who define Business Logistics as:

> "..... a term which denotes a total approach to the management of the distribution process including all of those activities involved in physically moving raw materials, in-process inventory and finished goods inventory from point of origin to point of use or consumption.

(Reference: La Londe et al (106))

As indicated by Figure 1.1:

BUSINESS LOGISTICS = MATERIALS MANAGEMENT + PHYSICAL DISTRIBUTION MANAGEMENT

Business Logistics is of increasing importance to companies through its ability to bridge the gap between production and marketing interests. It can work closely with marketing to maintain, or to improve, standards of customer service. It can coordinate with production to minimise total costs of manufacture and distribution.

Many commentators state that the concept of logistics management is going to be the next major change to be commonly adopted by business organisations (145). In many firms the change has already begun. Logistics management is elevated in some company hierarchies and exerts substantial influence over many activities and the decisions concerning those activities, where the effects of those decisions might have far reaching effects throughout the company.

3. The Background to the Study

Prior to carrying out this study the author spent four years working in the production and production control section of a multinational pharmaceutical manufacturing company. There the apparent need for a greater formalisation of decision-making procedures stimulated the author's interest in logistics management studies.

In that company decisions were made in individual departments, (production control, warehousing, inventory control, packaging, etc.) with a view to benefiting the operations of those departments, subject to fixed constraints as to the operating requirements of other departments. The author felt that if an overview could be taken of all departments' operating requirements, and that they be treated, instead, as variables in any decision-making situation, the interests of that company, as a whole, could be better served.

The structure of the company's organisation did not, however, encourage such an approach. The individual departments were the responsibility of either the production, marketing or finance directors. No logistics management section existed in the organisation to take an overall view of all departments' operations and requirements. Furthermore, as no common logistics objectives could be laid down, especially with respect to levels of customer service, each department tended to work solely towards the achievement of its own predetermined goals. Minimising costs in one department is not necessarily compatible with the overall business objective of minimising total company expenditure. Opportunities for profit enhancement were therefore seen to be being missed.

A situation which fairly well typified this apparently restrictive view of decision-making was in the assessment of alternative courses of operation for one department. For instance, the decision to increase the length of a production run in order to obtain manufacturing cost savings (increased overall yield and reduced clean-down time) was considered only in as much that it would reduce the inventory levels of certain products below a prescribed safety level. The safety stock levels were laid down by a marketing department in a European headquarters. There was no liaison between marketing's customer service policies and the logistics operation, or considerations in savings in other areas such as warehousing and purchasing.

The need for a more formalised approach to decision-making within the company seemed to be required; an aid that would enable an executive with logistics management responsibility to assess the effect of departmental proposals on the company as a whole.

Solution of the problem was thought to require a conceptual approach since the problem situation did not appear to be just specific to that company, or even just to pharmaceutical manufacturers. For this reason an academic solution was sought.

The 'total' approach to logistics:

In recent years there has been an increasing emergence from academic sources of 'the concept of physical distribution management' and 'the total approach to logistics'. The former regards physical distribution as being able to contribute towards the marketing effort in providing a service to customers, as well as providing the transportation back-up to production (109).

The total approach to logistics takes advantage of being able to trade off an increased cost in one department in order to achieve reduced costs and/or increased benefits in another department and thus produce a higher overall profit (6). The total approach views departments within a company as an interconnected whole, so that their interrelationships must be considered when making logistics decisions.

It was felt that the total approach could provide the basis for researching into the process of logistics decision-making in international pharmaceutical manufacturing companies.

Christopher (36) presents the approach as synonymous to a systems approach where the whole logistics operation is seen as one system, composed of a group of sub-systems, which in turn can each consist of groups of components.

He adopts the phrase integrated distribution management, as does La Londe (105), which recognises the interrelationships between the parts of the whole such that action affecting one part must affect all others. He states that:

> ":.... any action taken must therefore be considered in the light of its effect on all parts of the business and on the aims of the whole, which are of prime importance ....."
>
> (Reference: Christopher (36))

This approach ensures that sub-optimisation of individual departments' operations is less likely to occur.

This is in contrast to the many examples of optimisation of individual problem areas reported in the literature. Operations researchers have been particularly active, formulating optimised solutions among a restricted number of variables (12, 13). The total approach to logistics problem solving views these optimisations as being potentially sub-optimal to the whole company, in that they represent solutions to single problem areas, either disregarding completely, or having a limited regard for, the effects in other sections of the firm. These efforts were symptomatic, it was felt, of the decision-making shortcomings in the company where the author had previously worked.

In many companies only lip service has been given to the total approach. This could be a reflection of the difficulty of cutting across businesses' traditional organisational lines in order to incorporate all departments in a single logistics analysis.

Christopher (36) shows how this can be done through the method of distribution mission analysis in conjunction with a total logistics approach. A distribution, or logistics, mission is a set of goals for the logistics operation. They represent specific policies with respect to logistics costs and/or levels of customer service. The achievement of these missions requires effort, cooperation and, possibly, sacrifice from each department involved in the logistics spectrum.

Previous research into the analysis of companies' logistics operations has tended to be either conceptual in its approach, or, at the other extreme, restricted to optimising particular activities within the firm. Neither of these is directly appropriate as an aid to decision-making by logistics management generally. No work has been reported on analysing the logistics operations of pharmaceutical manufacturers in relation to their contribution to total company costs and customer service levels.

A few years ago the National Economic Development Office commissioned two studies (130, 131) to be carried out on the pharmaceutical industry. The first of these is primarily concerned with the structure of the industry, the nature of its operations, its relationship to Government, and its products. The second is concerned with the international marketing of pharmaceutical products from Great Britain. Neither of these studies attempts to recognise the logistics activities of the pharmaceutical manufacturers as a total operation and to relate them to an overall cost or measure of customer service. They are pre-occupied with marketing and production activities, viewing distribution solely as a transportation expense and, as such, a small contributor to total costs.

Whilst a very sizeable body of literature exists on the promotional and pricing strategies for pharmaceutical products, the manufacturing companies are notoriously reticent concerning their cost and profit figures. Very little information is thus available on the distribution activities of pharmaceutical companies.

It is felt that the gulf between production and marketing interests within a firm can be bridged to a large extent by logistics management playing a major role within the organisation. In order for decision-making by a logistics manager to be effective, it is necessary for him to perceive the scope of logistics as a coordination of inter-connected parts, the performance of the whole being measured both in terms of its total cost and the benefits to the company that it provides.

It is against this background therefore that this thesis reports the development of a decision-making approach to logistics management in considering alternative proposals for modifications to the existing company operation.

4. Statement of the General Research Hypotheses

Following a review of the logistics literature it became apparent that there were a number of shortcomings in the traditional analyses of logistics operations. Most of these tended to concentrate on one, or a few, aspects of departmental activities comprising the logistics spectrum. This narrow outlook is considered too restrictive to comply with the total logistics concept, as previously expounded. In addition traditional analyses tend to ignore the performance of the logistics operation and are essentially exercises in cost minimisation.

In strictly economic terms, the performance of the logistics operation should be measured by its contribution to sales revenue. As will be suggested later in the thesis, this is somewhat impractical and the level of customer service offers a more readily quantifiable criterion, reflecting as it does on customer goodwill.

The following general hypothesis emerged:

> Logistics managers need to recognise the interactive effects between departmental activities upon total logistics costs and levels of customer service if decisions taken by them are to benefit the company as a whole.

The research study is therefore structured in an attempt to identify the individual logistics costs for a pharmaceutical manufacturer, and the criteria of customer service pertaining to the distribution of pharmaceutical products. It is further designed to propose an aid to decision-making by isolating only those interactions and service criteria which would be relevant to a particular decision. It was envisaged that the type of decision typically encountered would be the consideration of an alternative proposal as a modification to the existing logistics operation.

Dicer's (56) investigation into the international logistics operations of companies in numerous industries, referred to previously, identifies an abundance of activity interactions within the typical operation.

It is, however, impossible for any manager to consider such a wealth of contributory effects when taking a decision.

Dicer reduced the number somewhat by conducting a survey to obtain the opinions of managers on what effects were relevant, and what were not. It is felt here that some more formalised approach is necessary in order to identify those interactive effects that are relevant to the situation in question. In the preliminary formulation of such a guideline, the following hypothesis suggested itself:

> Logistics costs are incurred whenever a material changes its form, place or time utility.

It has been suggested that logistics functions create time and place utility, and that production functions create form utility. Following on from the above hypothesis it is thought possible to group the logistics functions, or activities, of a pharmaceutical manufacturer according to the type of utility they change. Thus a classification of logistics activities will be made in terms of a measure of utility value, as much as they contribute to an overall objective or objectives.

It became apparent during the literature review and the initial consideration of the research problem that the manufacturer cannot assume the service needs of all his customers to be the same. Indeed Christopher and Wills (39) suggest that it might be appropriate to attempt to define segments of customers according to their service requirements.

Against this background a further hypothesis emerged:

> The performance of a manufacturer's logistics operation requires to be measured in terms of the service criteria appropriate to each type of customer.

The choice of appropriate service criteria and categorisation of customers for a company will depend upon the type of industry and the distribution channels employed.

Research Suppositions:

Leading from the previously stated research hypotheses a number of research suppositions will be proposed in the thesis, and a research programme designed to test the validity of each of them.

Intuitively the opinion was formed that if a material's utility value is changing through the logistics operation then this value will be increasing as the material passes through the company from raw materials acquisition towards finished product delivery to the customer. Here then is the necessary means of examining logistics activities in such a way that their interactive effects can be relatively assessed towards a common goal of increased utility. From this argument emerges the following research suppositions for both cost and time effects:

> If an activity appropriate to a conversion point(s) is operationally changed, then its cost and time effects on the type of utility represented by that point(s) will be reflected most by the other activities appropriate to the same conversion point(s).
>
> The changed activity's cost and time effects on the types of utility not represented by the appropriate conversion point(s) will be felt most by activities corresponding to the nearest conversion point(s) on the material flow path.

The concept of 'conversion points' will be discussed in greater detail later in the thesis but at this stage may be described simply as a step in the logistics process when some change occurs in the time, place and form utility of the materials in the system.

Specifically, for pharmaceutical manufacturers, three criteria of customer service will be selected: lead time duration, lead time consistency and lead time flexibility. In this context lead-time duration may be defined as the period of elapsed time between the customer placing an order and his taking receipt of the completed order. Lead-time consistency relates to the variation in lead-times experienced by a customer in placing similar orders on the same supplier over a period of time. Lead-time flexibility refers to the ability of the supplier to adjust his delivery schedule to meet the requirements of the customer. It is perceived that categorisation of a pharmaceutical manufacturer's customers can be made according to their type of institution: pharmaceutical wholesalers, hospital pharmacists and retail chemists. As a result three research suppositions emerge linking appropriate service criteria to each of the customer types:

Lead time consistency is a primary criterion of customer service for pharmaceutical wholesalers.

Lead time flexibility is a primary criterion of customer service for hospital pharmacists.

Lead time duration is a primary criterion of customer service for retail chemists.

5. Related and Supportive Research

Reference is now made to a number of research studies which support the previously stated hypotheses. As an introduction to the development of ideas in the main body of the thesis, reference to theories from other disciplines is also made where these have important implications for this research study.

The Systems Approach as a Technique for Analysing the Logistics Operation:

The early work of von Bertalanffy (14) in propounding a general systems theory heralded the use of a systems approach in analysing a large variety of complex operations. Cleland and King (42), in taking a systems approach to tackle general management problems, consider that the recognition and use of system interactions and interdependencies, as part of the manager's job, is today more essential than it has ever been before.

In studying particularly the complexity of the logistics operations of companies Christopher (37, 38) introduces the technique of logistics systems engineering which encourages a wider view of any logistics problem under consideration, and provides a systematic approach to its solution. This is in contrast to many earlier optimisation research studies which concentrated on only one part of the logistics operation and failed to give consideration to the interactions between the parts involved.

The framework of the logistics systems engineering approach will be brought out in detail in a later chapter.

Some notable large scale research studies into the design of physical distribution networks have been carried out. One of these by Bowersox et al (18), and his associates Helferich (79), Lawrence (108) and Marien (117) develops a powerful dynamic simulation model of the physical distribution process, from a basis of a systems analysis which first identifies the components of the process, and then develops programmed routines for each of them. A firm using this simulation model can hope to assess the financial and customer service implications of alternative physical distribution designs.

In a comprehensive study of the development of marketing management in larger ethical pharmaceutical companies, Palmer (139) compiles the advantages gained by those firms who have taken a systems type approach to structure their organisation.

Feature articles on two large ethical pharmaceutical manufacturers in the U.S. (167, 168) highlight how they have recognised the need to consider interactive effects between their logistics activities. In addition one of them (167) recently set up a customer service department to work in close liaison with the other groups in the logistics operation.

Formulation of Models to Reduce the Number of Interactive Effects:

Identifying the specific interactions within a logistics operation is a preliminary task in the logistics system analysis. It is aptly demonstrated by Dicer (56) who found 1,128 interactions in his attempt to build a theory of international logistics. When faced with such a formidable number of effects, Cannon's (29) perceived drawbacks to the systems approach take on some relevance:

i) The lack of any goal formation process which is so crucial to corporate performance.

ii) The difficulty of empirical investigation; the current literature on distribution research having consistently failed to suggest empirically testable hypotheses.

It is hoped that the postulated research suppositions, concerned with limiting the numbers of cost and time effects, will prove to have countered the second criticism of the systems approach.

In the selection of locations for warehouses, Kuehn and Hamburger (104) produce a set of rules for restricting the total possible number of sites. In this way the simulation (the selection technique used) is greatly simplified in only considering a feasible set of alternatives. These rules are termed a heuristic programme.

The previously stated research suppositions can also be regarded as heuristic rules since they attempt to limit the number of alternatives to a feasible set. They are, however, more broadly based than Kuehn and Hamburger's in that they apply to any logistics decision making situation.

The use of a flow path to represent the interconnection of activities or decisions has been used in operations research applications for many years. For instance, Jewell (95) constructs a basic logistics flow network and calculates the optimal flow patterns through it. At each of the distribution points, or nodes, he applies a multiplying factor to the flow to demonstrate how it has been augmented or partly absorbed en route. This augmentation might be considered equivalent to the progressive increase of utility value of material flowing through the company's logisitcs system.

Flow diagrams are used by a number of researchers (e.g. Bowersox et al (18)) to represent the physical distribution channel networks for a manufacturer, i.e., the physical links between plant and warehouses and customers. They have also been used to depict the decision sequences of company management when faced with a particular problem. For instance, Walson and Terry (172) use this method of analysis in identifying, and then quantifying, the factors considered relevant by management in the selection of distribution channels.

Customer Service Criteria as a Measure of the Logistics Operation's Performance:

Rider and Ostrom (145) propose that logistics will be the next major change that business will commonly adopt. They state that:

> "..... The logistics function furnishes a necessary ability to continue profit enhancement in a market place where ability to deliver will be the measure of success ....."
>
> (Rider and Ostrom (145))

Walters (177) considers that logistics management have failed to recognise the revenue generating possibilities of improved service, even though they have made great cost savings through applying a total cost approach in their business. He claims that this neglect is due to a failure to recognise the importance of physical distribution service and the difficulty of determining the level of service which contributes most to the firm's profits.

Three characteristics of lead time will be selected later as being the measures of customer service most suitable for evaluating the performance of a pharmaceutical manufacturer's logistics system. These characteristics are lead time consistency, lead time duration and lead time flexibility. Previously stated research suppositions relate each of these characteristics as the primary service criterion for a group of customers. Substantiating evidence for the selection of these three lead time characteristics is provided by Christopher and Wills (39) who reviewed a number of contributions from other researchers in the area of customer service related to both consumer and industrial products. Christopher and Wills suggest that, of the three service criteria, lead time consistency is the most important. They go on to conclude that, instead of grouping customers or accounts by the volume of business placed, location, or type of company, it may be more appropriate to attempt to define segments of customers according to their service needs.

Summary

Persistent examples of isolated decision-making in a pharmaceutical manufacturing company prompted this research effort. The author felt that the lack of consideration to other departments in the firm was causing it to incur excessive overall expenditure and missed opportunities for profit enhancement.

Ideally the gap between production and marketing in a firm could be bridged by logistics management. The decision-making role of such a manager could be greatly facilitated if a formalised procedure existed for reducing the extreme complexity of the interrelationships within the firm down to a manageable number; at the same time not losing sight of the firm as a single, whole operation.

The techniques, associated with the total systems approach and, resulting from this, logistics systems engineering seem to point the way to a solution.

Hypotheses are formulated, centred around the materials flow path through the firm, which could provide this necessary formalisation and aid the logistics manager when considering alternative courses of action. A programme of research will be described to both develop and test within the pharmaceutical industry a number of research suppositions resulting from the hypotheses.

Any assessment of alternative logistics proposals should balance both the costs and benefits to the firm. Selecting the primary output of the logistics system as customer service, hypotheses will be formulated and tested to show how levels of lead-time criteria are perceived by each of the main groups of customers within the selected industry.

The research suppositions will form a set of rules aimed at reducing the complexity of the logistics analysis. As such they are known as heuristics, or heuristic procedures.

Chapter 2

Introduction to the Pharmaceutical Industry

Introduction

The purpose of this chapter is to present the background environment against which the research study was conceived.

The pharmaceutical industry is discussed in the context of the objectives of the study with particular reference to the operations of pharmaceutical manufacturers in Britain. The operations of particular interest here are those concerned with the production, marketing and distribution of ethical pharmaceutical products to overseas markets and to customers at home.

The logistics management of the pharmaceutical manufacturer has to base its decisions on the complex of conflicting interests within such an organisation. Before discussing the decision making processes in more detail in later chapters, it is essential to have the background of the pharmaceutical industry in mind.

Most of the information contained within this chapter comes from the author's own working experience of the industry. Supplementary data and writings are included from a number of selected literature sources. This literature is drawn from a wide variety of areas either directly concerned with, or bordering on, the pharmaceutical industry.

1. The Pharmaceutical Industry in Britain

There are 91 pharmaceutical manufacturing companies in Great Britain registered as members of The Association of the British Pharmaceutical Industry (4) (ABPI). About 30% of these are foreign owned, either by parent companies in Europe or in the United States.

These companies have extensive manufacturing, marketing and distribution operations in Great Britain that are used to serve overseas markets, as well as the home market in Britain. The high value of pharmaceutical exports, £301.6 million in 1974, compared to the value of pharmaceutical imports, £92.2 million (4), indicates the significance of exports to the pharmaceutical manufacturers operating in Britain. The value of these exports from Britain almost equals the value of the total prescription sales to the National Health Service (N.H.S.), the home market (3).

The output of the pharmaceutical industry is continuing to expand at a much faster rate than for manufacturing industry in Britain as a whole. Production of pharmaceutical chemicals and preparations increased at 11% per annum between 1963 and 1970, compared with 6.8% for the chemical industry and 3.5% for manufacturing in total (3).

It was forecast that world sales of pharmaceuticals are expected to double between 1971 and 1980 (33, 182).

Most of the larger pharmaceutical companies have substantial investments in research facilities in Britain, the estimated annual expenditure having reached £50 million in 1974 (4).

Pharmaceutical products:

Many of the larger pharmaceutical manufacturing companies in Britain have diversified away from ethical pharmaceuticals into such fields as veterinary products, animal health compounds, cosmetics, over-the-counter medicines, foods, medical equipment, etc. Details and further examples of the diversification policies of pharmaceutical companies are given in a report by the author (76). Palmer (139) particularly notes the continuing tendency for mergers and acquisitions.

Although ethical drugs represent the largest potential source of income to a company, the diversifications guarantee a more stable profit level. This stability is essential to companies with considerable investment in new drug research; the risk factor in discovering new products is increasing, the competition between companies searching for new products is increasing whilst the rate of drug innovation is decreasing.

Market concentration:

A financial analysis group's review of the pharmaceutical industry (77) calculates that the sales by the top 5 companies in Britain represented two-thirds of the total produced by the top 60 companies surveyed. The bottom 20 companies represented only 4% of total sales value. On this basis the report concluded that the pharmaceutical industry was somewhat oligopolistic.

The National Economic Development Office (NEDO) notes a fall of over 7% in the number of firms in the British pharmaceutical industry between 1963 and 1968 (130). It also hotes features in the development of the industry, in marketing, in research and in production, which indicate the increasing advantage of size. It predicts that the number of very small firms is likely to decrease, and that medium sized firms will have to find ways of achieving rapid growth if they are to cover a range of market segments.

The concentration in the world's ethical pharmaceutical market is very low. The market leader holds only 3 - 4% of the world market (32).

Type of Facilities in Britain:

There is a considerable variation between pharmaceutical manufacturers in the type and extent of facilities which they operate in Britain. Some have large scale manufacturing and research centres coupled with marketing and distribution operations to serve the home and overseas markets. Others with only finishing production facilities market and distribute to the home market and, maybe, a restricted number of overseas markets. Others consist of only a marketing and distribution centre, serving only the home market.

2. The Multinationality of Pharmaceutical Manufacturers

Overseas growth:

Since the 1940's the major pharmaceutical companies have rapidly expanded overseas, both in their sales, which for many exceeds their domestic sales, and in the establishment of overseas manufacturing, marketing and distribution subsidiaries. Companies now deliberately seek new products which can be patented and marketed in specific national markets.

NEDO (131) reports that a company's immediate task in developing overseas markets is to acquire direct marketing control. The report notes that, to do this, it is usually necessary to establish a marketing subsidiary, which can then lead to the gradual establishment of overseas plant and local production.

This rapid growing process has resulted in large multinational companies having manufacturing facilities in as many as 30 countries and business dealings with more than 100.

The spread and location of manufacturing facilities around the world is influenced by many factors, e.g., mergers, acquisitions, sources of raw materials, transportation costs, technical knowhow, etc.

These factors tend to encourage firms to centralise their manufacturing operations with similar types of production plants in one location. On the other hand the attitudes of many foreign governments encourage a policy of decentralisation; they offer inducements to companies to invest capital in their countries by guaranteeing tax-free profits and giving capital aid. In addition certain governments are increasingly demanding more stringent controls over the production of drugs which they buy. In some cases they are not prepared to accept only a single function plant (e.g. packaging) but insist that the entire manufacturing process be carried out in their country (130).

The British Government has considerably intervened in the operations of the multinationals in this country in recent years. There is evidence to show that price and profit controls imposed by the Government have reduced Britain's attractiveness as a base for foreign pharmaceutical investment (131). Publications by the ABPI (3) and by the Director of the Office of Health Economics (163) express warnings in this respect. In fact the Sainsbury Committee report (72) points out that attention should be paid to the question of whether it is desirable, from the point of view of the British economy as a whole, to encourage the introduction or further expansion of foreign-owned firms, despite warnings from other quarters that government controls can only reduce major product discoveries (31).

The outcome of these influences is that multinational pharmaceutical companies show wide variations in their worldwide networks, with production and marketing facilities, at all stages of growth, scattered around the world.

International management organisation:

Scattered subsidiaries and diversification of product interests create many problems in the organisation of international management.

Skinner (154) poses the question of whether parent company headquarters should dictate policies to the subsidiaries, as the home office has the 'global' picture, or whether the local managements of these subsidiaries should determine their own policies as they have the local knowledge and experience?

Companies' answers to this question have differed widely, as indicated by the structures of their management organisations.

NEDO (131) illustrates these differences by giving examples of 2 pharmaceutical manufacturers, one which restructured its worldwide organisation on a regional basis, and the other which operates on a product division basis.

NEDO (131) warns that a competitive element between the manufacturing subsidiaries of a multinational company can be introduced when production activities are separated from those of marketing. Local production managers of subsidiaries may compete with one another to achieve minimum production costs in order to induce the parent company to place extra work with their plant and so enhance their status within the worldwide company organisation. This competition, encouraged by many parent companies from the U.S.,can even lead to process improvements not being disclosed by one subsidiary to others within the same organisation.

This competitive element is not so prevalent in subsidiaries' marketing activities as many company headquarters operate a group marketing department as a staff function in order to achieve an integrated corporate marketing policy (131).

Multinationals differ on their policies towards segmenting world markets to individual subsidiaries. This variance is probably a reflection on the degree of centralisation of the company's marketing activities. Some multinationals encourage marketing competitiveness between subsidiaries, as with manufacturing, whilst others arrange for their subsidiaries to only market to certain countries.

Physical supplies of materials:

> "..... all the companies, whatever the sophistication of their subsidiary networks, ship considerable quantities of pharmaceutical goods around the world. The mixture of exports and local manufacture is usually determined by the nature of the product and the opportunities and limiting factors which recipient markets present. Different levels of tariffs influence the export/local manufacture content of a company's total business and this is complicated further by the existence, in some countries, of sliding scale tariffs levied on various stages of production. Thus one company can at the same time be exporting its product in bulk raw

material form, bulk pharmaceutical form, fully finished and packed form, and also have subsidiaries producing in part or in whole ....."

(Reference: NEDO (131))

Skinner (154) ocnsiders that the great distances between overseas plants and the home office of the parent company could present great logistics and communications difficulties.

In order to overcome the difficulties in material movement and communications, and to respond to new pressures from national governments, McGarrah (125) suggests that international manufacturers would find it profitable to organise and manage their logistics functions by new means akin to those used for managing their financial functions.

3. Characteristics of Ethical Products

Ethical pharmaceuticals are medical products which can only be obtained on prescription.

They can generally be characterised as having high value, low volume and low to medium weight.

They mostly have a limited shelf life, and certain ones require to be stored or transferred under special physical conditions.

A trade product directory (169) indicates the very wide range of drug prices, varying from say 50 pence to £50 per 100 tablets, at the chemist buying level.

The prices of identical drugs can also vary from one country to another. In 1970, NEDO commissioned an international price comparison survey (129) which finds differences between country prices of an order of magnitude which cannot be just explained by problems of currency valuation, purchasing power or marketing costs. The report concludes, in fact, that Britain has become a relatively low-priced market for pharmaceuticals.

Nevertheless it is true to say that pharmaceutical products have a relatively high value-to-volume ratio.

Almost without exception, the volumes of individual products are relatively very low, consisting of capsules, tablets or dosages suitable for administering single treatments to each patient.

Liquid medicines usually have a higher weight-to-volume ratio than solids, although even with these the size of this characteristic can only be considered as medium, when compared to other consumable products, such as food.

The present day trend of switching from glass containers to ones made of plastic or polythene tends to lower the weight-to-volume ratio.

Where a product has a short shelf life, say less than a year, this can be a very important factor in determining production run lengths, inventory holdings and transit times, particularly if the product is to be exported.

The increasing practice of using air freight as an international mode of transport has significantly reduced transit times for exports. This is particularly useful for products with a short shelf life, and for those that must be stored under cool, or refrigerated, conditions. For sea freight, these products must normally be stored 'cool below water line'.

Product range:

The larger and more established pharmaceutical manufacturers usually have a substantial ethical product range, with upwards of 50 products.

Although the profitable life of most drugs may only be about 10 years, the engendered brand loyalty to a drug obliges a manufacturer not to remove it from the market. A patient, or a doctor, who has grown to trust a treatment over past years expects it to remain available.

Eventually, of course, a drug may be phased out, but the product range for most manufacturers remains very wide, with maybe 5 - 10% of their products accounting for 90% of their total ethical sales.

It is said that patents are the lifeblood of most industries that spend substantially on research (58).

Patents provide protection to pharmaceutical companies who discover, develop, test and market a new product, and who risk large financial investments in doing so, against other firms who might otherwise copy that product. In theory*, the company holding the patent has the market to itself until the patent life expires.

The more stringent safety standards experienced today and the increased complexity of present day medical problems have had two noticeable effects upon pharmaceutical research:

i) the lengthening time span for the testing of a new drug is increasing, and correspondingly, the available marketing time for the drug under patent protection is decreasing (43),

ii) the costs of research and development are increasing rapidly (163).

Both of these effects have contributed to the gradual decline in the number of drug innovations in the U.S. and Great Britain since about 1965 (43, 147).

Gale (68) notes that a declining rate of innovation would make manufacturers more reliant on their existing product range.

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* Section 41 of the 1948 Patents Act can be used by the Government to override a manufacturer's patent protection rights by importing a foreign substitute.

Product shipment sizes:

Coupled with their wide product range, a pronounced characteristic of pharmaceuticals is their diverse variety of size and shape.

Products are distributed in bottles, jars, tins, boxes, foil wraps, etc., all of varying size.

Orders are received for varying numbers and types of product items at a time.

For exports, many countries have special packaging requirements, in addition to the packet and instruction leaflets having to be written in the local language.

All these package type and size characteristics mean that the manufacturer has to deal with a wide variety of despatched shipments. Not only these but the nature of incoming material supplies vary widely; it is not uncommon for a pharmaceutical manufacturer to have more than 5,000 separate raw material and packaging component items on his stock books at any one time.

Considering, also, that a pharmaceutical product is often produced after as many as 12 separate processing stages, the variety of active, intermediate stocks is exceptionally high for a manufacturing industry that is essentially batchwise, or semi-continuous, in operation.

Categorisation of ethical pharmaceutical products:

Manufacturers may choose to categorise their ethical products on a number of bases, e.g., price, therapeutic similarity, demand, year of introduction (171).

One categorisation deserves special mention since it is common to all: degree of substitutability. The product range of a manufacturer might contain one or two products that are unique in providing a treatment for a particular ailment, or alternatively, are life-saving drugs.

Manufacturers widely acknowledge their moral obligation in always maintaining high stock levels of such products, and being able to supply them especially quickly to their customers, if required.

These stock levels and delivery speeds may be exceptional relative to the other products in the range; the products are categorised according to their moral value.

Moral obligations are usually in opposition to the strict economics of the situation. A non-substitutable product is free from competition and any lost sales due to stock-outs should not have too damaging effects upon future sales.

4. Characteristics of the Markets for Ethical Products

Most major manufacturing locations of multinational pharmaceutical companies serve nearly all, or a defined segment of, world markets.

In examining the characteristics of these markets it is convenient to consider separately the overseas markets and the home market.

Characteristics of overseas markets:

Although each country has its peculiar characteristics with respect to the import and sale of pharmaceuticals, a few generalisations are permissible.

A manufacturer usually exports to either one of the company's subsidiaries in the country concerned, or to an agent who receives a margin of product sales, the size of the margin dependent upon the extent of the service which the agent provides. For instance, he may provide salesmen and carry out promotional activities, or he may just act as a stock and distribution point.

Many foreign governments now participate directly in the overseas purchase of pharmaceuticals. Manufacturers are requested to tender for the sale and supply of certain products on a contract basis.

Characteristics of the home market:

Sales of ethical pharmaceuticals in Britain are made to the National Health Service via prescribing physicians who select the treatment appropriate to each ailing patient. The prescriber acts as a compulsory agent for the patient in this selection process.

It is important to stress the difference between two types of customer: one, the physician, is the 'product selection' customer who has the responsibility of selecting which type and brand of medicine the patient should receive, and two, the wholesalers, retail chemists, hospitals, armed forces, clinics and a certain number of dispensing doctors, who purchase and receive delivery of the prescribed products.

Manufacturers' promotional efforts are traditionally directed at the first tupe of customer, the physicians; it is in this area where competitive activity between manufacturers is most pronounced.

Bulk purchase of pharmaceuticals is a growing practice. It takes advantage of favourable discount terms offered by manufacturers. For example, instead of individual hospitals buying their requirements from a manufacturer, Regional Health Authorities (R.H.A.'s) are placing contracts with manufacturers for the supply of all the hospitals within their regions. Similarly, groups of retail chemists are increasingly making combined purchases.

The manufacturers generally encourage this trend towards fewer, larger orders by offering bulk purchase discount terms, by increasing their minimum order size restriction and by requesting that more orders be placed through wholesalers rather than directly with themselves. The contracts with R.H.A.'s now sometimes require products to be obtained via a specified wholesaler, who is appointed by the manufacturer as sole supplier to that R.H.A.

Competition within the market:

Most of the products in a manufacturer's range have numerous substitutes, available from competitors. The more established products in the range are more likely to be unprotected by patents, and as a result, usually face the fiercest competition in the market.

The competitive climate has changed somewhat in the past 10 years, or so. The declining rate of drug innovation has resulted in an increase in the numbers of rival products, and accordingly, a levelling out of price and therapeutic quality of the available substitutes.

The Government has had a considerable influence on drug prices. In 1961, the Minister of Health overrode one manufacturer's patent protection on oxytetracyclines and allowed importation of cheaper chemical equivalents from abroad, e.g., Italy,where patents are not recognised anyway. The manufacturer's appeal to the House of Lords was later turned down. Since then the Government has become increasingly involved in drug pricing enquiries, being concerned that the NHS is being overcharged by the pharmaceutical manufacturers.

The Department of Health and Social Security influences doctors' prescribing habits by keeping them informed of the varying costs of chemically equivalent drugs (34).

In 1967 the Sainsbury Committee reported to the Government on the British Pharmaceutical Industry's relationship with the N.H.S. (72). The report recommends that brand names should be abolished for new pharmaceutical products, and doctors, if they wish to prescribe a certain manufacturer's product, should write the generic name followed by that manufacturer's name.

Although this recommendation was not legally enforced, the Government have since encouraged doctors to prescribe generically as a means of saving money for the N.H.S. Gosselin (71) forecasts an increase in generic, over brand, prescribing in the U.S. prescription market.

A generic prescription enables the pharmacist to select the particular brand. Competition is particularly intense between products that are generically prescribed.

In the wake of these trends in the competitive climate, there is a tendency for price and quality of rival products to level out, and other factors to be included in the promotional spectrum. One of these, delivery service to wholesalers, retail chemists, hospital pharmacists and other sales customers, is becoming increasingly important.

5. Distribution Channels

A distribution channel is composed of the institutions through which goods successively pass from the manufacturer to the final consumer. As done previously, it is convenient to consider separately the distribution channels serving overseas markets and the home market.

Overseas distribution channels:

The nature of these channels depends upon the type of overseas marketing organisation set up by the manufacturer, e.g., own subsidiary, external agent. The details of the distribution network vary according to the medical supply requirements of each country.

Overseas distributors are selected by the manufacturer on the grounds of their national market knowledge, extent of storage facilities, size and effectiveness of their sales force, etc.

Distribution channels in Britain:

Figure 2.1 shows the product flow patterns in this country for the major institutional buyers: wholesalers, retail chemists and hospital pharmacists.

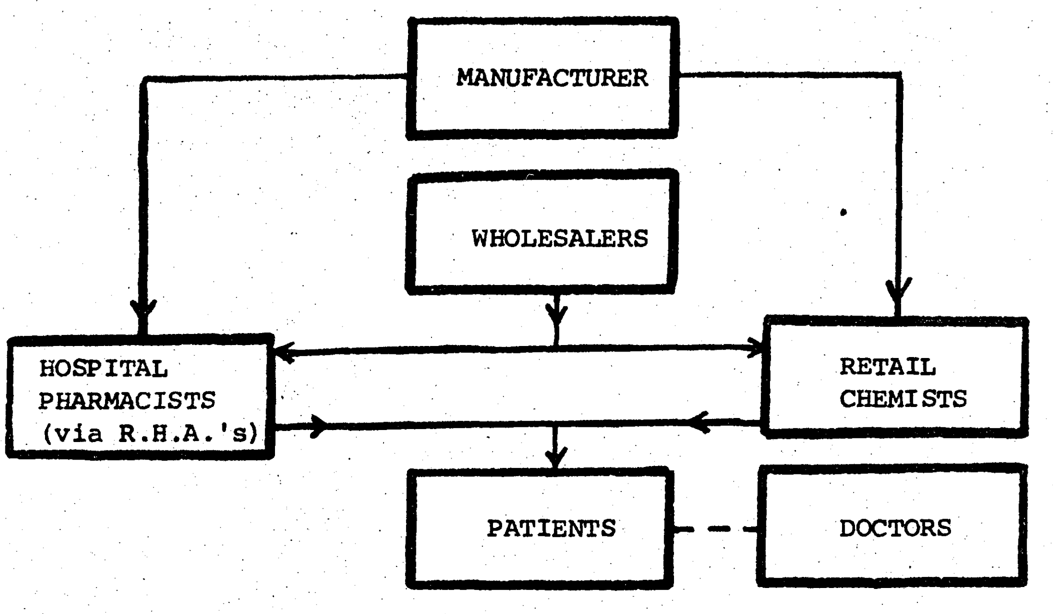

Figure 2.1: Distribution Channels in Britain showing Product Flows

A similar flow pattern is shown by Claycamp and Amstutz (41) though they indicate doctors as a separate buying group.

The quantities of medicines supplied to dispensing doctors in Britain are relatively small enough for the doctors to be omitted from this general description of distribution channels.

Each connecting line in Figure 2.1 represents a distribution channel. There are 5 channels up to the point of consumption by the patient. Each is now discussed in turn.

Manufacturer - Wholesaler channel:

Wholesalers should carry comprehensive stocks of manufacturers' products and provide a daily supply service to nearly every retail chemist and hospital pharmacy, or similar outlet. This is laid down by the code of practice of the National Association of Pharmaceutical Distributors (N.A.P.D.) (127).

The frequency of the wholesaler's distribution service is exceptional, and reflects the urgency with which the products of the industry must be supplied to the patient.

As manufacturers could not economically achieve this level of service across the whole country, they take advantage of the extensive wholesaler network for distributing their products.

The higher the inventory level that a wholesaler maintains of a manufacturer's product, the lower the stock level that the manufacturer has to keep.

Manufacturers usually request wholesalers to carry sufficient stocks to meet normal demand fluctuations; 6 weeks supply being a general level. They also encourage wholesalers to place large orders at less frequent intervals, say every 2 or 3 weeks.

The N.A.P.D. code of practice (127) requires wholesalers to maintain stocks of manufacturers' products at levels, agreed in consultation with the manufacturer, which are consistent with normal stock turnover. However the high value of pharmaceutical products means that a lot of working capital is tied up in inventories. In some cases wholesalers have bared their stock holdings down to an absolute minimum, and below that which the manufacturers would like to see.

Manufacturer - Retail chemist channel:

In saving the wholesalers' margin payments, there are financial advantages to the manufacturer in selling and distributing his products directly to retail chemists. The manufacturer can afford to offer a retailer 10% discount if he buys direct, when the manufacturer is saving, say, a 15% margin in bypassing the wholesaler.

Some pharmaceutical manufacturers have policies of never distributing directly to retailers. Their reluctance to do so is not surprising: retail accounts can comprise some 80% of the total number of accounts, account for some 80% of the total number of deliveries, and yet represent only 10 - 30% by value of the total business.

In order to discourage great numbers of small retail accounts, a manufacturer can impose a minimum order size value.

The retail chemist usually considers direct and indirect distribution as 2 distinct sources of supply: the first enables him to improve his profit margin by purchasing larger than normal quantities of products at attractive discount rates to meet a probable future demand, the second enables him to maintain a regular supply of small quantities of product items to meet a known present demand.

The chemist can usually tolerate a waiting time, from point of order to that of receipt of goods, of up to 14 days when ordering direct, but expects same day delivery when ordering from a local wholesaler.

Manufacturer - Hospital pharmacist channel:

A greater proportion of hospital pharmacists are supplied directly from manufacturers than are retail chemists. Nearly all manufacturers maintain accounts with individual hospitals.

There is a growing tendency now for R.H.A.'s to purchase supplies from a manufacturer, as part of a contract agreement, that will meet the requirements of all the hospitals within each authority.

This practice partly overcomes one major problem for manufacturers: hospitals traditionally carry very low stock levels, and manufacturers have not as great a degree of control over these inventory levels as they would like. This results in excessive distribution expenses for the manufacturer unless hospital pharmacists can be persuaded to buy more supplies through the local wholesaler.

However contract agreements do not specifically state how much product will be required by each R.H.A. The manufacturer has to be flexible enough to respond to each demand as it is made.

Manufacturer - Wholesaler - (Retail chemist) channel
(Hospital pharmacist)

There are 3 definite advantages to a retail chemist, or to a hospital pharmacist, in purchasing his ethical medicines through a wholesaler. These are:

1) the products are always locally available,

2) he is guaranteed a 24 hour delivery service, often much quicker, if he buys through a manufacturer-approved wholesaler,

3) he is not forced to buy more than his immediate requirements, since there are no minimum order size restrictions, as for direct accounts.

These advantages enable the retail chemist, or hospital pharmacist, to keep his inventory levels down to a minimum.

Wholesalers generally deliver with their own vans making regular runs in their neighbourhoods, calling once, twice, three times, or even four times a day.

The distribution of wholesalers around Britain is such that most retail chemists, or hospital pharmacists, have a choice of 3 or 4 (more in city areas) from whom they can purchase supplies.

6. The Pattern of Demand

It is appropriate here to consider, from the manufacturer's point of view, the normal demand patterns and the demand fluctuations with respect to both the home and overseas markets.

Normal demand - home market:

The demand in Britain for ethical medicines is growing slowly, but steadily, at around 10% per year (130), and remains fairly predictable.

An investment analysis report (86) records the 'rather poor growth rate' in the British market in recent years.

Wholesalers usually place orders with manufacturers at weekly, or fortnightly, intervals, and mostly on set days of the week.

Retail chemists' and hospital pharmacists' orders are generally received at fairly frequent, regular intervals since they comprise a large number of relatively small orders.

The number of product items requested on an average home order can usually be anything from about 4-30.

Bulk purchasing trends by R.H.A.s and groups of retail chemists result in fewer, larger orders.

Normal demand - overseas market:

De Zoete and Bevan (182) forecast more than a 100% increase in the value of world pharmaceutical sales between 1971 and 1980. In their report, the countries they predict to show the greatest increasing sales rate are Russia, France and Asian countries, with the U.S. showing a significant decline in growth rate whilst still accounting for approximately a quarter of total world sales.

Within the last 18 months there has been a considerable increase in orders taken from Middle Eastern countries, made richer by their higher-priced oil exports.

The demand patterns from most overseas countries are typified by fluctuations rather than by predictable order quantities. Export orders are large, infrequent (say, once every 3 months from each country), and many are subject to contract agreements with the governments concerned.

Fluctuations - home market:

There are various causes of demand fluctuations in the home market, the main ones being described as follows.

Seasonal fluctuations are fairly easy to predict since they are usually a result of the climatic conditions.

There is a traditional surge in demand in January and February, the coldest months, when the incidence of colds and influenza is at its peak. There are often very marked increases in demand for anti-hystermines in May and June when hayfever suffering is at its most critical.

Epidemics, less easy or impossible to predict, generally cause local surges in demand. Usually the victims of a local outbreak of an illness or disease will first be treated at a hospital within that area. The treatment prescribed at the hospital tends to be repeated by other doctors in the locality treating the same complaint. In this way the demand for a product on the local wholesalers can be multiplied many times and the distribution channels supplying that area need to be able to react quickly to avoid a local out-of-stock situation.

The introduction of a new product on the market, whether the manufacturer's own or a competitor's, can cause substantial downturns in demand for other products, which the doctor is replacing with the new product.

Surges in demand can be caused by the sudden popularity of a product. These surges are usually related to the level of promotional activity, but not always. They can be most difficult to predict and are often short-lived.

When a manufacturer is out-of-stock of a product, for say any longer than a week or two, this can result in serious demand fluctuations following the stock-out.

Faced with a known stock-out situation on a product, customers (especially wholesalers) tend to either increase the frequency or the size of their orders for that product to ensure, in the event of a partial delivery, that their normal demand requirements are fulfilled.

This results in a false demand picture for the manufacturer*. During the stock-out period there is a sharp upturn in demand. When the product is back in stock, and all the outstanding orders have been met in full, customers find that their resultant inventory levels so far exceed normal re-order level that they might not have to place their next order for that product until much later. The effect upon the manufacturer is an immediate sharp downturn in demand.

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* Unless he adopts a policy of no backorders. He then delivers the order to the customer, invoicing him for the goods it contains and requesting him to reorder those items that are out of stock.

Fluctuations - overseas markets:

Overseas demand, especially from the developing countries, is characterised by severe fluctuations.

Export orders are usually large and sometimes subject to contracts with foreign governments.

Most overseas distributors are expected to hold about 2 - 3 months stock, c.f., wholesalers in Britain who are expected to hold about 4 - 6 weeks supply.

Worldwide seasonal fluctuations tend to even out due to winter months in the Northern Hemisphere coinciding with summer months in the Southern Hemisphere, and vice versa.

Demand surges due to outbreaks of disease and national disasters (e.g., Bangladesh) are virtually impossible to forecast. Stocks of required products can be very quickly run down and a very flexible production schedule is necessary to satisfy further demand.

It is the policy of many manufacturers to only maintain buffer stocks for home requirements, and to supply overseas markets only to order.

7. Traditional Organisation

Organisation structures of large manufacturing companies are forever in a state of gradual change.

Revising objectives for the jobs of key management posts, establishing new staff functions, combining 2 or more departments under one manager, are all examples of the consequences of new company goals and a changed outlook on the part of the firm's top executives to how the organisation should be structured in order to meet these new goals.

There are signs of an acceptance of the total logistics concept in some companies, where the place of distribution management is gaining greater significance in those organisations as a result.

The impact of distribution management within pharmaceutical manufacturers' organisations will be the basis behind many of the suppositions of this research. However these will be brought out later. For now it is sufficient to discuss the present day organisations of many pharmaceutical manufacturers.

Divisions:

Multinational manufacturers usually organise their top management structure on a regional basis, e.g., European, Latin American, Middle-Eastern and Far-Eastern management divisions.

Some organise on the basis of their product types.

British subsidiaries are almost all structured, management-wise, around product divisions.

Often a single division exists to produce, distribute and market ethical pharmaceutical products only. Sometimes this division is sub-divided into ethicals of a therapeutically-similar type.

Departments:

Departments are the foundation of most company organisations. They exist to perform the specific tasks required in manufacturing, distributing and selling products to customers.

Typical of departments within a pharmaceutical manufacturer's organisation are Purchasing, Order Processing, Production, Warehousing, Packaging, Production and Inventory Control, and Marketing.

The traditional acceptance of departmental organisation of resources, as a means of fulfilling company objectives, is fairly universal.

Cleland and King (42) consider that the departmental structure of organisation is not conducive to the most effective achievement of company objectives. It does not facilitate taking an overall approach, where all departmental variables are considered simultaneously. At the same time, though, these authors concede that the departmental organisation structure is a workable proposition.

Christopher (36) demonstrates how traditional lines of departmental operation can be cut across, structuring the management organisation around the achievement of specific company missions. Management on these mission lines would require a major restructuring of most manufacturers' organisations.

In recognising the value of the missions approach, some companies draw together members of several departments to act as a task force, the task usually being a short-term project of an exceptional nature. Others set up staff functions to aid line management decision making in representing the overall interests of the company.

<u>The production - marketing dominance:</u>

Neuschel (132) observes that

> "..... physical distribution is rarely managed with the same effectiveness and efficiency as, say, manufacturing and marketing. Lying as it does in a no-man's land between these two functions, physical distribution performance is difficult to measure and control".

(Reference: Neuschel (132))

The majority of pharmaceutical manufacturers operate their ethical products divisions under the dual directorship of production and marketing interests.

Marketing achieves its high status in the organisational hierarchy due to the high values and mark-ups of the products concerned; product sales are essential in providing the necessary revenue for continued expenditure on research.

Production attains its place by virtue of the high level of technical complexity involved in many of its basic manufacturing operations. These can involve very complex chemical syntheses where a low reaction conversion yield can significantly lower levels of finished goods supplies, endanger stock levels, incur a high incidence of stock-outs and hence lose sales, if not customers.

The influence of marketing acts very strongly in pharmaceutical manufacturing and distribution operations.

One example of this is the sales forecast made by the marketing department which is a necessary precedent to plans and budgets used to control the annual expenditure of all departments.

Another example of marketing's influence is the often-heard policies of 'we are never out-of-stock' and 'the product always reaches the customer in sufficient time regardless of the cost'. Transportation costs, it can be argued, form a negligible proportion of total sales value from most ethical products.

How 'out-of-stock' is defined, and whether 'in sufficient time' is satisfactory from the customer's or the manufacturer's point of view are questions that will be dealt with later.

Production operations, especially the basic processes, are traditionally cushioned from short-term demand fluctuations by the high inventory levels maintained on finished goods. There are indications that these levels are now being substantially reduced on many products in order to decrease the amount of capital tied up in idle stock.

This necessitates greater flexibility in production operations and an increasing emphasis is placed on effective production scheduling.

The necessary batchwise, or semi-continuous, nature of the production processes, and the multistage character of the manufacturing operation renders it inherently inflexible and labour-intensive. This inflexibility is worsened when one considers that the product range is large (the same pieces of equipment are usually used for several production processes), and the delays incurred through quality control testing and clearance are sometimes prolonged.

It can be supposed that, as the rate of drug innovation slows down, the role of production loses some of its significance, whilst that of marketing gains. Technical ability is most needed in establishing new processes and production methods; marketing skills are most essential in highly competitive markets where established products compete against a growing number of possible substitutes.

Distribution management:

The functions of Transport, Warehousing, Order Preparation and Materials Handling are rarely the specific responsibility of an executive at director level. The distribution manager usually reports to the production director in the organisation structure of most manufacturers in this country.

This lack of status probably reflects the relatively low direct costs of distribution compared to those of manufacturing, or the values of the sales revenue attributable to marketing.

Inventory control is rarely the responsiblity of distribution mangement, usually being under the control of production or marketing management. As a result the distribution manager is not directly involved in formulating stock-out policy and the implied customer service considerations.

8. Marketing Methods

A distinction may be drawn between the marketing methods for overseas countries and those for the home market. Each is dealt with in turn.

Overseas marketing methods:

NEDO (131) reports five methods of overseas marketing, that represent a sequence of overseas market development.

1) Exports - supplying the market from production abroad, for sale by an independent party in that market. This party usually acts as a distributor and provides marketing and promotional services for the company's products within his territory.

   This method concedes control of promotion and representation to the agent, who is likely to be handling a whole range of other companies' products, all competing for his time and promotional efforts.

2) Licensing involves the granting of the right to manufacture a product together with the relevant know-how, in return for a royalty payment.

   It provides a means of entry into a market which would not be easily penetrated by other methods. It can be used to develop a market share prior to establishing a direct presence in the market.

   The merits of licensing rest very much with the terms of the negotiated agreement between licensor and licensee. The licensor tends to lose control of promotion using this method.

   NEDO (131) reports that the more fully-developed multinational companies usually now only reserve licensing methods for exceptional circumstances.

3) Marketing agreements with another pharmaceutical company involve the initiating company supplying the new product and using its partner's developed marketing or distribution abilities in the area concerned, whilst the partner benefits from commission or royalties.

   From the initiator's point of view, the object of the agreement is usually to establish the new company name in the market and to derive revenue on which future growth can be based.

   The host company takes on the sales management of the initiator's product(s). NEDO (131) warns that the main risk of the marketing agreement is that the host company may, after a time, lose interest in these products, especially if their sales have started to decline.

4) Joint ventures involve the legal establishment of a jointly-owned subsidiary undertaking. Their main benefit lies in the sharing of heavy capital expenditure.

   This method is not widely used in the pharmaceutical industry since it is not highly capital-intensive, and the non-capital advantages conferred can usually be obtained through a marketing agreement.

5) Establishing overseas subsidiaries enables the company to directly control its own marketing and distribution activities in overseas markets.

   When a company becomes strongly established in a large market, it may begin to think of setting up a local subsidiary. This can vary from just a sales office to a manufacturing complex. The latter rarely has the full capability for producing the company's range of products, and is usually dependent, to some extent, upon the parent or associated companies.

Home marketing methods:

Pharmaceutical manufacturers in this country employ a sales force of medical representatives, or detail men, who regularly visit doctors, pharmacists and wholesalers.

The manufacturer's emphasis is on the doctor visits, since doctors are the customer group who have the authority to select between manufacturers' competing brands. The representatives keep doctors informed of new products and remind them of existing ones within the range. Promotional literature is also mailed to doctors for these purposes, but sales revenue largely depends upon the success of the representatives' efforts.

Representatives' visits to the other customer groups (retail chemists, hospital pharmacists and wholesalers) are also very important in furthering manufacturer-customer contact.

When a new product is launched it is essential that adequate supplies are available with all 3 groups before the demand commences.

A doctor who, having been persuaded to try a new product on his patients, finds out that supplies are not yet available, might have little time for that manufacturer in the future. As a result sales of the company's whole product range could suffer.

Representatives inform chemists, pharmacists and wholesalers of likely future demand increases; they explain details of discount schemes; they accept direct orders; they take up customer complaints at first hand; they encourage wholesalers to place larger orders less frequently rather than smaller orders more frequently.

In the main representatives provide a close contact between the manufacturer and all members of the distribution channel, keeping them informed of developments and feeding back field information to the manufacturer.

One manufacturer has appointed nearly 1000 selected retail chemists around the country. These act as service centres, carrying supplies of the manufacturer's full product range, carrying product information literature and providing information feedback to the manufacturer with respect to his product sales.

In determining the distribution of delivery times to customers in all regions of the country, it is the practice of certain manufacturers to enclose reply paid cards with all deliveries. The customer is asked to fill in the date on which the goods were received, and to return the card. Figure 2.2 shows a typical reply card.

Code

ETHICAL DISTRIBUTORS

Dear Sirs,

We are conducting a survey on distribution times to your area. This order was despatched on .... and we should be grateful if you would indicate in the space below the date received.

Date received 197

For Office use	
	C.O.D.
	O.R.B.
	T.C.
	R.W.
	D.W.
	R.C.
	D.N.

Figure 2.2: Reply card used by a manufacturer for a survey on delivery times.

Stock-outs:

There are many kinds of stock-out situations: they may be long term, short term, localised or widespread.

The effect of any stock-out can be damaging to a manufacturer. It can lose him revenue, directly through lost sales and lost customers, and indirectly through diminished customer goodwill.

It can also incur excess costs in raising backorders and altering production schedules.

If a retail chemist, or a hospital pharmacist, is not in stock of a prescribed medicine, he may try to obtain it from one of his local wholesalers, from a fellow pharmacist, or sometimes direct from the manufacturer. If he still cannot obtain the product within a reasonable time, he will contact the prescribing doctor either directly, or via the patient, to request a substitute medicine.

Hopefully for the manufacturer, the doctor is not influenced by this failure to supply the next time he comes to prescribe that product. In this way the manufacturer has only lost one sale, not future sales through losing a customer. The doctor's attitude to the stock-out situation can vary according to a number of factors, e.g., the ease of substitutability of the prescribed medicine, the urgency with which the patient requires that medicine, the number of times similar stock outs successively recur.

One significant feature of the situation, in respect of a stock-out, is that the retail chemist or hospital pharmacist rarely, if ever, informs the doctor that a product is back in stock again. After all it makes little difference to him which brand of medicine the doctor prescribes as long as he keeps, or can quickly obtain, a supply of it.

It is the job of the sales force to keep abreast of the distribution situation; through their representations with doctors the representatives are the only people who can reclaim a lost customer.

9. Production Methods

The production of pharmaceuticals can be viewed in two stages: one, the basic (or chemical) production of the active pharmaceutical materials, and two, the processing of that material into finished goods. The second stage is called pharmaceutical production.

Basic production:

This includes the processes of fermentation, clarification, refining and organic synthesis in preparing the bulk, active pharmaceutical materials required as input to pharmaceutical production.

Since the nature of each of these processes is characteristically batchwise, or semi-continuous, intermediate products are produced and stored after the completion of each stage. These may be in the physical form of liquids, slurries or solids.

Some of the raw materials required for these processes are available from only one or two sources in the world.

The total range of raw materials is large and their storage requirements are correspondingly diverse: they may include bulk liquids, acids, pressurised liquids and gases, refrigerated liquids and gases, solids, and toxic substances requiring specialised handling.

Basic production processes are usually of a very complex technical nature requiring a great deal of professional know-how. Building new plants, or making substantial improvements to existing plants, requires considerable capital investment. The plants themselves have to be large since materials are being produced in bulk. Much of the equipment needs to be made of stainless steel, be glass-lined or constructed out of some other anti-corrosive material. Service facilities have to be installed to provide steam, refrigeration and demineralised water to the plant. Specialised storage and waste recovery equipment must be installed. Instrumentation has to be accurate and available on most of the equipment to provide the sensitive conditions required by many of the processes. The plants have to be protected by stringent safety and fire precaution equipment. These reasons provide ready incentives for multinational pharmaceutical manufacturers to centralise their basic production in only a few locations.

This is made easier when basic intermediate products from different stages of production can be moved around in bulk. This provides a degree of multinational flexibility at the earlier production stages which a policy of centralisation might not otherwise allow.

Pharmaceutical production:

This comprises the pharmaceutical finishing of active bulk materials (e.g., the addition and mixing of certain preparations), capsuling and tabletting operations, and packaging into small containers, the primary packs.

The characteristic nature of these processes is becoming more continuous with automatic machinery now readily available.

In most cases pharmaceutical production processes are fairly standard across the industry, and are technically straightforward. Therefore less technological skill is required at all levels of operation and the capital investment in plant is relatively small.

For these reasons, amongst others, pharmaceutical production plants of a multinational company are more numerous and widespread than its basic production plants.

Decentralising pharmaceutical plants can better serve the local requirements of a national market, especially with respect to labelling and packing, than exporting from a plant many hundreds or thousands of miles away.

NEDO (131) notes that when several markets are to be supplied from one production centre, considerable demands may be placed upon production and packaging flexibility to cater for the differing national requirements of formulation, preparation and packing.

The NEDO report (131) also points out that the scatter of pharmaceutical production which does exist around the world is sometimes a response by companies to external barriers imposed by foreign government trade restrictions or to overseas marketing opportunities.

Production scheduling:

The scheduling of all the production processes usually stems from an overall production plan based on a sales forecast and safety stock level policies.

The yields of active material and the raw material usages should usually be accurately known for each process. Therefore it is possible to calculate back, from knowing the required quantity of finished goods, the total outputs from each stage and the overall raw material requirements.

Since many successive production stages, both basic and pharmaceutical, are carried out in the same equipment production scheduling is an important operation in compromising between the two conflicting policies of, one, minimising equipment clean-down times (costly as this represents loss of production time) and, two, minimising inventory levels of intermediate products and finished goods. The first policy encourages long, unbroken runs at each stage; the second encourages short production runs at each stage.

Figure 2.3 shows a general material flow chart for a typical pharmaceutical manufacturing process .

Production scheduling usually compromises between these two policies, balancing the costs of inventory holding against the costs of manufacturing, by calculating an economical manufacturing quantity

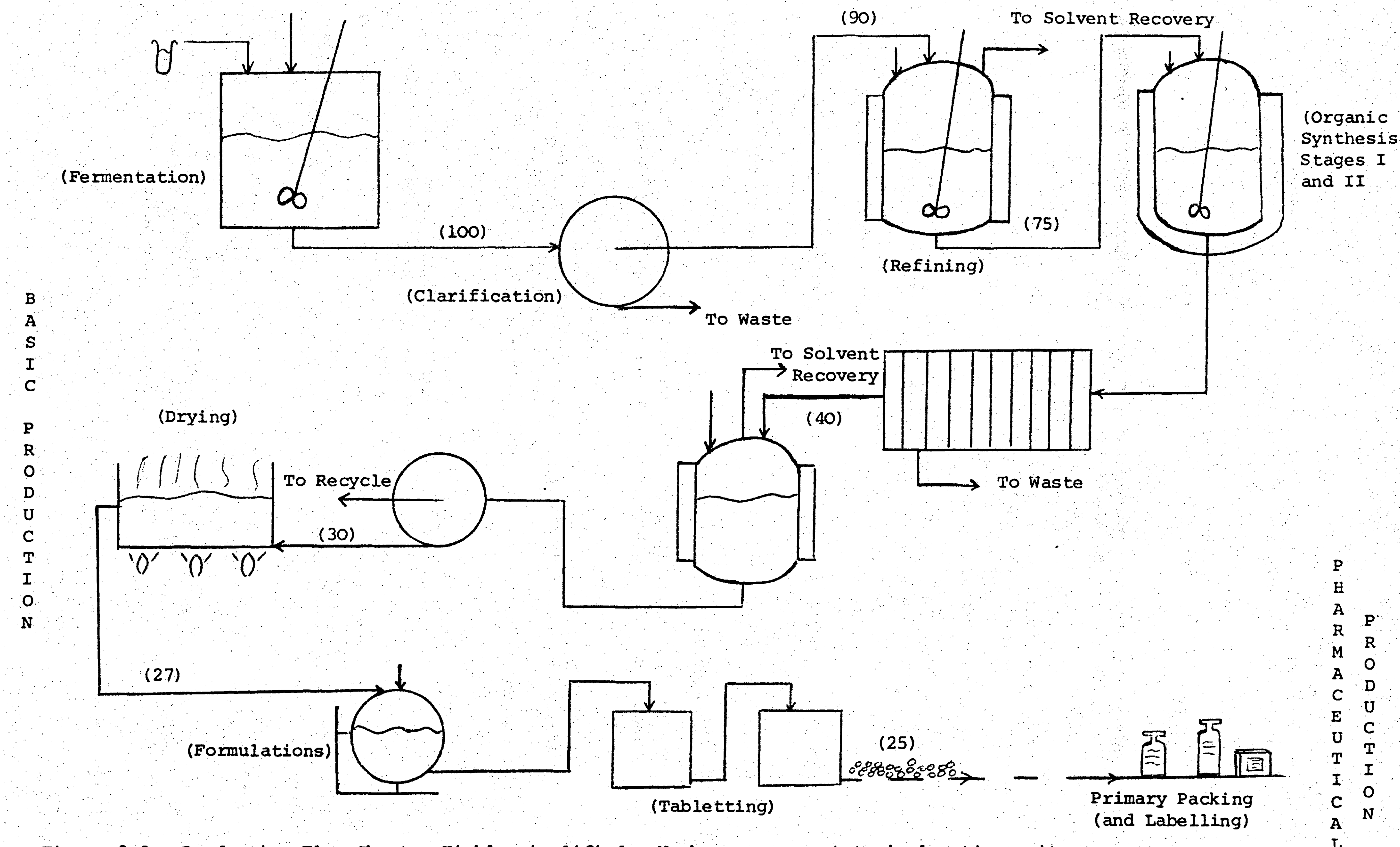

Figure 2.3: Production Flow Chart. Highly simplified. Numbers represent typical active units at each stage. Overall yield of manufacture = 25%.

(EMQ) for each product stage. The number of batches, and hence the production time, required to produce each EMQ depends upon an equipment capacity constraint, the processes being of a batchwise, or semi-continuous, nature. Equipment constraints are more restrictive than labour constraints since, as Hirsch (85) notes, the labour force is easily moved from one production line to another.

The fundamental policy behind production scheduling for most basic production processes is to maintain nil inventories of active materials. Of course, in practice, this is usually impossible to achieve for a multistage operation where there are always active intermediates held as work-in-progress, or as surplus resulting from an above standard yield at any stage.

It is generally considered undesirable to hold large stocks of active intermediates for the following reasons:

i) they represent a substantial investment,

ii) unless thoroughly dry they can be unstable and decompose,

iii) the inflexibility that the carrying of zero intermediate stocks gives to production has traditionally been offset by substantial safety stock levels held as finished goods.*

The level of inventory investment in finished goods stocks depends upon product value, turnover, uncertainty of demand (as this will affect safety stock levels), degree of product substitutability and level of urgency with which the medicine is normally required. A combination of these factors can be used to categorise products, say, A, B and C. This is the foundation of the classical A-B-C method of inventory control.

This method can also be used as a guideline to schedule production.

Products category A, and preceding intermediates are produced in frequent, short runs (say, 10 - 12 per year), resulting in short overall lead times through the production sequence.

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* Carrying high stock levels as finished goods may appear to be in opposition to i) and the general economic principle of maintaining stocks where they are of least value. The complex multistage nature of pharmaceutical manufacture and the everpresent uncertainties of satisfying quality control at each stage can make it more of a favourable proposition for the manufacturer to maintain safety stocks as finished goods ready for despatch.

Products category B may be scheduled for, say, 4 - 6 runs per year, whereas products category C are made at whatever times become available; nobody is particularly worried if 12 months stock of a category C product is made during one run.

Figure 2.4, below, illustrates a typical bar chart for a pharmaceutical manufacturing schedule.

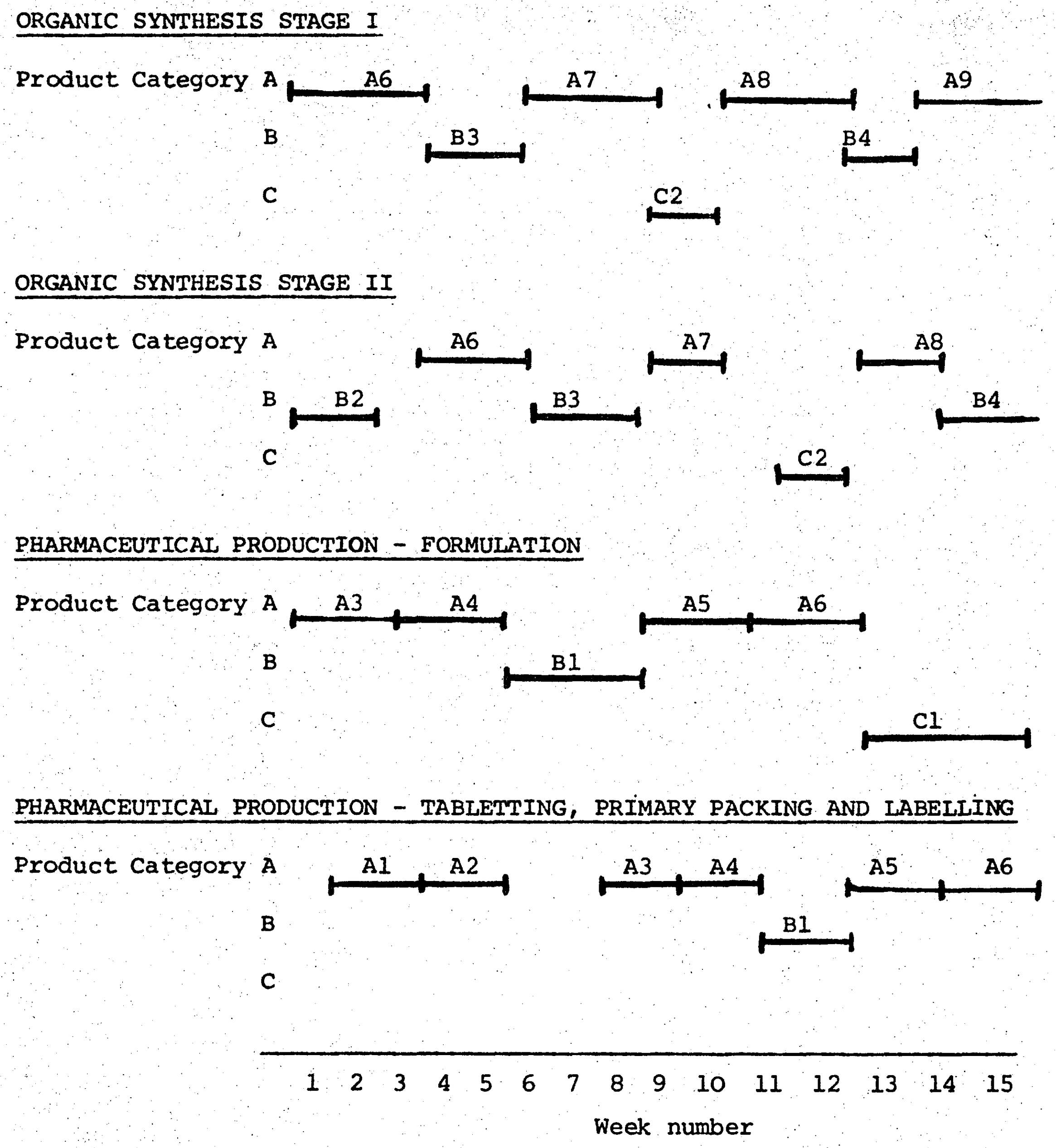

Figure 2.4: Typical Production Schedule for a Multi-Product Situation. Only 3 products (one in each category) shown for only 4 process stages.

10. Distribution Methods

This introductory chapter restricts distribution to including only those activities associated with the movement of materials from the point of completion of manufacture to the point of receipt of goods by the customer. These activities are Storage and Warehousing, Order Processing, Order Preparation and Packaging, Inventory Control, Materials Handling, and Transportation.*

In considering these activities, a distinction can be drawn between distribution to overseas markets and distribution within the home market.

Overseas distribution:

In penetrating foreign markets Stuart (162) considers that one of the major problems to be solved is how to deliver the products to the overseas distributor.

It was pointed out earlier that NEDO (131) reports how pharmaceutical manufacturers ship considerable quantities of goods around the world between overseas subsidiaries.

These goods can be as bulk raw materials, bulk intermediates or packed finished goods, depending upon whether the subsidiaries are producing in part or in whole. When no subsidiary exists in an overseas market, only a local distributor, then the exports will usually consist of packed finished goods.

Production for overseas requirements is usually carried out after the order is received, i.e., manufacturing on a per order basis.

The export orders are large, often based on a contract agreement between the foreign government and the manufacturer, following acceptance of the manufacturer's submitted tender.

The required lead time between order placement and delivery for exports is often several months; overseas stocks are traditionally maintained at far higher levels than stocks at home.

Exports can be either paid f.o.b. or c.i.f.** by the overseas

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* The scope of distribution management will be widened in the following chapters when company logistics is considered.

** f.o.b. "free on board" essentially means that the consignor pays for the movement of goods to the point of embarkation; the consignee pays for the transport of the goods from there to his premises.

c.i.f. "cost, insurance, freight" indicates that the consignor pays all the distribution costs to the customers'premises.

purchaser. Whichever it is can have a significant bearing on the mode of transport selected to carry the goods.

Air freight rates are some 4 - 5 times more expensive than equivalent sea freight, although the shorter delivery times do allow reductions in the inventory level investments at the overseas depots.

There is a wide variation in attitude towards air freight amongst exporting pharmaceutical firms. Some use it for emergency supplies only; others use it as a regular mode of delivery. Chartering of aircraft to lift bulk shipments is gaining acceptance.

Both Jackson and Brackenridge (92) and Murphy (122) present the advantages of using air freight. If inventories are reduced through shorter delivery times then the capital investment tied up in goods held in the pipeline is decreased. Packaging and handling costs are also reduced. The shorter delivery times resulting in greater product availability is an important competitive feature of the overseas marketing situation.

Freight forwarders are generally used for certain exports to save costs on the detailed documentation and routing patterns involved in overseas freighting. They can also gain rate advantages by consolidating shipments. The forwarding agents are occasionally given sufficient latitude to influence the mode of transportation itself.

Although sea transport gives relatively low freight costs, the problems on certain routes are increasing; the recent oil price rises, port congestion, dock strikes and more detailed overseas documentation requirements are all helping to cause delivery delays, which can be a critical factor when considering the supplies of urgently-needed pharmaceuticals.

On certain routes containers are now virtually compulsory. The advantages they offer in reduced handling costs, and reduced pilferage and losses, can only be economically realised if , one, the shipper has a sufficient quantity of goods to ship that make up a full container load (charges are made per container) and, two, if it is possible to arrange for two-way traffic flow so that empty containers are not carried back.

Suitable return products can usually be found from the U.S., Europe and Australia. However in developing countries like Africa their products are less easily containable, e.g., timber.

Road transport is gaining growing acceptance for export shipments; road hauliers from Britain and Europe now extend their runs to as far away as the Middle East.

A pharmaceutical manufacturer generally uses common facilities for the storage and handling of home and export goods, and common services for the processing and preparation of home and export orders.

Home distribution:

Road transport is widely used by manufacturers for distributing their products to customers in Britain. Other carriers are also often used, e.g., Post Office, British Rail.

Most companies find it more economical to lease vehicles or to hire contract carriers than maintain their own fleet of company-owned vehicles.

There are numerous combinations of carriers used to cover various regions of the country to try to obtain the most favourable rate agreements and yet not to make the manufacturer too dependent on any one operator.

Certain regions of the country are notorious distribution black-spots to where delivery times can be both prolonged and uncertain, e.g., Wales, North and West Scotland, Northern Ireland, South-West England, East Anglia.

Those firms who include some more bulky products in their range are often able to negotiate more favourable transport rates, since they can use fewer runs with larger vehicles.

The average weight of a home order parcel can vary from 20 - 70 lbs., depending upon the company's customers and its own product range.

Many companies now run scheduled delivery services where the customer is informed beforehand on what day the delivery will take place. These scheduled deliveries are carried out using company's own transport vehicles or those of contract carriers, since the reliability of the postal service has declined in recent years and guarantees on delivery dates cannot be given.

Lead times from the time of the customer placing the order to the time the goods are received vary from a few days to, say, 3 weeks. The average is generally 5 - 9 working days. Scheduled deliveries are, as a rule,made every fortnight.

For emergency deliveries, where products are urgently required, the British Rail Red Star parcels service can be used, although a multitude of examples exist where manufacturers have responded to urgent requests by using passenger trains, security vans, taxis, hired cars, etc.

During a recent new product launch one company felt it necessary to use Security Express to supply every appointed wholesaler in the country with initial stocks in order to guarantee immediate nation-wide availability of the new product.

Storage and warehousing are mostly confined to a single location, although leased or public warehouses are sometimes used to supplement storage capacity in the near vicinity.

Depot storages around the country are not generally considered to be economical when used for storing only ethical pharmaceuticals; the cost of the increased aggregate inventory holdings and facility investment exceeds the savings made in transportation.

Sharing distribution of ethicals with bulkier non-ethical products can help to make an extra warehouse a more economic proposition, although the possibility of contamination then becomes a problem.

The compactness of most pharmaceuticals means that they can be handled on standard size pallets by conventional fork lift trucks. A choice is generally available between wide aisle storage using more conventional lift trucks, and narrow aisle storage with specialised trucks not requiring the normal full turning circle. The latter arrangement allows more effective use of existing storage capacity.

The materials handling of pharmaceutical goods is essentially very flexible, a necessary factor in dealing with a large variety of shipment sizes.

Manufacturers sometimes stipulate a minimum order size so as to eliminate very small orders whose value is not sufficient to even cover the cost of processing the order.

The total cost of the order processing operation is considerably increased when a back order is raised for a product that is out-of-stock. Recognising this, some manufacturers partially fill the order, at the same time requesting customers to re-order all items that are out-of-stock.

The speed of the order processing operation has much improved in recent years, due partly to increased automation and better communications; an order can now be transmitted down to the warehouse, irrespective of its location, within 24 hours of receipt by the company.

Order preparation, involving picking items off the warehouse shelves and packing them for despatch to customers, remains essentially a manual operation. The company's material turnover is not usually of such a high enough volume to warrant the savings in labour costs ever justifying the investment involved in automated warehousing and order picking.

Nowadays plastic and polythene containers are gradually replacing glass as the material for the primary pack. Shrink wrapping, (encasing in polythene sheeting) is being increasingly used to save on outer packing materials for despatch, and on labour costs.

With less capital available in industry generally, there is increasing pressure to reduce inventories of materials at all stages of conversion. Inventory control can establish itself as an essential link between customer service and the company operations.

Current levels of finished goods stocks, in most cases, are sufficient for a few weeks supply, rather than for several months, as in the past. Drastic cutting of all round inventory levels increases the risk of stock-outs and introduces delivery performance as an important factor in customer service.

Strict inventory control measures are necessary in order to co-ordinate purchasing, production control and transport policies to keep in line with company objectives on customer service levels and inventory investment.

Summary

This chapter has been intended to set out the pharmaceutical industry as being one dominated by multinational manufacturing companies, where, traditionally, the methods of marketing and production are of paramount importance to the economic success of each company.

The diversity of overseas markets, the physical characteristics of pharmaceutical products and materials, and the wide spread of production facilities indicate that the methods of distribution can also have a significant bearing on company costs.

The increasing pressure that is now being brought to bear on inventory levels right through the company is one of a number of reasons for bringing another factor into the competitive spectrum for ethical products, that of customer service.

In the next chapters it is intended to show how logistics management, as defined in Chapter 1, can contribute to improving the efficiency of the operations of pharmaceutical manufacturers.

Logistics management can bridge the gap between any conflicting interests that exist between production and marketing. It cannot do this by being too restricted and remote from customer service policy, nor by being too cut off from the everyday operations that enable material and information to flow through the company.

It will be shown later that logistics management must cut across the traditional production and marketing organisations in order to direct their combined efforts towards corporate goals.

One corporate goal may be to minimise total company costs. Another may be to maximise customer service. These two objectives are conflicting; there must be a cut-off point when increasing expenditure further does not justify any further increase in customer service levels.

The production director is likely to be more concerned with the first goal than with the second; the marketing director, vice versa. Brown (23) points to the 'never-out-of-stock' policies often laid down by marketing people in the pharmaceutical industry. The recently increased pressure on production divisions to reduce inventory levels endangers the achievement of this policy, and brings this conflict of objectives to the forefront.

One of the tasks of logistics management is to simultaneously consider the cost and customer service implications of any alternative proposal affecting any part of the material or information flows through the company. The decision of whether or not to implement the proposal must be made in conjunction with corporate objectives rather than the individual objectives of any one department. The effects of the decision need to be looked at as they influence the whole material or information flow rather than just individual parts.

Chapter 3

The Systems Approach as an Aid to Logistics Decision Making

Introduction

The previous two chapters defined the background to the research study; they defined the pharmaceutical industry in general, and the pharmaceutical manufacturer's logistics situation in particular.

It was felt that opportunities for cost saving (111) and profit enhancement (29) are being missed. LeKashman and Stolle (111) suggest that the failure to simultaneously measure all department costs leads to the lack of real success in generating logistics savings in many companies. Likewise, Cannon (29) foresees that possibilities for increasing revenue are going to be missed if all departmental interests are not represented.

In order to take full advantage of these opportunities, there is a need to analyse the company's total logistics effort.

The impracticability of so doing could possibly be overcome if a more formalised approach to logistics decision-making were available to the logistics management of a company.

As stated the problem seems to suggest a conceptual solution, i.e. the application of the logistics concept to the diverse activities of manufacturing companies.

The increasing emergence of 'the concept of physical distribution management' and 'the total approach to logistics problem solving' in academic research and writings would point towards the successful finding of a solution from this source.

One of the purposes of this chapter is to examine the possible approaches reported in the literature.

It is proposed that a systems approach is the most suitable method in this context, for analysing the logistics activities of a manufacturer and for developing a formalised aid for use by logistics management in decision making.

In justifying a systems approach it is first shown that a company's logistics activities may be represented as a system where no single component function can act independently of another. When the component functions are acting together to achieve overall company objectives, the input to one is formed by output from others. In other words, the actions of one department can affect the performance of others in respect to contributing towards overall company objectives, e.g. altered production schedules can affect inventory holdings, distribution costs and marketing requirements.

A recent development is a method of systems analysis called logistics systems engineering, which recognises the existence of interrelationships within the logistics system. It is a method which requires these interrelationships to be quantified if new logistics systems are to be designed, or decisions made concerning improvements to existing ones.

The performance of a logistics system can be measured by two standards: i) the level of customer service, and, ii) the total cost required to attain that level. The level of customer service can be considered as the system's effectiveness.

Cost-effectiveness analysis is a widely recognised foundation of decision-making. Logistics systems engineering can aid decision-making as a means of exposing, and quantifying, all the relevant cost and effectiveness factors resulting from each alternative logistics configuration. Many of the relevant factors arise through interactive effects occurring within the logistics system.

A step-by-step procedure for cost-effectiveness analysis, incorporating the principles of logistics systems engineering, is described. It is possible to present an outlined operational logistics decision-making model by specific application of this procedure to the manufacturer's logistics system.

This outline model is only, though, a philosophy for broadening and directing the scope of logistics management thinking, so that their decisions can better meet the needs of the whole logistics operation, rather than of individual departments.

The logistics manager needs to have a detailed model of his logistics system if he is to assess the effects of any alternative logistics system configuration.

There are a number of different methods available for modelling the logistics system. These are classified into three types: formalist, simulation and heuristic models.

The characteristics of each are discussed in the context of the logistics system. Reference is also made to the hybrid forms of models developed by some authors.

1. Methods of Distribution Analysis

Distribution channels

The distribution channel comprises the set of institutions which supply finished products from the manufacturer through to the consumer. One product may be supplied through several alternative channels, and a single market served by several channels.

Much early literature on distribution analysis is concerned with the functioning of the complete distribution channel.

Fisk (63) refers to the 'A-B-C' of marketing study development: A represents Alderson's work (5), B represents Breyer's (21), C represents Cox's (170).

Alderson (5) visualises distribution channels as a marketing flow where changes in the form and identity of a product are made at the latest possible place in the distribution channel, and where changes in inventory location are postponed to the latest possible time.

Breyer (21) describes distribution channels according to their characteristic patterns of institutional members, e.g. manufacturers, wholesalers, retailers.

Cox (170) shows how goods are collected, stored and dispersed in the distribution channels, identifying flows of physical possession, ownership, promotion, negotiation, financing, risking, ordering and payment. Later he and Goodman (48) trace back the channels of supply for the materials involved in building a house.

Since then, Bucklin (25) has identified five functions that every distribution channel must perform: communication, ownership, transit, inventory and production. Later he selects four economic variables (lot size, delivery time, market decentralisation and breadth of product assortment) as representing the performance criteria of a distribution channel (24).

Baligh and Richartz (8) have formulated models to determine the equilibrium number of middlemen in a channel that would minimise the costs of communication, manufacture, order filling and inventory holding.

The complexity of their models illustrates the immense number of variables that would need to be included in a comprehensive study of a distribution channel. Particularly so in the case of a multinational pharmaceutical industry distributing a wide range of products to upwards of 100 world markets.

Possibly the idea of being able to analyse distribution channels with a view to their planning and selection by manufacturers is in any case suspect.

McVey (126) considers this manufacturer-oriented approach to be oversimplified in that middlemen inherently have varying degrees of freedom of action. The middleman serves primarily as a purchasing agent for his customers, and secondly as a selling agent for his suppliers.

Heskett and Ballou (83) suggest that conflicts between organisation members of a distribution channel present problems which require solving from a consideration of organisational and individual behaviour.

Company logistics

In recent years attention has increasingly been drawn towards analysing the manufacturer's own distribution operations, over which he does have control, rather than those of the distribution channel as a whole.

Business, or company, logistics is the subject of several texts, e.g. Heskett et al (24), Ballou (9), Mossman and Morton (120), Constantin (46). Here the emphasis is placed by the authors on examining interfaces within a company, and the effects of the internal operations upon customer service levels.

These authors envisage company logistics as playing a major role in numerous departmental decisions, e.g. facility location, inventory location, customer service policy setting, choice of transportation, choice of order processing methods, choice of information flow systems, setting of inventory levels, production scheduling, warehouse design.

The logistics concept is concerned with the interfaces between these, and other associated, departmental decisions. It is concerned with both identifying and quantifying these interactions, in how they affect total logistics costs and levels of customer service.

Pope (143) illustrates this with an example where inventory levels are reduced. A systematic analysis is essential for a company having to operate with reduced inventory holdings in view of the far reaching adverse effects on many other departments. For a pharmaceutical manufacturer with high value products, and multi-stage production processes, the pressure to reduce inventories is high since they usually account for a disproportionately large part of total logistics costs.

Magee (115) notes that, traditionally, company logistics has been most concerned with transportation, but there is now a growing interest in the logistics management of many other activities.

LaLonde (105) points to four factors giving rise to the developing acceptance of the logistics concept:

i) A more scientific approach to business management in general.

ii) Recent advances in computer technology.

iii) The growing importance of distribution in providing customer satisfaction.

iv) The potential 'profit leverage'* that is increasingly available through improved distribution efficiency.

Rider and Ostrom's article (145) expands on these last two factors in predicting that today's competitive environment will make logistics the next major change to be commonly adopted by business organisations, generally.

They state that:

> ".... the logistics function furnishes a necessary ability to continue profit enhancement in a market place where ability to deliver will be the measure of success."

These authors feel that a separate logistics management structure is mandatory for a firm wishing to gain economic advantages by considering the total effects of possible solutions to problems of distribution and supply.

However, as Pettit (141) warns, the interests of production, marketing and distribution can only be balanced by a coordinated pursuit of overall corporate objectives, when the philosophy of the logistics concept is accepted by senior management with responsibility for the control of the business. In recognising the conflict of departmental objectives, De Hayes and Taylor (55) state:

> ".... lacking is a common thread of understanding from which a concept of logistics can be defined. Systems theory provides a logical and meaningful response to the confusion".

LaLonde (105) defines company logistics as representing a total systems approach to the management of the entire distribution process, from the acquisition of raw materials to the supply of customers with finished products.

Before developing further the implications of the total systems approach it would be as well to show how the logistics activities of the company can indeed be represented as a system.

2. Company Logistics as a System

Following a review of a substantial body of literature on systems theory, Timms (164) selects Optner's (138) general definition of a system:

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* Profit leverage is a term used to denote efforts to increase the profitability of a company, either through reducing costs in certain areas of taking actions to increase sales revenue, or both.

"A system has been defined as an idea that is addressed, not to an individual phenomena, but to the total pattern of phenomena that create an environment and a state of being for a given process." (Reference: Optner (138)).

A system is composed of the elements illustrated in Figure 3.1 (137)

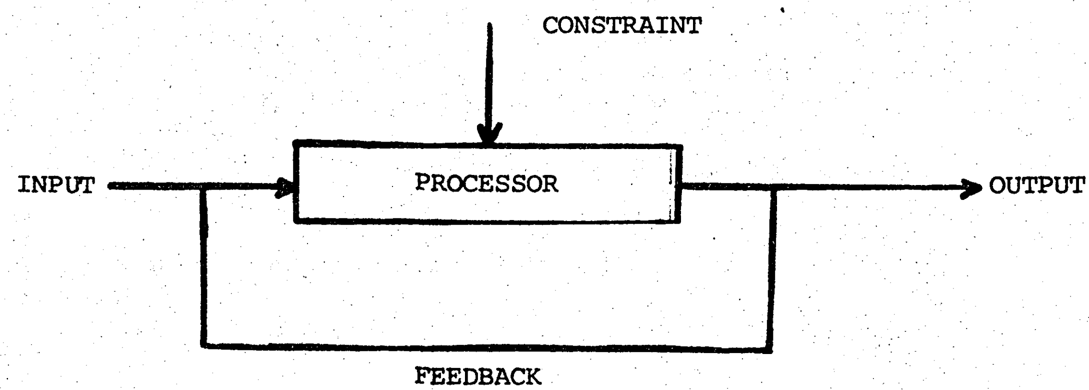


Figure 3.1: System Elements (Reference: Optner, S.L. (137))

Optner (138) goes on to state that the systems concept contends that optimum decisions cannot be made on the basis of individual functions alone because of the complex interrelationships between functions; decisions that are made within the company should be concerned with the final outcome, not with individual phenomena along the way.

Companies are typically divided into 'manageable' functions (departments) with the implicit understanding that each functional manager should subjectively consider the effects of his decisions on the other functional areas of the company; or, as Johnson, Kast and Rosenzweig (96) define the concept of the business firm:

"A business firm is an integrated whole where each system, sub-system and supporting sub-system is associated with the total operation. Its structure therefore is created by hundreds of systems arranged in hierarchical order. The output of the smallest system becomes input for the next larger system which in turn furnishes input for a higher level." (Reference: Johnson et al (96)).

There is evidence, therefore, to suggest that company logistics may be represented as a system in that it portrays a total pattern of phenomena whose components are interrelated, and it demonstrates the system's main features of process, inputs, outputs, feedback and constraints.

In terms of the material and information flows within a company's logistics these features could be as follows:

- The process could be a production process, where the material is changed physically, or a sorting or accumulation process (e.g. a warehouse) where the exterior form only of the material is altered and its residual time within the company is increased.

- The output of a process will generally form the input to another process, in terms of material flow, until the goods leave the company.

- The input to a process can be the raw material, the intermediate production material, the finished goods or whatever physical form the material takes when it enters a process. Alternatively the input could be a customer's order or internal instructions to that process department, when considered in terms of information flow.

- The feedback monitors the operation of the process by feeding back knowledge of its output. For example an inventory control could represent a feedback on production and warehousing processes.

- The constraints on a process provide the boundary conditions within which it must operate. For example a constraint could be a minimum production quantity,or a minimum level of inventory to be maintained at any time,or the capacity of a warehouse.

The increasing attention now being paid to the logistics concept reflects the rapid growth of interest in the interaction of the functional areas within a company in decision-making situations. The application of systems analysis as a tool for decision-making in company logistics can be seen as a logical outgrowth of these developments.

Systems Analysis:

Christopher (37) defines systems analysis as basically meaning the study and, hopefully, the solution of problems by an identification of the components of the problem and their interrelationships.

Figure 3.2 shows a diagrammatic representation of the systems analytic process (38).

The 'model' to which Figure 3.2 refers is the portrayal of the company logistics system so as to show the relationships between inputs and outputs, and thus to identify (and maybe also quantify) the interactions therein.

The form of these models will be discussed in a later section of this chapter.

Geisler and Steger (70) identify 9 major characteristics of a logistics system. These are:

i) They contain many interacting elements.
ii) They contain elements affected by randomness, unpredictability, risk etc.

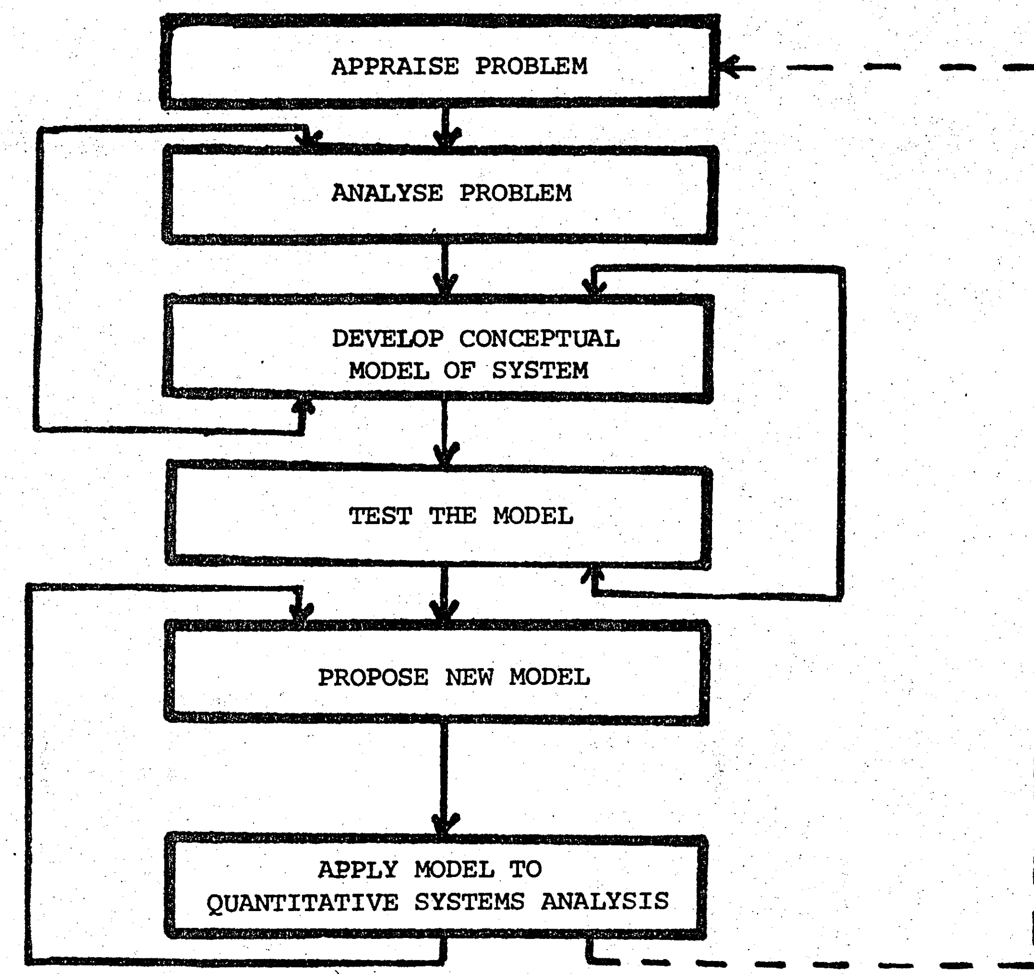


Figure 3.2 The Systems Analytic Process

(Reference: Christopher (38))
(Source: O'Keefe (136) p.164)

iii) They include activities whose performance is affected by time lags.
iv) They require resources.
v) They require policies, rules and problem solving capabilities for their operation.
vi) They employ information and data.
vii) They embody component organisations.
viii) They have objectives.
ix) They have mutual impacts with other systems.

Geisler and Steger (70) proceed to list four objectives for a systems analysis of a logistics system:

i) It should determine the operating characteristics of a logistics system, in order to help determine such essential patterns of the supply system as its costs and effectiveness.

ii) It should study the logistics system's completeness and consistency.

iii) It should evaluate new policies and procedures.

iv) It should carry out a sensitivity test, so that before introducing a new policy or procedure, or deciding on a system's total cost and effectiveness, logistics management can determine how well the system would work over the range of conditions that could arise, e.g. the variety of demand patterns, transportation times, programme changes.

These authors consider that a logistics system analysis should try to achieve one or more of these objectives, the analyst's problem being to select an appropriate technique for so doing, bearing in mind the logistics system's characteristics.

Optner (138) attempts to justify using systems analysis for business problem solving by equating the nature of systems to the characteristics of the business problem. Some of his points are worthy of special mention in the context of logistics problems.

He sees the systems analysis approach as having its greatest value in addressing large-scale, complex problems -

> ".... where the stakes are high and management is willing to invest in a carefully derived conclusion ....." (Reference: Optner (138)).

The foreseeable large number of interactions within the logistics network would render a problem intrinsically complex, irrespective of its apparent simplicity. For instance, a small reduction in the inventory level of a single product may appear to management to be a simple change giving an immediate cost saving. However, changes in stock holding can have far reaching effects on other departments that are not clearly apparent at first. The interactive effects produced by a small operational change can snowball to present logistics management with a highly complex problem to solve, involving many areas of logistics concern.

Optner also sees systems analysis as providing an objective standard by which problems can be organised for solution.

It would seem particularly important for logistics problems to be solved within an objective framework. The large number of conflicting interests between departments can only be measured relative to each other on a measurement scale provided by a common objective.

Optner additionally recognises systems analysis as being the newest technique to be applied to solving 'mixed' business problems (those with both qualitative and quantitative attributes). It enables the problem to be suitably structured and provides the means for iterating a range of alternative outputs.

Logistics problems frequently fall into the mixed category. For instance, a cheaper, but slower, mode of transportation may give a readily calculable cost saving on transport, but what price is the loss of customer satisfaction in relation to sales revenue?

In a recent article, Freight Management (67) insists that a distribution systems analysis is essential as part of the decision-making structure of an organisation, if, for example, it is to decide whether air freight will benefit the company as a whole.

3. Logistics Systems Engineering

The systems analysis approach to company logistics has led to a new field of study being termed logistics systems engineering.

This utilises the approach of systems analysis in solving logistics problems by identifying the components of the problem and their interrelationships.

Logistics systems engineering, in using a systematic approach to logistics problem solving, encourages a wider view to be taken of the problem under review (37).

Christopher (37) considers the identification of cost trade-offs, or interactions, to be the crux of logistics systems engineering.

A successful identification of these interactions requires the detailing of all activity centres within the logistics system, and of course their interrelationships.

Logistics systems engineering is concerned with the totality of the company logistics systems and its awareness of interactions between the various parts of the whole. It strives to provide a means for solving logistics problems whereby subsystems can relate to each other in the most effective way, ensuring that internal contradictions in the corporate activity are minimised (37).

Having said all this, the guiding principles of logistics systems engineering, as stated above, can easily be related to examples in practice.

If the departments within a company are not relating to each other in a way most effective to the whole, then sub-optimisation of certain areas will result, to the detriment of the company. The production manager may keep his manufacturing unit costs down by having long runs on each product stage and thus reducing his non-productive clean-down times. However, the increased costs of inventory holding that will inevitably result may well be significantly greater than the production cost savings.

An illustration of the lack of coordination of overall logistics in many companies is in the attitude towards industrial engineers. Frequently they will be found expending much time and effort in comprehensively analysing the operations involved in a single production process. The savings that they might achieve through a rescheduling of manpower allocation may look quite significant against the production manager's cost budget. However, in the pharmaceutical industry such a saving can be considered negligible in relation to the investment reduction from, say, a 5% decrease in stock levels.

The decision on what inventory level to hold may be taken by one manager in isolation, at a brief meeting, or even by a junior stock clerk.

Unlike some modern management techniques, which tend to encourage sub-optimisation, if not always thoroughly applied (e.g., management by objectives), logistics systems engineering requires that a framework of corporate objectives be established beforehand.

The components of the logistics system then have a clearly defined purpose to which their costs and performance can be related.

Inverse cost relationships between functions in the logistics system can complicate the analysis. They arise from the interactions within the system and represent the potential trade-offs by which an optimum cost balance can be derived. Cost savings adjustments in one of the functional areas can often cause cost increases in one or more of the others, e.g. the previous example of production run length versus inventory holding, another example is the raw material savings obtained by purchasing in bulk to take advantage of discounts being offset by increased costs in inventory holding and material handling, and also causing a decrease in available warehouse space.

It may be that an increased cost in one activity can lead to an increased revenue for the system as a whole. For instance, a faster, or more reliable, transportation service can cost the supplier more money, but correspondingly lead to a higher level of customer satisfaction.

In this way greater revenue may be generated by the system as a whole, even if some areas are incurring higher costs (37).

It may be that different departments can work together in such a way that their total cost is less than the sum of their individual costs. This is termed "synergy".

Christopher (36) considers that opportunities for distribution synergy are present in most operating systems. For instance it may be visualised that a more reliable, though less frequent, delivery service could not only result in transport cost savings but in order preparation and order processing cost savings, in reducing finished goods levels of safety stock, with no reduction in the overall level of customer satisfaction.

However, recognising the opportunities may be one thing but taking advantage of them is another. Magee (113) points out that the balancing of cost trade-offs often poses difficulties for those firms whose thinking and organisation is set traditionally on rigid department lines.

Logistics systems engineering provides a systematic and practicable approach to a new way of logistics thinking, and a guide to cutting across department organisation in decision-making situations.

4. Logistics Decision Making: Cost-Effectiveness Analysis

Logistics decision-making can take two forms: those concerning logistics system configurations and those concerning logistics system comparisons. The first relates to the design of a system, and the second to the comparison of alternative system configurations. If one department proposes making a change in its operations that would affect other departments, then implementation of the proposal will produce an alternative system configuration.

Since logistics management decision-making is usually carried out within an existing system, operational decision-making falls into the second category where alternative proposals are being considered.

Kline and Lifson (101) list a sequence of steps in the decision making process:

- i) Synthesise alternative solutions
- ii) Analyse, or test, these alternative solutions
- iii) Evaluate the alternative solutions
- iv) Select the best alternative

Bowersox, Smykay and LaLonde (19) suggest that the performance of the physical distribution system can be measured by two standards:

- a) the level of customer service, and
- b) the total cost required to attain that level.

Physical distribution is a major sub-system of the logistics system in that it embodies the activities of freight transportation, warehousing, materials handling, protective packaging, inventory control, plant and warehouse site selection, order processing, market forecasting and customer service (19).

The standards of measurement referred to above could therefore apply equally well to the logistics system, as a whole.

Typically customer service and cost are opposed to each other in that a higher level of customer service requires more expenditure, and vice-versa.

The optimum, or preferable, balance of service and cost can be calculated through making a <u>cost-effectiveness analysis</u>.

Kazanowski (99) presents a standardised approach to cost-effectiveness analysis of alternative system configurations. The steps are:

- i) Define the missions of the company's logistics system.
- ii) Identify the mission requirements necessary to attain those missions.
- iii) Identify the nature of the possible alternative logistics system configurations.

iv) Establish performance criteria that can be used to relate the system capabilities to the mission requirements.
v) Determine the capabilities of the alternative system configurations in terms of the performance criteria.
vi) Generate an array of costs vs performance for each alternative configuration.

This approach is similar to one put forward by Chestnut (35).

It is important that some framework of objectives be explicitly established before any analysis is attempted, in order that the components of the logistics system (the sub-systems) have a clearly defined purpose (37). These objectives may be termed distribution missions. More closely defined, they become distribution mission requirements.

Most cost-effectiveness analyses are made on a basis of either fixed-cost or fixed-effectiveness.

In the fixed-cost approach, the foundation for choosing between alternatives is the level of customer satisfaction achieved for a determined expenditure. In the fixed-effectiveness approach, the selection criterion is the level of expenditure incurred to obtain a determined standard of customer satisfaction.

Kazanowski (99) stresses the importance of choosing one or other of the approaches, since the choice can have a significant impact on the outcome and utility of the analysis.

A Cost-effectiveness analysis

Kazanowski's six-step procedure for a cost-effectiveness analysis is now described in more detail:

i) Defining the logistics missions - Christopher (36) states that it is necessary to establish the missions of the logistics system before any analysis of that system is made.

Stasch (159) views the physical distribution sub-systems as serving the needs of the company in one of two ways: either as a demand stimulant, or as an activity supporting the sales brought about by other demand stimulants, e.g., promotion. The first way sees physical distribution as a means to stimulate sales. The second way sees physical distribution only as a means of facilitating sales, ensuring that the product is available to the customer after the sale is made.

These two ways illustrate the two very different viewpoints which a company may have regarding its logistics system, and which accordingly influence its logistics missions. If logistics is thought of as stimulating demand, then the logistics system configurations employed will affect customer satisfaction, and in turn sales revenue. On the other hand, if logistics is regarded merely as a necessary expenditure to facilitate sales, then any logistics analysis becomes an exercise in minimising costs; the fixed-effectiveness approach.

It is doubtful whether a company will have prescribed logistics missions, known to all departments. It is only relatively recently that companies are coming to regard logistics as an integral part of marketing's sales generating activities, or the marketing mix as Lazer (109) describes it.

How a company sees logistics should be apparent from an observation of that company's logistics operations. If the logistics missions can be defined even broadly, then this should enable an easier identification to be made of the logistics mission requirements.

ii) Identifying the logistics mission requirements - Fulfilling the logistics mission requirements is essential to the attainment of the logistics missions.

Missions and their requirements are closely interrelated; the mission requirements are more specifically defined statements of the missions themselves.

For instance, a logistics mission may be stated as requiring the logistics operation to act as a demand stimulant in helping maximise company profitability in a particular market. The corresponding mission requirement may be to use existing distribution channels and operating facilities to achieve the mission by a careful balance of the customer service needs in that market against the cost involved. This example illustrates the placing of policy constraints on the broadly-defined logistics mission.

Kazanowski (99) warns against including too many mission requirements which, if conflicting, can only confuse the decision maker.

The possible mission requirements of a large, multinational pharmaceutical manufacturer can be envisaged as being both numerous and conflictive. However, those ones that are most essential to the benefit of the company as a whole must be segregated from those that are less essential. The whereabouts of such a cut-off point will have to be decided by the limiting resources of the analysis and by the judgment of logistics management.

iii) Identifying the nature of possible alternative logistics configurations - It has already been noted earlier that operational logistics decision-making usually involves a comparison of alternative logistics system configurations.

One way of anticipating the nature of alternative configurations is to examine in more detail the logistics system itself. It is from within this system that alternative proposals can be expected to originate.

A typical company's logistics system is organised on functional lines with each department attempting to achieve functional objectives within a fixed cost budget.

Fig. 3.3. illustrates how logistics missions usually cut across functional boundaries (36). Additionally, Christopher (36) points out how cost accounting on functional lines by the company can disguise the contribution that each function makes to the achievement of these missions.

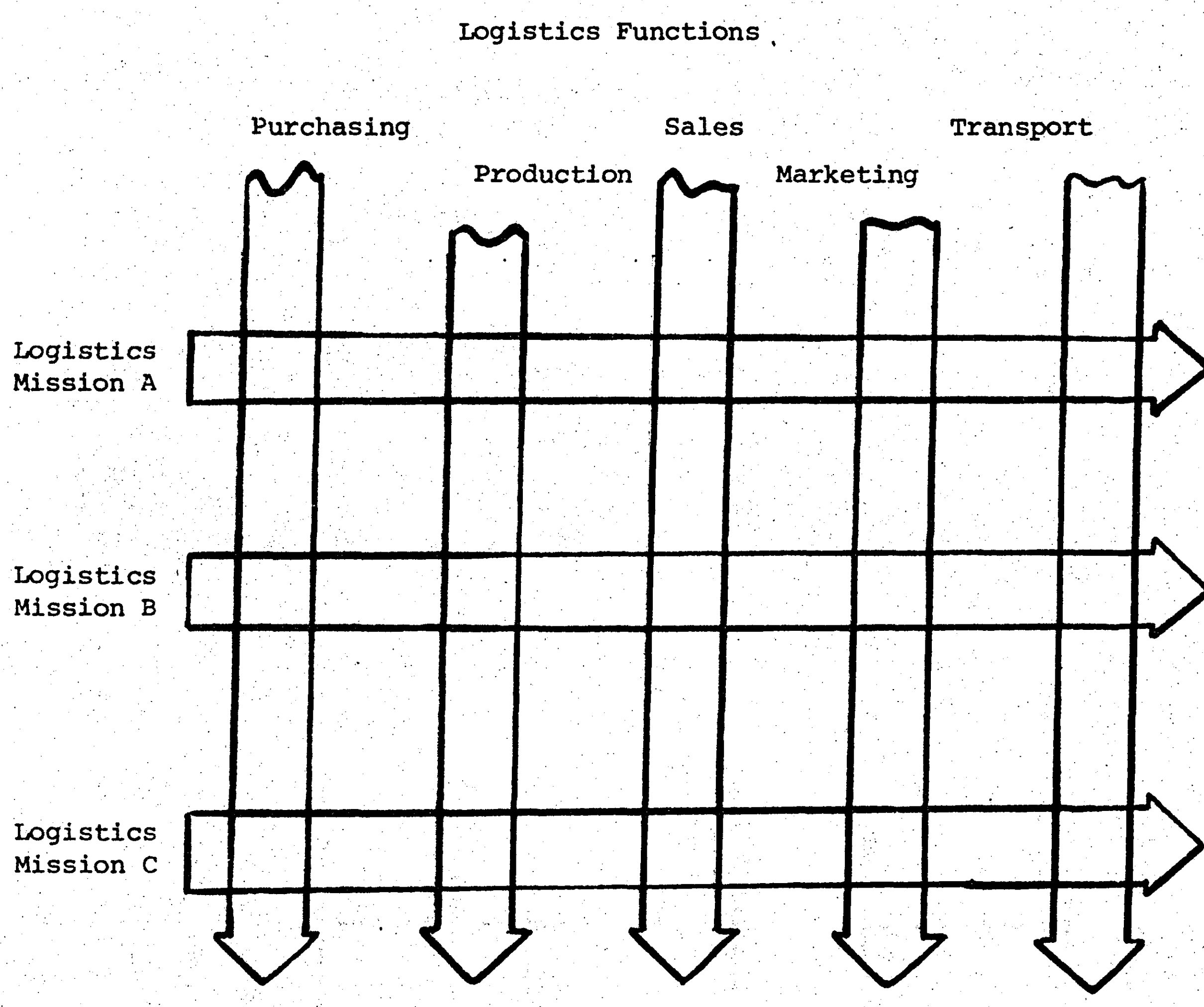


Figure 3.3. Logistics Missions that Cut Across Functional Boundaries
(Source: Christopher (36) p.61)

Departments may propose alternative ways of carrying out their functional activities in order to improve their own functional efficiencies. For instance, production can nearly always increase their plant loading by lengthening their production runs on each process stage to reduce total turn-round time. Also transport may favour a slower mode of transportation, at reduced freight rates, to reduce their functional costs.

Such alternative proposals become difficult to evaluate when the resulting configuration can be affected by each of the interactions illustrated in Figure 3.3. The evaluation becomes more complex when the department lends weight to its proposal by introducing additional claims of benefit. For instance, production might claim that chemical reaction efficiency, and hence product output, is increased as the length of equipment exposure time to the same process increases; transport may argue that whilst the proposed mode of transport is slower, it is also more reliable than at present.

By what criteria then, are these functional proposals to be judged? How well do the resulting logistics system configurations relate to the achievement of the overall logistics missions and mission requirements?

These questions must be answered if alternative logistics systems configurations are to be evaluated in terms of cost and effectiveness to the total system.

iv) <u>Establishing performance criteria</u> - A performance criterion can be considered as a yardstick which judges the effectiveness of a system's performance. For the total logistics system that performance is the achievement of logistics missions and mission requirements.

It is, however, inconceivable that the criterion used as a yardstick for total system performance (termed a 'macro' criterion) can be used as a similar measure of functional (or sub-system) performance (requiring 'micro' criteria).

For instance, examples of macro performance criteria for the total logistics system could typically include: speed of delivery times, amount of capital investment, amount of sales revenue. How, though, can such criteria be applied to, say, evaluating the effectiveness of a re-scheduled production programme? Directly, they cannot, yet micro performance criteria need to be established for all sub-systems that relate to the overall logistics mission requirements.

There is no universal answer to how many micro performance criteria can be included in a cost-effectiveness analysis. It depends on such factors as: the nature of the alternative logistics configurations to be evaluated, the logistics missions and mission requirements, the measure of accuracy required in the analysis.

These factors point to each analysis having to be carried out individually depending on the type of decision and the particular logistics system. It is the style of approach, and sequence of analysis stages, which can hopefully be generalised to suit varying types of decisions and logistics operations.

It is worthwhile here to mention some examples of performance criteria recorded in the literature.

Stasch (159)uses delivery time as a standard for judging the performance of the physical distribution sub-system. By relating total distribution costs to the delivery characteristics of volume, distance and transit time, he forms a 'performance criterion schedule' which can indicate whether a certain volume shipment being moved a certain distance in a certain time incurs costs above or below a derived standard.

Niskanen (134) considers the choice of measures of effectiveness (performance criteria) to be"the most difficult, unique problem of cost-effectiveness analysis." Kazanowski (100) highlights this problem by listing some 400 criteria that are appropriate to cost-effectiveness evaluations of various equipment systems for space missions.

The appropriate selection of micro performance criteria is essential in ensuring that the capabilities of alternative logistics systems configurations are related to the overall logistics missions and mission requirements.

The schematic, shown as Fig. 3.4, illustrates how a set of performance criteria can relate the sub-system outputs to the achievement of a logistics mission.

Without performance criteria, the situation would be as shown in the schematic of Figure 3.5, where each sub-system output relates to each logistics mission requirement. The result is a 'tangle'requiring a complex analysis.

v) <u>Determining capabilities of alternative logistics system configurations</u> - The next step in the analysis is to examine how the performance criteria can reduce the sub-system outputs into a single output having a value compatible with the measure of degree of achievement of the logistics mission requirement. In other words, to determine the capability of the alternative logistics system configuration.

The sub-system outputs, expressed as measures of effectiveness, are likely to be diverse and in both qualitative and quantitative terms. This is a problem of the 'mixed' type, mentioned earlier, where a systems approach method of solution is so appropriate.

vi) <u>Generating an array of costs vs. performance for each alternative configuration</u> - this final step in Kazanowski's sequence is not applicable to the type of logistics decision-making situation that is envisaged. One proposal at a time is likely to be under consideration by logistics management. The decision is then whether to implement the proposal, or to maintain the existing logistics configuration.

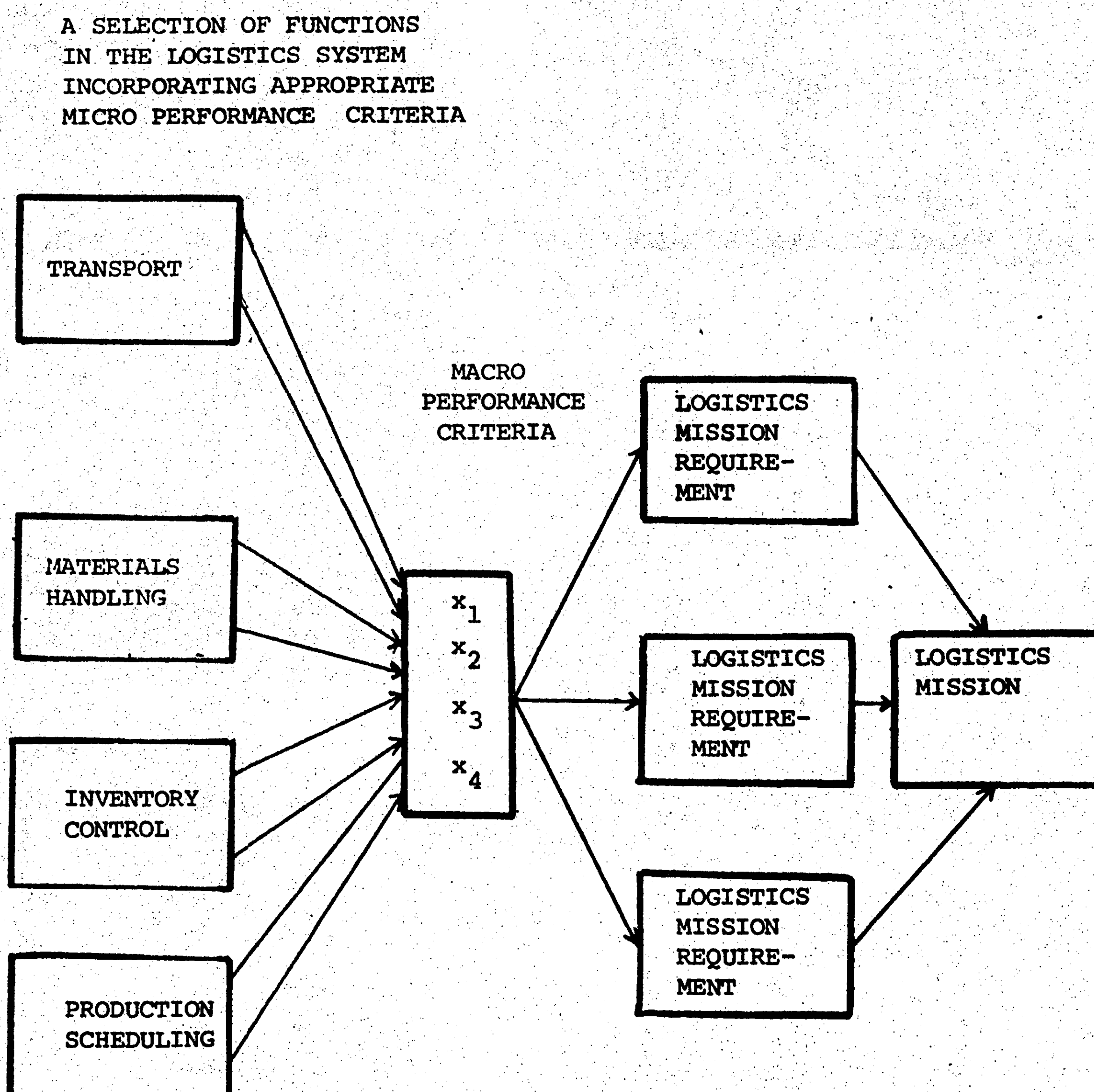


Figure 3.4: Logistics Mission Achievement with Performance Criteria

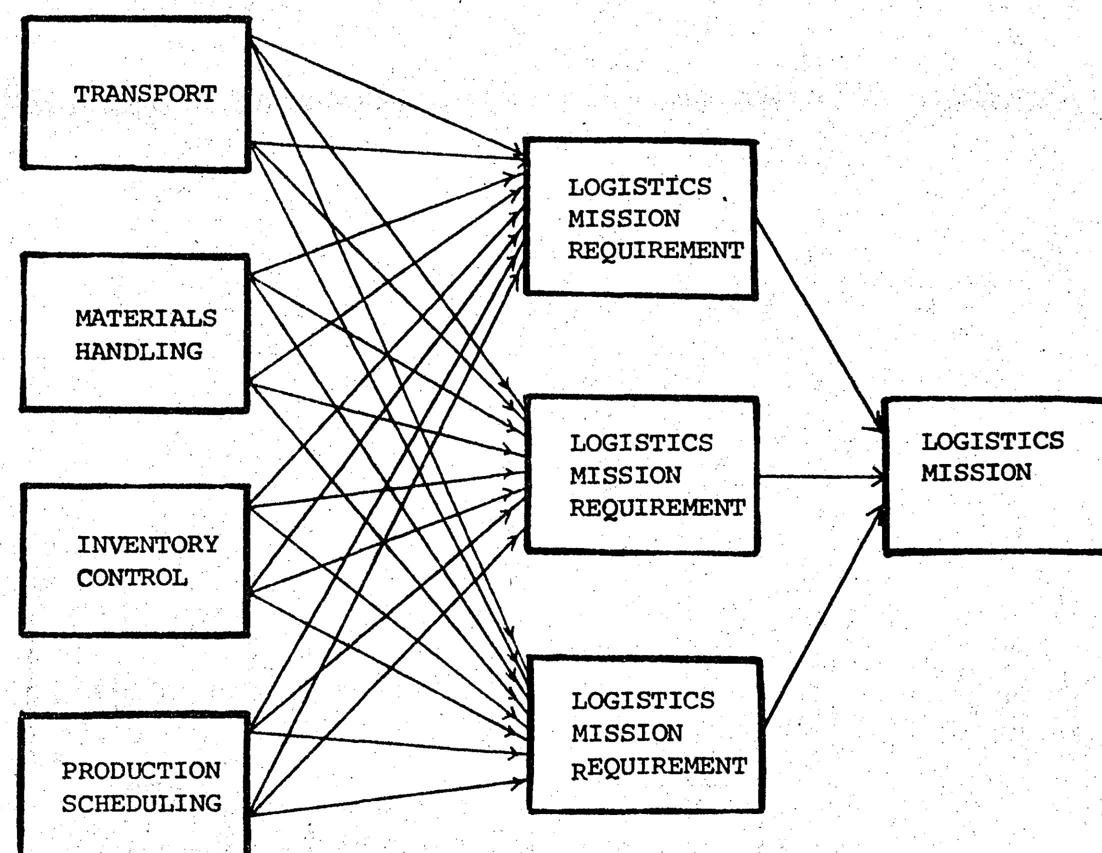


Figure 3.5. Logistics Mission Achievement Without Performance Criteria

If, however, there is a breakdown in the logistics operations at one stage, or a specific area is under review as requiring improvement, then several alternative proposals to meet the same problem might be considered together. In this case a tabulation of the costs and performances for each alternative configuration, allied to the logistics mission requirements, is a useful aid to the decision-maker.

For instance it may be that a type of container, previously used for packing a certain product, is now unobtainable, and several available alternative designs are up for consideration.

5. Logistics Decision-Making: An Operational Model

The cost-effectiveness analysis procedure, detailed in the previous section, can be represented as a schematic, Figure 3.6. The result is an operational model appropriate to the decision-making process of deciding whether or not to implement a proposed functional alternative. This model can be considered to be the "framework" in the context of Prest and Turvey's (143)definition:

> "..... cost benefit analysis ..... is a technique for taking decisions within a framework which has to be decided upon in advance..." (Reference: Prest and Turvey (143))

6. Models of the Logistics System

The central block of Figure 3.6 shows the logistics system of the manufacturer. It comprises the logistics functions, some of which are specified in the diagram. However, Figure 3.6 gives no indication of the configuration of that logistics system, how each function relates to another, except to show that their combined effect incurs a total logistics cost and contributes to some measure of customer satisfaction.

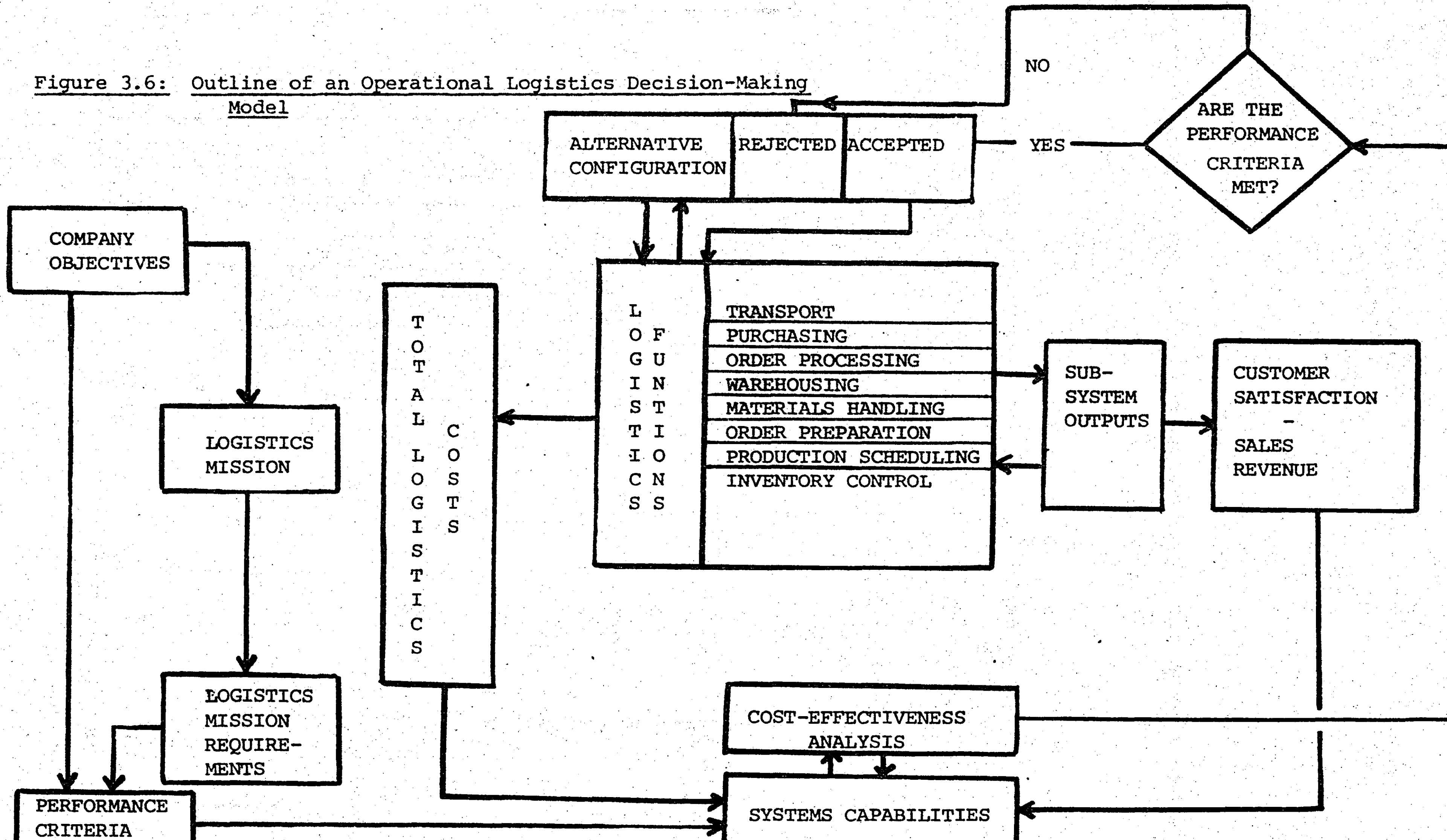
The knowledge of the existing logistics system configuration is the hub of any logistics manager's analysis of alternative strategies. Only by knowing the network of interactions within his company's logistics system can he derive measures of cost and effectiveness for each function.

Every decision is taken on the basis of some sort of model that the logistics manager has of his logistics system. Without being able to carry out a prolonged'trial run' on the alternative proposal, and hence with the resulting alternative configuration, he must assess its effectson the other parts of the system using this model.

The form of the model may be simple or complex, and it may take on a different form for various situations.

The logistics systems engineering philosophy tends to widen the scope of the logistics manager's model by expanding it to include more variables that represent departmental interactions.

Figure 3.6: Outline of an Operational Logistics Decision-Making Model



The details within the boxes in Figure 3.6 will be filled in more accurately, with respect to the pharmaceutical manufacturer's situation, as this thesis progresses.

If a generalised model is to be postulated for the logistics systems of pharmaceutical manufacturers it is helpful, first of all, to review the available models recorded in the literature. From reading a wide range of literature on techniques of analysis, it is found to be possible to classify the types of models under three headings:

i) Formalist models
ii) Simulation models
iii) Heuristic models

i) Formalist models

These represent the ideal where each interaction is analytically calculated, on a common basis, and an optimum solution is obtained. An example of a formalist model is a linear programme where a single objective function, containing all the pertinent variables of the system, is minimised.

Linear programmes can be used for instance, to derive optimum shipping patterns, optimum warehouse locations (13) and optimum production schedules (20). Dorsey et al (57) use a network approach to find the minimum cost flow for a multi-facility, production-inventory scheduling problem. It is apparent, though, that in each of these solutions interactions with other functions are largely ignored. The resulting number of operational variables would just be too great for any solution using a formalist model.

Baligh and Richartz (8) amply demonstrate the resultant vast complexity from a thorough analysis of just a portion of the logistics system.

Formalist models have little contribution to make to the solution of the mixed type of problem described here.

ii) Simulation models

These provide an experimental environment for interactively testing hypotheses, decision rules and alternative system configurations under a variety of assumed conditions. They are applicable to modelling the interactions within the logistics system where the number of variables is so large that a formalist approach is ruled out. They aim to achieve a near-optimum solution.

Examples of reported simulation models indicate, however, that (a) they require a considerable outlay of resources (7), and, (b) a large quantity of detailed cost information (150).

The technological advances in recent years with digital computers make simulation models a viable proposition as an aid to logistics decision making.

One benefit of using a simulation model to assess alternative logistics system configurations is that it enables the dynamics of the situation to be investigated. The performance of the logistics functions can be simulated for each of a number of successive time periods. As a result, the long term opportunities and problems of a situation can be included in the analysis.

Stasch (157) uses a simulation model to evaluate the instabilities of distribution channels, and also uses another as a basis to evaluate trade-offs and alternative courses of action in the physical distribution sub-system (159).

iii) Heuristic models:

These are basically simulations of the decision processes used by individuals. In simplified form they are rule-of-thumb procedures, contributing to a reduction in the complexity of problem solving (164).

They are particularly useful in dealing with the qualitative aspects of problems, which are inappropriate to mathematical analysis.

An example of a heuristic model is provided by Kuehn and Hamburger (104) who use one to propose feasible sets of alternative warehouse locations which can then each be evaluated through simulation. The solution which then minimises the total cost of distribution is selected.

Another example is provided by Jones (97) who uses two rules, one for the number of the work force, and one for the production quantity. These rules contain parameters which can be evaluated to seek out the set which provides the lowest cost or highest profit for a particular firm.

Heuristic models do not guarantee an optimum solution.

In reviewing the three types of models, Stasch (158) presents their advantages and disadvantages in applying to the analysis of logistics systems as follows:

a) With respect to realistically representing a logistics system, a simulation model is the most favourable and a formalist model the least favourable.

b) With respect to data requirements, a simulation model demands most and a formalist model demands least.

c) Customer demands are more realistically represented by a simulation model than by either of the other two models.

d) Heuristic and simulation models are capable of analysing the multi-product logistics system, while a formalist model is limited to the single product situation only.

e) Both heuristic and formalist models are capable of evaluating alternatives. A simulation model is only capable of evaluating alternatives by a repeat of the simulation for each alternative being considered.

It may be that a suitable modelling approach is of the 'hybrid' form where two models are used in unison. The previous example of Kuehn and Hamburger (104) combines a simulation model with a heuristic one.

Nolan and Sovereign (135) use a 'recursive' approach to determine the optimum size of military transportation forces. This approach uses simulation and formalist models in a complementary manner to tackle the optimisation problem. DeHayes and House (54) recommend the use of a recursive approach as a methodology for modelling the logistics system. They first explore the problem at an aggregate level using a formalist model, then use a simulation model to fill in the necessary details which can be passed back to the formalist model to arrive at an optimum solution.

Matt (118) provides an example of a hybrid formalist/heuristic model. He minimises the combined physical distribution and warehousing costs with respect to particular decisions on distribution using a linear programme (formalist model). He simplifies the necessary calculations by using a heuristic model to allow only certain parameters of the problem to vary. This reduces the possible number of choices available, as does Kuehn and Hamburger's heuristic.

In studying an international chemical market, Chyung (40) uses a simulation model to optimise distribution variables with the aid of a linear programme. This is an example of a hybrid simulation/formalist model being used to derive the minimum cost of supplying all the demands in each market.

Summary

There is an increasing movement away from the analysis of complete distribution channels towards the internal examination of a company's own logistics operations.

In the context of the research problem, as presented in the Introductory chapter, the systems approach is suitable for considering how the logistics functions interact with each other. Logistics systems engineering is an emerging philosophy for incorporating the principles of the systems approach into the logistics decision-making situation.

A procedure was outlined for a cost-effectiveness analysis of alternative logistics systems configurations. The steps in this procedure could be translated into an outline model to guide the logistics decision-making of a manufacturer.

The logistics manager must have some sort of model, either in mind or on paper, of the logistics system about which he is required to make decisions. Three categories of models were described: formalist, simulation and heuristic.

In the following chapter, the logistics system of the pharmaceutical manufacturer will be described in more detail. This should enable the operational decision-making model to be more accurately portrayed in the context of this research study. Additionally, it will also lay the foundation for the selection of a suitable model type to represent the interacting functions within the logistics system of a pharmaceutical manufacturer.

In summary, then, this chapter concludes that a systems approach is appropriate to an analysis of the logistics system, and that an outline model for operational decision-making can be based on a cost-effectiveness analysis procedure.

Chapter 4

Analysis of the Pharmaceutical Manufacturer's Logistics System

Introduction

Chapter 1 outlined the research problem, the broad background to the study and the research objectives. The research problem was basically presented as that of devising a suitable framework to aid the logistics manager of a pharmaceutical manufacturing company in decision making. This could likely be the situation where an alternative proposal, directly affecting the operation of a part of the company's logistics, has to be assessed with respect to its impact on the total system.

Chapter 2 provided an introduction to the pharmaceutical industry, discussing in particular the production-marketing-distribution organisation of the pharmaceutical manufacturer. This is the environment from whence the research problem arose, and at which any solution to the problem must be directed.

Chapter 3 reviewed a number of academic approaches directed at logistics analysis. Of these, the systems approach and, in particular, logistics systems engineering appeared to offer a suitable method of solving the research problem. This approach is founded on the notion that each part of the total system should not be viewed in isolation, but as a component of a network of interconnected parts. In the case of a logistics system, a component logistics operation is regarded in the light of its contribution to the attainment of the missions, or goals, of the company's total logistics system.

A cost-effectiveness basis for decision making within a company is a logical extension of applying the systems approach. Any part of the logistics system is viewed in terms of its contribution to the total logistics cost and in terms of its contribution to the overall attainment of the logistics missions (its effectiveness).

Hence, any proposal to amend the operation of a part of the company's logistics can be considered as an alternative; the decision on whether or not to implement the alternative would rest with an assessment of its dual cost and effectiveness contribution, plus a comparison of this with the respective contributions of the existing operation.

This chapter is concerned with examining the method of assessing the contribution made to the total logistics cost by parts of the logistics system (the cost side of the cost-effectiveness evaluation).

It is possible to identify those operations which make up the logistics of the company, but the difficult task facing the logistics analyst is to derive accurately what contribution each makes to the total logistics cost.

Logistics systems engineering emphasises the interrelationships between parts of the logistics system: how one part's activities can affect both the costs and performance of other parts within the logistics system.

The cost contribution of a single part of a company's logistics are changed when the operations, or activities, of that logistics area are affected. These effects may be brought about by either a change being made directly on one of its activities, or by interactions from other associated activities in different parts of the logistics system. The total result is a complex network of interrelationships, which grows more complex as the number of parts of the system are increased by closer specification.

A logistics system analysis of the pharmaceutical manufacturer's logistics must therefore map out the system in terms of those parts that make a relevant contribution towards the total logistics cost.

1. Identifying the Logistics Functions of the Pharmaceutical Manufacturer

Business logistics was defined earlier (in Chapter 1) as:

> "...a term which denotes a total approach to the management of the distribution process including all of those activities involved in physically moving raw materials, in-process inventory and finished goods inventory from point of origin to point of use or consumption." (Reference:LaLonde et al (106)).

Christopher (36) recommends that the first step in a systems design should be to draw out the logistics system in the form of a flowchart, showing the physical flow patterns of materials and information.

Figure 4.1. represents such a flowchart. Flows of materials (as raw materials, intermediate products and finished goods), information and customers' orders link the operations of the pharmaceutical manufacturer. Those operations are termed 'activity centres', e.g. quality control, documentation, inventory control.

The inputs to the logistics system are:

i) Raw materials (including packaging components)
ii) Demand forecast information.
iii) Customers' orders.

The outputs from the logistics system are:

i) Packaged products (finished goods).
ii) Bulk intermediate products to foreign subsidiaries.
iii) Invoices to customers.

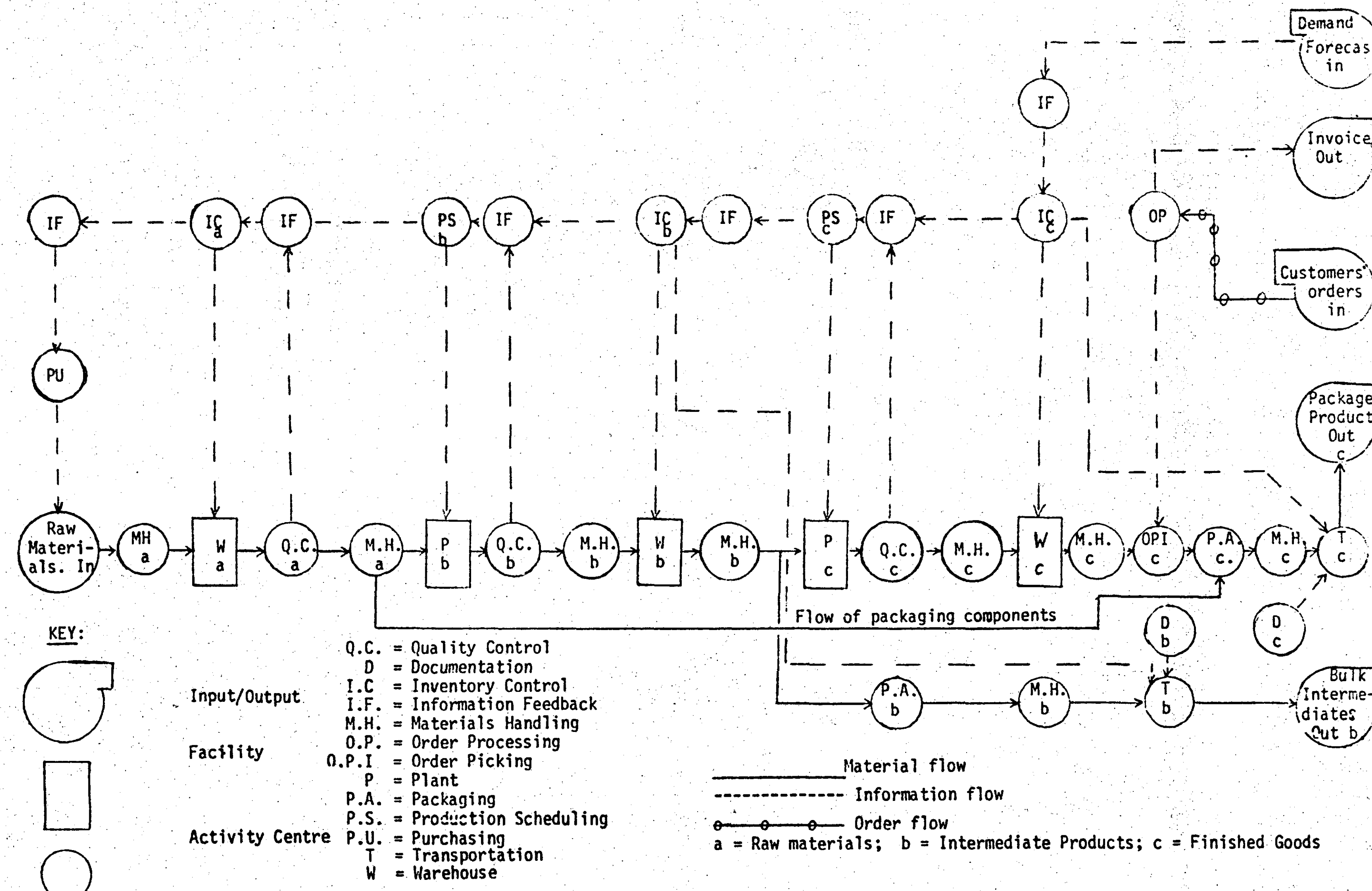
However, Figure 4.1. does not comply with the full extent of the business logistics definition: the customers and consumers are not included. This extension will be covered in the next chapter when customer service considerations are taken into account.

Figure 4.1 illustrates the activity centres involved in physically moving raw materials, intermediate products and finished goods from the point of introduction to the firm to the point of despatch to the customers.

It can be seen that the physical flow of materials, represented by solid lines, occurs simultaneously with a reverse flow of information, represented by dashed lines, with frequent points of mutual contact. Magee (114) similarly constructs the opposing flows of materials and information; he considers the information flow as governing the material flow by acting as a control.

The lower portion of Figure 4.1 provides for the movement of bulk materials between overseas subsidiaries of a multinational company. Since the customer for such movements is the company itself, this output of bulk intermediate products will not be included in the further analysis.

Figure 4.1: Logistics System Flowchart for a Pharmaceutical Manufacturer.



The pharmaceutical manufacturer can be considered to have control over all of the operations, and hence the costs, of each of the activity centres included in the flowchart of Figure 4.1.

These activity centres would likely be included in the logistics system of any manufacturing industry. LaLonde et al (106) list the following functions as being related to the total logistics mission of a manufacturing company.

1. Facilities location
2. Purchasing *
3. Packaging *
4. Production control *
5. Materials handling *
6. Storage and warehousing*
7. Inventory control *
8. Transportation *
9. Order processing *
10. Distribution communications*
11. Parts and service support
12. Personnel movement
13. Returned goods *
14. Salvage and scrap disposal
15. Customer distribution programmes *
16. Vendor distribution programmes

The functions marked * are included (or, implied) in the schematic of Figure 4.1. It additionally includes the activity centres of quality control and order picking as especially relevant to the pharmaceutical manufacturer. Certain of the remainder of LaLonde et. al's functions will be included for consideration in the next chapter when analysis of the logistics system extends to the customers and the distribution channels.

It should be possible to construct a flowchart of the logistics system for any type of manufacturer, knowing the nature and sequence of their operations. The resulting diagrams would appear much like that of Figure 4.1, except certain functions would be ignored, by omission, and others would be stressed, by inclusion, according to the features of the industry concerned.

The nature of the pharmaceutical manufacturers' marketing, production and distribution activities were discussed in Chapter 2. The individual activity centres will now be elaborated by dealing with each in turn.

Quality Control

For pharmaceutical manufacturers this is a most important function. It ensures that they comply with the standards of in-process quality control and avoid contravening the safety objectives of the Medicines Act of 1968.

Pharmaceutical materials are tested throughout the production process: incoming raw materials, intermediate products and finished goods.

The stringent safety standards of quality control can cause considerable delays to the flow of materials through the logistics system. The inherent batch production nature of the pharmaceutical industry requires material samples to be tested as being representative of their production batch, be they raw materials, intermediate products or finished goods. The rejection of a sample as being sub-standard can often lead to the rejection of the whole batch. Whether a rejection occurs at the beginning of the logistics system, with bought-in raw materials, or at the end, with finished goods, or anywhere in between, it can result in lengthy delays causing re-purchasing or re-processing.

Information giving the results of the tested materials is fed back to the appropriate controlling functions.

Documentation

This function is associated with the physical distribution task of transporting materials from the manufacturer to the customer.

It involves the preparation and handling of shipping documents, government documents and financial documents, e.g.

Bills of lading
Freight contracts
Freight bills
Insurance policies
Export declarations
Certificates of origin
Import licenses
Invoices
Credit control files

Pharmaceutical manufacturers frequently use the services of a number of freight forwarding agents for arranging their export shipments (128). Companies may hand over complete control of shipments to these agents, but more likely they will use them to facilitate the progress of the associated export documentation.

Tookey (166) sees documentation as having three main purposes in its direct relation to physical distribution:

i) To evidence the contract of sale and prove its fulfillment in the despatch and routing of goods.

ii) The documents stand in lieu of the goods, conferring ownership by their possession, defining responsibility for their care and protection, and providing the means of payment for the goods.

iii) To ensure safe and correct handling by all parties involved and to ensure progress of the export order.

Errors, or anomalies, in documentation can affect the materials flow of the logistics system by causing delay to the transportation of goods to the customer through hold-ups in 'awaiting clearance' or mis-routing.

Figure 4.1 shows documentation as providing a direct information service to the transportation function.

Inventory Control

The large number of production stages involved in the manufacture of pharmaceuticals necessitates a relatively high aggregate holding of in-process inventory. For reasons stated earlier in Chapter 2 the usual policy of pharmaceutical manufacturers is to aim at holding nil safety stocks of active intermediate products, and to hold only cycle stocks that are currently in production. However, due to quality control rejection, re-processing or, merely, excessive production yields, this policy cannot always be followed.

A widening of the range of pharmaceutical products, and the resultant increase in the number of product variations, in turn means greater inventory levels with correspondingly less movement in each type of product inventory (161).

Considerable pressure has recently been applied in companies to reduce their inventory holdings at all stages, or stocking points, in the logistics flow. The overall result is an increased importance for the inventory control function who now have to operate within much narrower limits and are involved with the performance of other functions within the logistics system. Manufacturers are now aiming to hold, on average, 8-9 weeks demand of finished goods, whereas in the past upwards of 4 months supply would frequently have been stocked.

With epidemics now less common, and more predictable, sudden fluctuations in demand are less marked. On the other hand, the recent irregularities and uncertainties in supply of many raw materials and components, particularly packaging components, caused manufacturers to buld up large stocks of certain items to ensure no future failure in supply. Inventories can then exceed their economically determined levels.

One noticeable feature of the impact that inventory control measures have on the logistics system is in reducing the number of, or totally eliminating, regional warehouses. There is a tendency amongst pharmaceutical manufacturers to carry all finished goods stocks for national distribution in one centralised warehouse, and thus enable a reduction in the manufacturer's aggregate inventory holding.

Inventory represents capital investment that is yielding no monetary return. The cost of inventory investment is represented by the interest that could be gained by investing the amount of the capital involved elsewhere. The high value of pharmaceutical products, the large number of raw materials required in their manufacture, and the often high number of production stages results in a substantial contribution by inventory to the total logistics costs of a manufacturer.

Inventory control results in a flow of information to purchasing, storage, production and tranportation functions. Failure to comply with inventory control requirements can result in excessive production costs, purchasing costs, storage costs and shortfalls, eventually resulting in a failure to supply the customer within an adequate time.

Information Feedback

This is not usually a recognised function within a company structure in that it is not carried out by a separate group of specialists. However, now that the computer is being increasingly used to process logistics information (30, 114) the significance of information feedback as a recognised entity is growing.

Information feedback is a very necessary part of the logistics system in ensuring that information flows readily back along the information flow path. Six separate information feedback requirements are depicted in Figure 4.1.

Looking at information flow in a broad sense, Hertz (82) sees:

> "..... information streams as combining to provide business management with an ability to examine the possible ..... looking at the consequences of alternative ways of operating or making decisions within a business ..... evaluating the performance of the various functional activities and of the business as a whole ....." (Reference: Hertz (82))

In order to achieve this, functions such as inventory control, production scheduling and purchasing rely on fast and accurate information feedback on the operations of other activity centres.

Whether the direct expense of information feedback facilities is significant in relation to the direct costs of other functions is questionable. Magee (115) considers that, in general, the cost of information communications and processing is a small part of the total logistics system cost.

Figure 4.1. indicates that specific information is being fed back from inventory control, production scheduling, market forecasting and quality control functions, though doubtless there are numerous other feedback flows operating within a company's logistics system.

Materials Handling

The function of materials handling can be considered to operate in four respects:

i) Offloading raw materials and components from incoming transport.

ii) Handling within the warehouse.
iii) Movement of materials between production areas (plants) and warehouses.
iv) Loading packaged products, on to outbound transport, including the packing of containers for overseas shipment.

Six materials handling activity centres are included in Figure 4.1; the number would be greater if each individual production stage were included.

The equipment and operations of the materials handling function in the pharmaceutical manufacturer's logistics system is, to a large extent, determined by the material's handling characteristics. Murphy (122) indicates these characteristics as: the ease with which a product can be palletised; the weight limitations it imposes on handling equipment; any special temperature, or other climatic or physical storage conditions.

The storage characteristics of the warehouses, and the characteristics of the transport vehicles, and the production vessels, also affect materials handling.

Pharmaceutical materials, be they products or raw materials, have broadly similar handling characteristics; low bulk, low weight, (per package, anyway) and easily palletised.

Storage characteristics are also essentially similar in that one warehouse is usually used to store the majority of materials.

In addition, the versatile plant used for the manufacture of several products, and the fairly widespread use of road transport into and out of the manufacturer's premises, also produces a similarity in the other characteristics.

As a result, pallets are widely used for carrying all manner of pharmaceutical materials and packaging components. Conventional fork-lift trucks can be used for handling the pallets, plus materials, in each of the four previously-listed handling situations. The design of these trucks must recognise the method of warehouse storage; for wide aisle width turning circles are permissible, for narrow aisle width they are not.

Materials handling activity centres are depicted in Figure 4.1 as having no associated information flows.

Order Processing

Customers' orders are received by the order processing section of the pharmaceutical manufacturer who sends a copy of the order to the warehouse for preparation and despatch of the goods, and prepares an invoice for the customer.

Communications difficulties can arise if orders are received at a location distant from the finished goods warehouse. However, with the recent technological advances in data communication and processing, this now poses less of a problem than ever.

Orders are received by post, telegraph or telephone. Each order must first be checked for its accuracy and acceptability. The order is then priced, allowing for any discounts.

It is becoming the increasing practice of pharmaceutical manufacturers, especially those who deliver directly to retail chemists, to impose a minimum order size restriction. This has the effect of reducing the customer's ordering frequency and ensures that the manufacturer's operational cost in just processing an order does not exceed that order's value. This acts against a trend noted by Bullen (26) that customers are now tending to order more frequently and in smaller quantities.

One particular cause of excess expenditure and effort in order processing is in the duplication of orders when a product is out of stock. In this situation a 'back order' or 'extraction' is raised, whereby the out-of-stock item is separately entered on an order that has to be reprocessed and despatched later when available.

Back orders additionally cause increased costs in packaging and transport, when a single item on an order has to be prepared and despatched separately.

Order processing's interface with customers results in it frequently being the receiver of customers' complaints. Customer service or customer complaints managers are thus often incorporated into the organisation of the order processing section.

Order Picking

For most pharmaceutical manufacturers, order picking remains essentially a manual operation.

A copy of the customer's order, maybe containing up to 40 separate items in varying quantities, is received by an order picker. He manually picks the relevant items from the warehouse shelves, marking any that are out-of-stock for extraction.

The finished goods stock from which he picks is replenished periodically from the bulk of stock, so that a quantity of each product is available for selection within a manageable area.

An exception to the manual picking operation is provided by "Boots" who operate an automated warehouse with computer-controlled picking (60, 121).

In this country, both the turnover and diversity of pharmaceutical products are usually insufficient to justify the capital investment for a completely automated warehouse installation by a pharmaceutical manufacturer.

Referring to Figure 4.1, order picking is a link in the material flow path from materials handling to packaging, with an information feed-in (order copies) from order processing.

Packaging

There are two design facets of packaging that concern the pharmaceutical manufacturer: one, the internal pack for each product and two, the outer pack for despatch to the customer.

The first is primarily associated with the merchandising potential of pack design: graphics, instructions, leaflets and consumer utilitarian factors, e.g., medicines are supplied in individual packs per single treatment per person, where possible.

The second type of pack design is most concerned with protection against damage and loss.

Recently, however, increasing attention is being paid to materials handling efficiency, order picking facility and ease of inventory control, in designing both the inner and outer packs (94). For instance, prominent marketing identification of the inner pharmaceutical pack can greatly facilitate order picking and stock taking, both in the manufacturer's warehouse and in the customers' premises, as well as being desirable in helping to avoid dispensing errors. Shrink wrapping of customers' orders is a fairly recent innovation in outer pack design; it can save on packaging materials, packaging labour (when the shrink wrapping is automated), make identification easier and reduce damage and loss in transit. Polythene sheeting is usually used for shrink wrapping.

The packaging operation itself may be manual or automated. Packaging inner containers, or packs, tends to be part manual/part automatic, whilst outer packaging is usually carried out manually, unless shrink wrapping is used.

Banks (11) notes that

> ".... packaging requirements may add significant increments to total distribution expense, and in fact be the ultimate determinant of choice among several transport alternatives."
> (Reference: Banks(11))

Jantzen and Alexander (94) suggest that this interrelated effect on physical distribution cost is the most significant of their listed package design parameters.

Certain pharmaceutical products have to be transported under special storage conditions, e.g., kept cool below 10°C. For hazardous, toxic, inflammable or irritant materials, there are restrictions on acceptability for air freight. (123, 166).

Containerisation has revolutionised overseas distribution; one major effect is the packaging cost saving for sea-freighted exports (180).

One very important feature of pharmaceutical distribution, especially overseas, is in the avoidance of cross-contamination by goods previously carried, or by accompanying goods. Sound, protective packaging is therefore essential, in addition to the usual protection required from the hazards of the climate, oil contamination, sea water seepage, etc.

The operation of packaging finished goods to the customer differs in its emphasis between national and overseas distribution. The first concerns the packaging of relatively small individual customer orders, whilst the second is primarily concerned with packaging much larger shipments, requiring more protective outer packaging or containers.

Plants and Production Scheduling

The details of the manufacturing operations and production scheduling were discussed in Chapter 2.

The costs of manufacture do not usually contribute towards the total cost of the logistics system, except inasmuch as production scheduling can affect these costs, through determining the duration of each process stage.

As shown in Figure 4.1, the pharmaceutical chemical and pharmaceutical production plants each receive information from production scheduling.

Production scheduling, in turn, relies on information feedback from demand forecasting, inventory control and quality control. Basically, production scheduling controls three manufacturing decision areas:

i) Deciding which product to make in a multi-product plant.
ii) Deciding the lot size, or the number of batches, of each process stage.
iii) Scheduling the times of each process stage to allow for plant operating constraints.

These decisions require a balancing of conflicting interests between the functions of inventory control, manufacturing, warehousing (and maybe others) to determine an "economic manufacturing quantity".

Manufacturing prefer long, uninterrupted runs of each stage to reduce equipment clean-down times and so reduce their per unit product manufacturing costs.. Inventory control, and warehousing, on the other hand, favour short durations of each process stage to minimise inventories and to provide maximum flexibility in responding to unpredictable demand fluctuations.

Production scheduling directly controls the flow of materials within the manufacturing plants primarily on the basis of information feedback.

Purchasing

Figure 4.1 shows purchasing at the tail end of the information flow path, c.f., beginning of the material flow path.

Three main decision areas are involved in the purchase of raw materials, packaging and other components from outside suppliers:

i) Deciding how much of each raw material, or component, to purchase at a time.

ii) Deciding when to purchase these quantities.

iii) Deciding with which suppliers to place the orders.

Purchasing's performance relies upon a fast and accurate information feedback service from other functions, notably production scheduling, inventory control and demand forecasting. In addition, there is usually a close liaison maintained between the purchasing and quality control functions of a pharmaceutical manufacturer. This is necessary to ensure that quality standards imposed by the manufacturer on chemical and pharmaceutical raw materials are understood and agreed upon by the outside suppliers.

The growth of purchasing's role in logistics is emphasised by a collection of articles by McElhiney and Cook (124). The underlying theme of some of these articles is the purchasing executive's accountability to top management and with it the need to coordinate his activities with those of other departments. Another is the necessity for purchasing to be recognised by management as a profit-making activity.

Many suppliers offer bulk purchase discounts. The cost savings in purchasing larger than normal volumes at one time have to be weighed against the increased costs of the greater inventory holdings.

Many pharmaceutical manufacturers are now commissioning computerised systems for calculating the numbers of each raw material and component items required to meet periodic demand forecasts, using predicted production efficiencies at each process stage. Some companies have already installed such systems.

Interest in automating the operations of this area of the logistics system can be attributed to two primary characteristics of the pharmaceutical purchasing function: one, the essential requirement for fast and accurate information feedback from other parts of the logistics system, and two, the extremely large number and variety of raw materials and components employed in the manufacture of pharmaceuticals (say, up to 5,000 separate items.)

Storage and Warehousing

In Figure 4.1, the Warehouse facility represents the function of storage and warehousing. This involves the storage of raw materials and components, intermediate products and finished goods.

Although certain pharmaceutical manufacturers use regional warehouses for distribution in Britain, the usual practice is to operate from one central warehouse. Benefits in regional warehousing are probably realised when pharmaceuticals are distributed together with other, more bulky, products in the company's range. The savings in transportation costs can then offset the extra cost of warehouse investment, operation and increased aggregate inventory levels.

Examples of activities performed by the storage and warehousing function are:

- Selection, and use of public and/or leased warehouses, to increase capacity and to allow manufacturers to place inventories at a wide variety of locations in anticipation of customer demand.. (87)
- Selection, and use, of foreign trade zone facilities.
- Use of special storage arrangements, e.g., refrigeration, bonded storage or high security storage for certain pharmaceutical materials.
- Protection of the physical condition of the inventory during storage.

Each of the three warehouse facilities, in Figure 4.1, receive an information feed from their appropriate inventory controller.

Transportation

The methods of overseas and national distribution were broadly covered in Chapter 2. It was indicated there that a wide variety of modes of transport are employed by pharmaceutical manufacturers, although road transport predominates for national distribution.

Although transport costs may account for less than 1% of the total product cost in many cases, the transportation function is a very significant one within the logistics system. In Figure 4.1 it is depicted as the last activity centre of the materials flow path. It therefore provides a direct customer-manufacturer interface for the logistics system.

Additionally, the delivery patterns of transportation to the customer influence both the customer's ordering routine (the timing and frequency of his order placements), and the operations of the other activity centres preceding transportation in the materials flow path.

Smykay (156) emphasises how transportation can affect the size of transit stocks, suggesting that:

> ".... the major force which influences a decision in favour of shortened transit periods is the value of the product ..." (Reference:Smykay(156))

The advocates of using air cargo, e.g. Jackson and Brackenridge(92), use this argument in support of their claims.

The Pharmaceutical Journal (142) notes that pharmaceuticals lend themselves to air transport because many are perishable, in terms of temperature sensitivity or short shelf-life, and many are needed urgently at their destination.

However, despite predictions of substantial upturns in the volume of goods being transported by air (123), both conventional shipping and containerisation on deep sea routes, and 'roll-on roll-off' road haulage retain a considerable proportion of the pharmaceutical export business from Great Britain.

As Tookey (166) points out, there is frequently a conflict of interests between the method of despatch favoured by the manufacturer and the method of importation favoured by the overseas customer.

National distribution may be carried out by several alternative modes of transport, e.g., road haulage by own vehicles, contracted carriers or national carriers; rail freight using parcels service (including 'Red Star'), or passenger train service; postal deliveries; air transport to remote regions.

One of the most significant recent developments in transportation planning strategy by pharmaceutical manufacturers is in the increasing use of scheduled deliveries to larger customer groups. Such a service may only deliver once a fortnight, but on a pre-determined date. This arrangement encourages the use of self-operated, or privately contracted, road haulage vehicles rather than nationalised carriers.

There are substantial savings to be gained in 'shopping around' amongst carriers, whose levels of service and freight rates to certain areas can vary considerably. Management of the transport function should be aware of these opportunities, and also of those for consolidating shipments, obtaining the best insurance rates, continually being aware of packaging requirements and transport regulations.

In recognising that there is no 'ideal' transport mode, Murphy (122) states that:

> ".... any attempt to standardise the type of mode used within a large organisation with a variety of products and markets must naturally be a compromise." (Reference: Murphy (122))

He goes on to say that the transportation function operates in a dynamic environment, and that its operations require continual review.

In Figure 4.1, the transportation activity centre is shown as being linked to the documentation and inventory control functions.

2. The Logistics Functions as Cost Centres

Each of the previously discussed activity centres can be seen as contributing towards the total logistics system cost. The fact that an activity centre exists as a recognised function in a company organisation implies that its operations incur a cost to the company. This cost may appear as a direct expense, or as a capital investment, or as an overhead cost, or whatever, but it may still be considered as a contributor to the total logistics system cost.

It seems reasonable, therefore, to regard each activity centre, or logistics function, as a cost centre within the logistics system.

It is unlikely that any logistics system analysis is able to consider every contributory cost centre.

Those considered most significant would hopefully, be included, and those deemed least significant would be excluded.

The measure of significance could be based on:

i) direct cost contribution,
ii) indirect cost contribution,
iii) the potential variation in cost contribution to the total logistics system cost.

e.g.

i) transportation makes a direct cost contribution in terms of its freight rate expenditure;

ii) production scheduling makes an indirect cost contribution in that, whereas its own operating expenses may be fairly low, its influence on costs of manufacture can be considerable;

iii) storage and warehousing costs, both in terms of investment and direct expenditure, may be fairly low, yet the necessity for additional warehouse capacity could involve considerably more costs in building or leasing extra facilities.

It would be helpful, at this stage in the analysis, to review some other authors' published logistics cost analyses, and to indicate which cost centres they include.

Table 4.1 lists the cost centres (previously termed activity centres) that are included in Figure 4.1. Those included in each of the reviewed analyses are indicated down each column.

Table 4.1 highlights two areas of total omission from the reviewed logistics system analyses: production costs and quality control operations.

List of Cost Centres		Bowersox et al (18)	Dicer (56)	Garnett and Smith (69)	LeKashman and Stolle (111)	Pope (143)	Stasch (159)	Wayman (178)	DeHayes and Taylor (55)
Purchasing					✓	✓			✓
Materials Handling	- raw materials	✓	✓	✓	✓	✓	✓	✓	✓
	- intermediate prod.		✓		✓	✓	✓		✓
	- finished goods	✓	✓	✓	✓	✓	✓	✓	✓
Storage & Warehousing -									
	raw materials	✓	✓	✓	✓	✓			✓
	- intermediate prod.		✓		✓	✓			✓
	- finished goods	✓	✓	✓	✓	✓			✓
Quality Control	- raw materials								
	- intermediate prod.								
	- finished goods								
Production	- intermediate prod. stages								
	- finished goods stages								
Order Picking		✓	✓	✓	✓	✓		✓	✓
Transportation	- finished goods	✓	✓	✓	✓	✓	✓	✓	✓
Packaging	- finished goods	✓	✓	✓	✓	✓		✓	✓
Documentation	- finished goods	✓	✓		✓	✓			
Order Processing		✓	✓	✓	✓	✓	✓		
Inventory Control	- raw materials		✓	✓	✓	✓	✓	✓	✓
	- intermediate prod.		✓		✓	✓	✓		✓
	- finished goods	✓	✓	✓	✓	✓	✓	✓	✓
Production Scheduling									
	- intermediate prod.		✓		✓	✓			✓
	- finished goods		✓		✓	✓			✓
Information Feedback		✓	✓		✓				

Table 4.1. Cost Centres Included in Logistics Systems Analyses

The reviewed analyses also group together the operations of materials handling, storage and warehousing, inventory control and production scheduling, and do not differentiate each with respect to the stage of material conversion (raw materials, intermediate products or finished goods). This is in line with the departmental organisation of companies where only one materials handling, one storage and warehousing, one inventory control and one production scheduling department usually exist at each company location. In fact the information feedback activity centres of Figure 4.1 are listed as a sole cost centre in Table 4.1, since no hierarchy of information types is designated as it is with material flow.

A general, though comprehensive, logistics system analysis might therefore be considered to include the following cost centres:

Purchasing
Materials Handling
Storage and Warehousing
Order Picking
Packaging
Transportation
Documentation
Order Processing
Inventory Control
Production Scheduling
Information Feedback

The relevance of quality control to the pharmaceutical manufacturer may be sufficiently great, in cost terms, to include it in the above list.

The exclusion of production itself would seem to be reasonable since its costs, other than those affected by production scheduling, are generally allied to process, equipment and labour operating efficiencies, which are not controlled by either the objectives or the constraints of the logistics system.*

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* Only when production scheduling directs the manufacture of less than a complete batch size, or when chemical reaction efficiency, or equipment and labour utilisation efficiency, is lowered due to short runs on each process stage with frequent clean downs.

3. Interactions Between the Cost Centres

The systems approach to logistics analysis, proposed in Chapter 3, is founded upon the recognition that the individual logistics functions represent a series of interconnected parts making up the total logistics system. In other words, no single function should be considered in isolation from the rest of the logistics system during the process of decision making.

If logistics functions can be regarded as cost centres, each contributing towards a total logistics system cost, then it follows that the interrelations between these cost centres must have a bearing on the total cost.

For example, if the total logistics cost is made up of the three cost centres of transportation, inventory, and storage and warehousing, i.e.

Total logistics cost = transportation costs + inventory investment
+ storage and warehousing costs.

An increase in transportation cost by, say, £X will not result in a corresponding increase in total logistics cost by the same amount, £X. Due to the interrelated effects on the other two cost centres, which may be positive or negative, the total logistics cost could change by an amount greater or less than £X.

Flaks (64) concludes that the ultimate judgment of a distribution study must be based upon an examination of the total costs involved and their interrelationships.

The interrelation of cost centres is the principle behind 'trade-offs' mentioned in earlier Chapters 1 and 3, and referred to by logistics system analysts. For example, Christopher (38), considers that:

> ".... the successful identification of cost trade-offs is the crux of logistics systems engineering .... it requires the detailing of all activity centres within the logistics system and the listing of alternative methods of performing their functions...." (Reference: Christopher (38)).

If, in the above example, an increase in transportation cost of £X results in a saving in inventory investment equivalent to £Y, then the transportation and inventory cost centres could be said to have been 'traded-off' against one another. All other effects being equal, the trade-off would be favourable, in terms of the total logistics system, if Y is greater than X.

There are numerous examples of interrelated effects between cost centres, or trade-offs, mentioned in the literature.

Both Constable (45) and Das (51) devise models to select from amongst transport alternatives on the basis of their effect on transport costs and inventory investment. Das compares inventory costs for the consignee against alternative sets of lead time characteristics provided by different transport arrangements.

In noting that:

> ".... the increased awareness of the systems approach to decision-making has focussed recent efforts on determining the relationships between decisions made in different functional areas of the firm....." (Reference: Constable (45))

Constable focussed his research on the relationships between the inventory and transportation decisions, considering the specific situation of shipping products to a storage facility.

Sims (153) takes a systems approach to materials handling management and investigates the inter-organisational relationships of materials handling with each of the following materials flow functions: production control, packaging, purchasing and inventory control.

Franco and Schorr (66) demonstrate how the selection of a low cost form of transport (Rail) can result in escalated costs of warehousing, inventory investment, packaging and order processing, that could far outweigh the transport savings.

Jantzen and Alexander (94) warn that the great strides made recently in packaging technology are primarily pre-occupied with reducing costs attributable to damage and losses. However, the authors do state that increased packaging expenditure can often have a significant effect on logistics costs is many other respects, e.g. materials handling efficiency, order picking facility, ease of inventory control.

Wronski (180), in looking at the impact of international container shipments on corporate physical distribution management, is specifically concerned with its impact on the transportation, warehouse - inventory and documentation - communication functions. He recognises that the interrelated effects caused by the move to container shipments are sufficiently great to necessitate a complete restructuring of the overseas distribution process. The full potential of containerisation cannot be realised by only considering its cost effects upon one logistics function, e.g. packaging.

Many further examples of interrelation between cost centres can be found in the literature, though unfortunately none relating directly to the functions of the pharmaceutical manufacturer.

The few examples, cited above, do serve to illustrate the necessity to account for the interactions between cost centres if a logistics system analysis is to derive a meaningful total logistics cost for that system.

However, the question arises as to whether all of the relevant interactions are included in the logistics analyses of the above examples. In other words could a true logistics system cost be obtained by an analysis which considers only a portion of the functional interactions?

Dicer (56) includes 8 functions in his postulated logistics system. Figure 4.2. taken from Dicer, indicates that there are 28 possible functional interactions within the logistics system. Each one has to be considered if a truly accurate total logistics cost is to be derived; ignoring interactions can only jeopardise the accuracy of the analysis unless their cost effects are considered and calculated to be negligible.

Stasch (159) specifically considers the trade-offs between i) the levels of safety stock in a warehouse and the reliability of incoming transportation from the factory to the warehouse, ii) the levels of cycle stocks and the speed of transportation, iii) the speed of communications and order processing, and the speed of transportation, and iv) the speed of communications and the speed of transportation.

However Stasch states:

> ".... That a physical distribution system represents a great many trade-off possibilities should be apparent from the foregoing discussions of several of the trade-offs found in only a small segment of the entire physical distribution system. If the reader reflects on the fact that the total physical distribution system consists of many such segments, or basic physical distribution modules, in tandem, he will recognise the proliferation of trade-offs, which might be found in the total system....." (Reference: Stasch (159)).

The 'proliferation' of trade-offs, in tandem, amongst the 11 logistics functions (excluding Quality Control) for the pharmaceutical manufacturer, as indicated earlier, would number 55.

$$\frac{n\ (n-1)}{2} = \frac{11.10}{2} = 55$$

This figure is almost double that of Dicer's for an increase in only 3 functions.

Stasch (159) did add that:

> "...This proliferation (of trade-offs) is not something that is unmanageable...." (Reference: Stasch (159)).

He uses a tree diagram of the logistics system to identify those branches, and the pertinent logistics functions performed therein, where trade-offs are more likely to be found. This tree diagram is used in conjunction with a performance criterion schedule, incorporating the volume, distance and delivery time relationships with total distribution costs. Both are shown in Figure 4.3.

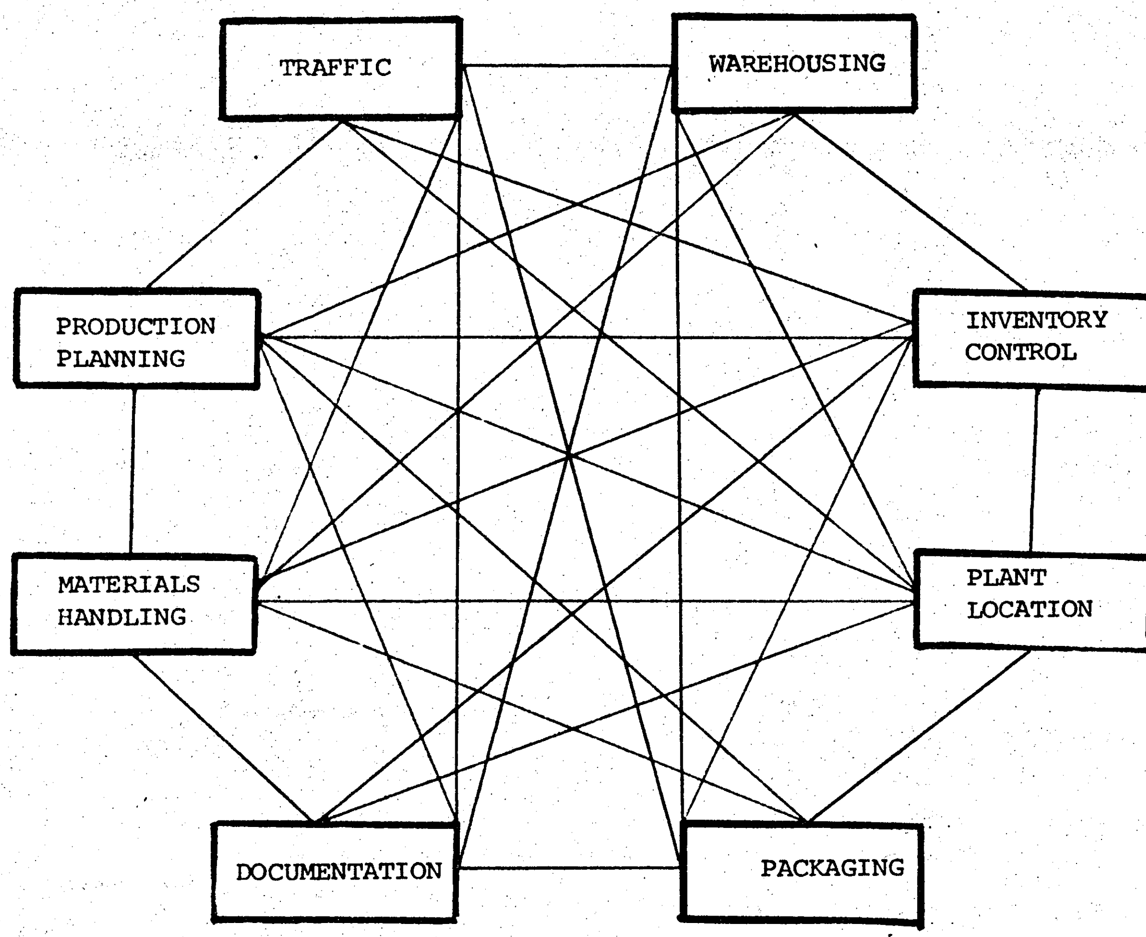
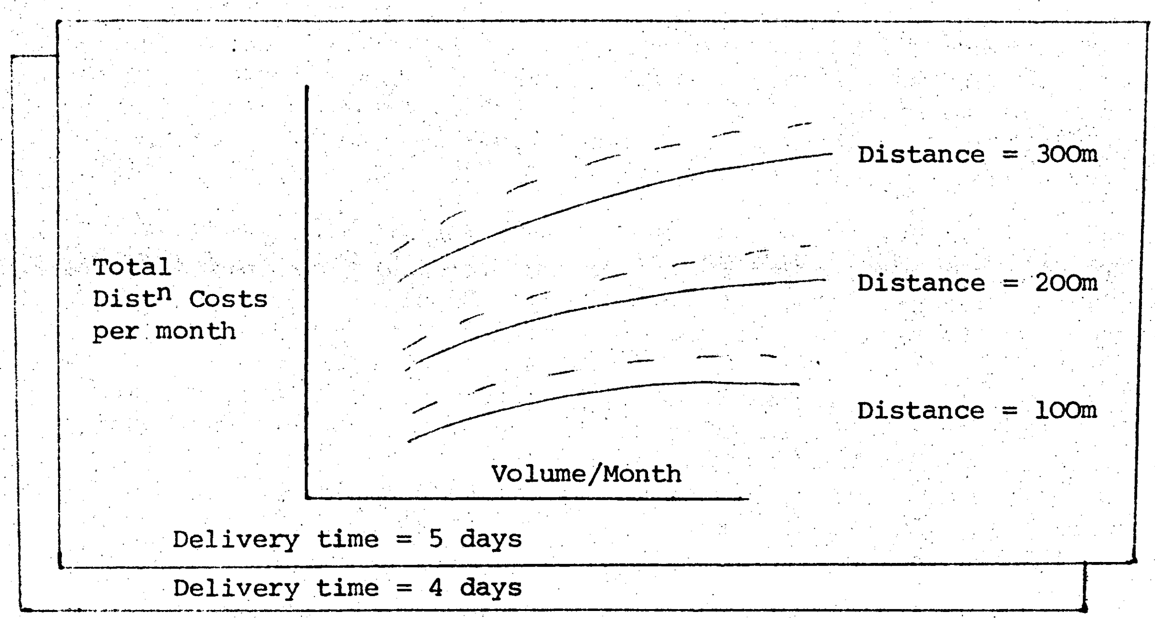


Figure 4.2. Logistics System Showing Functional Interactions (Source: Dicer (56))



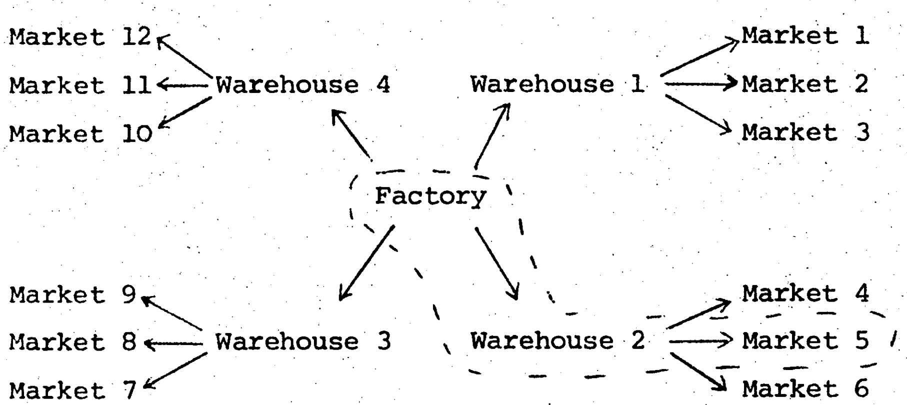


Figure 4.3. Physical Distribution Criterion Schedule - Tree Diagram of a Physical Distribution System. (Source: Stasch (159))

For instance, if market five's physical distribution costs are above average for the volume - distance - delivery time category into which it falls, an analysis should be made of the portion of the physical distribution indicated by the dotted lines on the tree diagram in Figure 4.3.

The heuristic approach, as providing a guideline to the reduction of alternatives open to the logistics decision maker, was discussed in Chapter 3. Figure 4.3 portrays Stasch's heuristic method for reducing the proliferation of trade-offs to a manageable scope.

If a logistics system analysis is to cover all, or most, of the functions in the total system and the interactions between them then it would appear that the possible number of interactions will have to be reduced; only then can a meaningful cost for the total logistics system be derived.

Summary

As a first step in logistics systems analysis a flowchart was constructed of the pharmaceutical manufacturer's logistics system. This depicted the inputs and outputs to the system and identified the logistics functions contained therein as activity centres. These could be connected with the flow of materials through the system, the flow of information or the flow of customers' orders.

In the absence of any specific reference to the logistics functions of a pharmaceutical manufacturer, the activity centres were compared to those listed by LaLonde et al (106) for a manufacturing company in general.

Each of these activity centres was discussed in turn with respect to its function as a part of the logistics system. 12 activity centres were identified.

Since each activity incurs costs which contribute towards the total cost of the logistics system, the activity centres were regarded as cost centres, even though the types of cost contribution may be of different forms.

A comparison was made of the cost centres identified for the pharmaceutical manufacturer with those of some other authors' logistics systems analyses. As a result of this comparison, the number of cost centres to be included in this logistics system analysis was reduced to eleven. Quality control, it was noted,has special relevance for pharmaceutical material testing.

The systems approach to logistics analysis requires that the interactions between cost centres should be considered if a true total logistics cost is to be derived. However, the number of these interactions to be included in the logistics system analysis is sufficiently large to be a daunting prospect; Stasch (159) terms it a 'proliferation of trade-offs'. However he (Stasch) reduces the problem to a manageable scope by employing a heuristic approach.

It was pointed out that the logistics system represented in flowchart form in this chapter omits the flows through the distribution channels to the customers, whose inclusion is essential to cover the scope of business logistics.

The next chapter will consider this extension to the logistics system in terms of delivery time criteria as measures of customer service. Decisions taken that affect the operations, and costs, of the pharmaceutical manufacturer's logistics functions can also affect the times of carrying out these operations. If the lead times to the customer are correspondingly affected then the logistics contribution to customer service can be changed. The next chapter will highlight three lead time characteristics as measures of customer service, and will also describe each of the types of pharmaceutical manufacturers' customers and their service requirements.

Chapter 6 will propose a number of research hypotheses that will:

i) provide a heuristic approach to reducing the number of interactions,or trade-offs, to be included in the logistics system analysis,

ii)relate the lead time characteristics of customer service to each customer type, and their particular service requirements.

These proposals should provide the basis for a logistics system analysis to consider the cost and effectiveness, measured in terms of customer service, of any alternative proposal to the operation of the logistics system of the pharmaceutical manufacturer.

Chapter 5

Customer Service Considerations

Introduction

Chapter 3 outlined the principles of taking a systems approach as a philosophy to guide decision making in logistics systems. The technique of logistics systems engineering, a direct result of the systems approach, involves a cost-effectiveness analysis as the basis for an operational decision making model.

Chapter 4 described the logistics system of the pharmaceutical manufacturer in sufficient detail to expose the individual functions that comprise the logistics system. A total logistics cost for the system was obtained as a result of the combined individual costs of the various activity centres which are dependent, to a considerable extent, upon interactive effects between them.

This chapter will now look at the effectiveness side of the cost-effectiveness balance.

It will be asserted that the operations of the logistics system do make a contribution to the marketing interests of the pharmaceutical manufacturer, through their effect upon customer service, and that customer service can be used as a measure of the effectiveness of the logistics system.

Customer service, in itself, is a somewhat nebulous term. It needs to be defined more specifically to suit the particular logistics system - market situation by identifying relevant criteria of customer service. For the pharmaceutical manufacturer supplying the pharmaceutical home market, it is contended here that the relevant customer service criteria are those of lead time duration, lead time consistency, and lead time flexibility; lead time is defined as the time the customer waits for receipt of goods from the moment he places his order.

In order to support these contentions, this chapter will first examine each of a number of groups of customers, identified by extending the flowchart of the logistics system for the pharmaceutical manufacturer, constructed in the previous chapter, to include the distribution channels within the home market.

Having established that customer service is a suitable measure of logistics system effectiveness, a literature review will be made to identify possible criteria of customer service. The three criteria associated with the characteristics of lead time are established as those most relevant to the pharmaceutical situation, considering the service requirements of the three main groups of customers: the wholesalers, hospital pharmacists and retail chemists.

1. Identifying the Customers and Distribution Channels of the Pharmaceutical Manufacturer.

Chapter 2 discussed the types of customer and distribution channels used by a pharmaceutical manufacturing company for both home and overseas distribution.

It was pointed out that the types of channel for overseas distribution can vary from country to country. The distribution channels for home distribution in Great Britain were represented as a schematic in Chapter 2, identifying the product flows between each of the customer institutions.

In the previous chapter, a flowchart of the pharmaceutical manufacturer's logistics system was drawn illustrating the necessary material, information and order flows linking the logistics functions, represented as being activity centres.

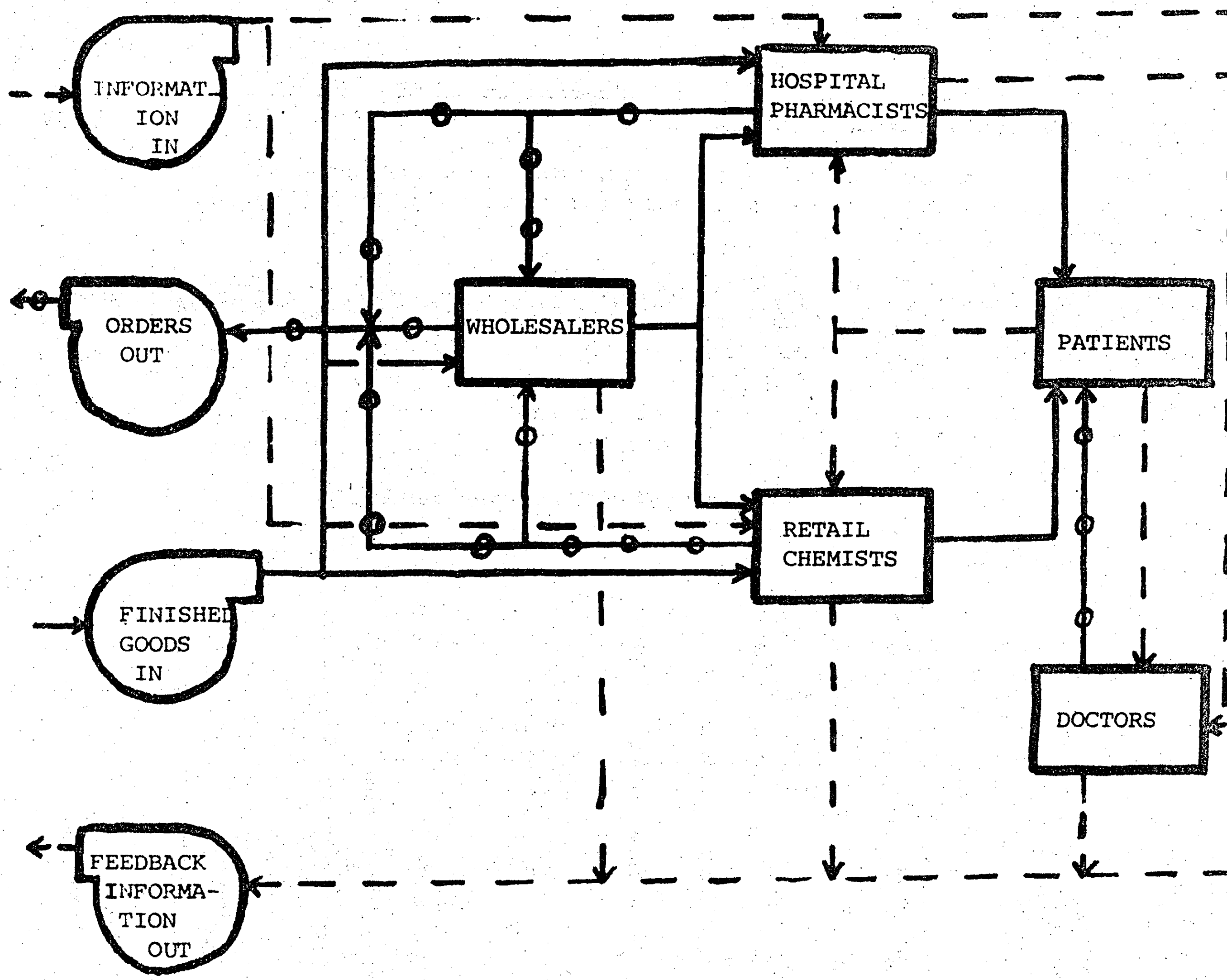
It was noted there that this charted logistics system is incomplete when considered against the original definition of business logistics, defined in Chapter 1. The full extent of the logistics system for a pharmaceutical manufacturer's home distribution can now be presented by incorporating the flows within the distribution channels with those already identified within the internal logistics pattern of the manufacturer. The necessary extension to the logistics flowchart is given in Figure 5.1.

With Figure 5.1 included, the logistics system analysis now widens to include the customers, and the distribution channels that serve them. Further to considering the logistics system's own internal interactions, or trade-offs, the interface between marketing and the logistics system is now included.

An illustration of the importance of the marketing/logistics interface could be as follows: the most certain way to lose the benefits of all the promotional sales effort put into the launching of a new product is for that product to be unavailable at the time of introduction to the market. If a doctor is persuaded to try prescribing a new product, then finds it is unavailable, he is likely to be annoyed, dissatisfied and to never prescribe that product again.

In this case, if communications between marketing and the logistics system do break down, then a conflict situation can arise whereby marketing require that the product must be made immediately available at all national outlets, while the logistics functions can only respond by incurring excessive costs, particularly in distribution and affiliated areas.

The information flows in Figure 5.1 do not represent transfer of promotional information from the marketing department to each of the customer categories. They relate only to the manufacturer's logistics system of the previous chapter, and not to the marketing department. Although marketing is thus considered as external to the logistics system, the logistics system's impact upon the marketing performance of the company can be considerable, as will be seen later in this chapter.



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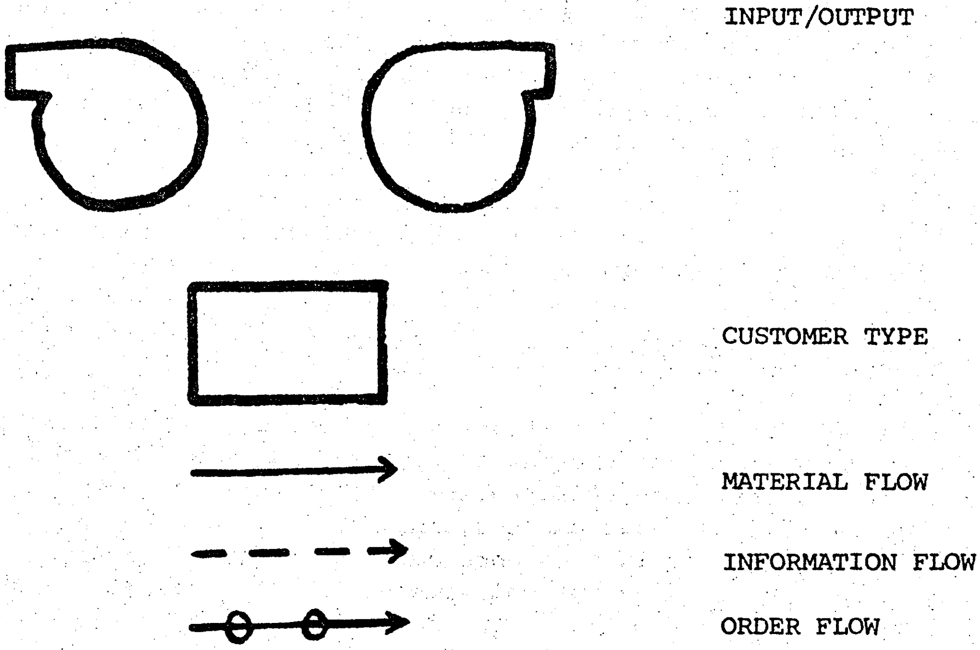

Figure 5.1: Extension to the Flowchart of the Logistics System for the Pharmaceutical Industry to Include Home Customers and Distribution Channels.

The order flow sequence begins with the doctor's prescription written for his patient. A pharmacist receives the prescription from the patient, or, in the case of internal hospital patients, from one of the hospital staff. This transfer is regarded here as a flow of information rather than an order flow, since the patient, himself, makes no ordering decision.

The pharmacist, whether hospital or retail, can order either directly from the manufacturer, * or via a local wholesaler.

The wholesaler, in turn, orders from the manufacturers.

The material flow of finished goods from the manufacturer follows a reverse path to the order flow, ending with receipt of the medicine by the patient who is the consumer. This is not always true since a number of doctors in Great Britain are dispensing doctors**, who will order and receive supplies of medicines from manufacturers and wholesalers. The proportion of finished goods to flow directly to doctors is, however, very small in relation to the rest of the system, and this channel is omitted from Figure 5.1. It should however be pointed out that Claycamp and Amstutz (41), in their portrayal of pharmaceutical distribution channels, do include these flows to dispensing doctors.

Five possible categories of customer are represented in Figure 5.1.

Wholesalers
Hospital Pharmacists
Retail Chemists
Doctors
Patients

Some other categories are omitted, e.g. clinics, armed forces, on the grounds that their share of the total throughput is relatively small.

Seven channels of distribution for the flow of finished goods are also represented in Figure 5.1.

Manufacturer → Wholesaler
Manufacturer → Hospital Pharmacist
Manufacturer → Retail Chemist
Wholesaler → Hospital Pharmacist
Wholesaler → Retail Chemist
Hospital Pharmacist → Patient
Retail Chemist → Patient

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* Some manufacturers do not allow, or discourage, such practice and ordering must then be done through wholesalers.

** Dispensing doctors are registered with the Department of Health and Social Security. They are permitted to dispense medicines from their own stocks as well as to prescribe them.

With the exception of the last two, these distribution channels were discussed in some detail in Chapter 2.

Each of the five customer groups are now discussed, in turn, in relation to their place in the total logistics system of the pharmaceutical manufacturer.

Wholesalers

A.C. Nielsen (133) identifies three categories of wholesalers supplying retail chemists and hospital pharmacists:

i) traditional wholesalers supplying drugs, ethicals and patent medicines;
ii) traditional wholesalers supplying other chemists' lines, including photographic goods, sundries, glassware, etc;
iii) cash and carry wholesalers.

In 1973, the numbers of each category for Great Britain, though excluding Northern Ireland, were:

i)	162	
ii)	77	
iii)	74	(Reference: A.C. Nielsen (133))

Only category i) is of real concern to this research, since it is confined to the distribution of ethical products only.

There are 171 traditional wholesaler members currently registered with the National Association of Pharmaceutical Distributors (the N.A.P.D.) throughout Great Britain (127).

Of this number, 116 (representing approximately 68% of the total number), belong to, or are subsidiaries of, the largest five wholesaler chains in the country. The remaining 40 members are relatively small indendent companies operating either from a single location, or from a few depots in a local area.

Figure 5.2. illustrates the regional distribution of the traditional pharmaceutical wholesalers, registered as members of the National Association of Pharmaceutical Distributors.

The figures represent the total number of wholesaler members for each region; the figures in brackets are the number of those that belong to one of the five largest wholesaler chains.

A.C. Nielsen (133) presents a similar regional distribution for traditional wholesalers' depots operative in 1973. It considers a total of 206 depots in England, Scotland and Wales.

The report (133) concludes that the proportion of depots in each of the regions (the same as in Figure 5.2) is very much in line with the proportion of the numbers of independent chemists trading in each of the regions. It notes exceptions, though, in the Greater London area where there are many fewer wholesaler depots than might be expected on this basis, and, at the other extreme, in the North and Yorkshire/Humberside region which has more wholesaler depots.

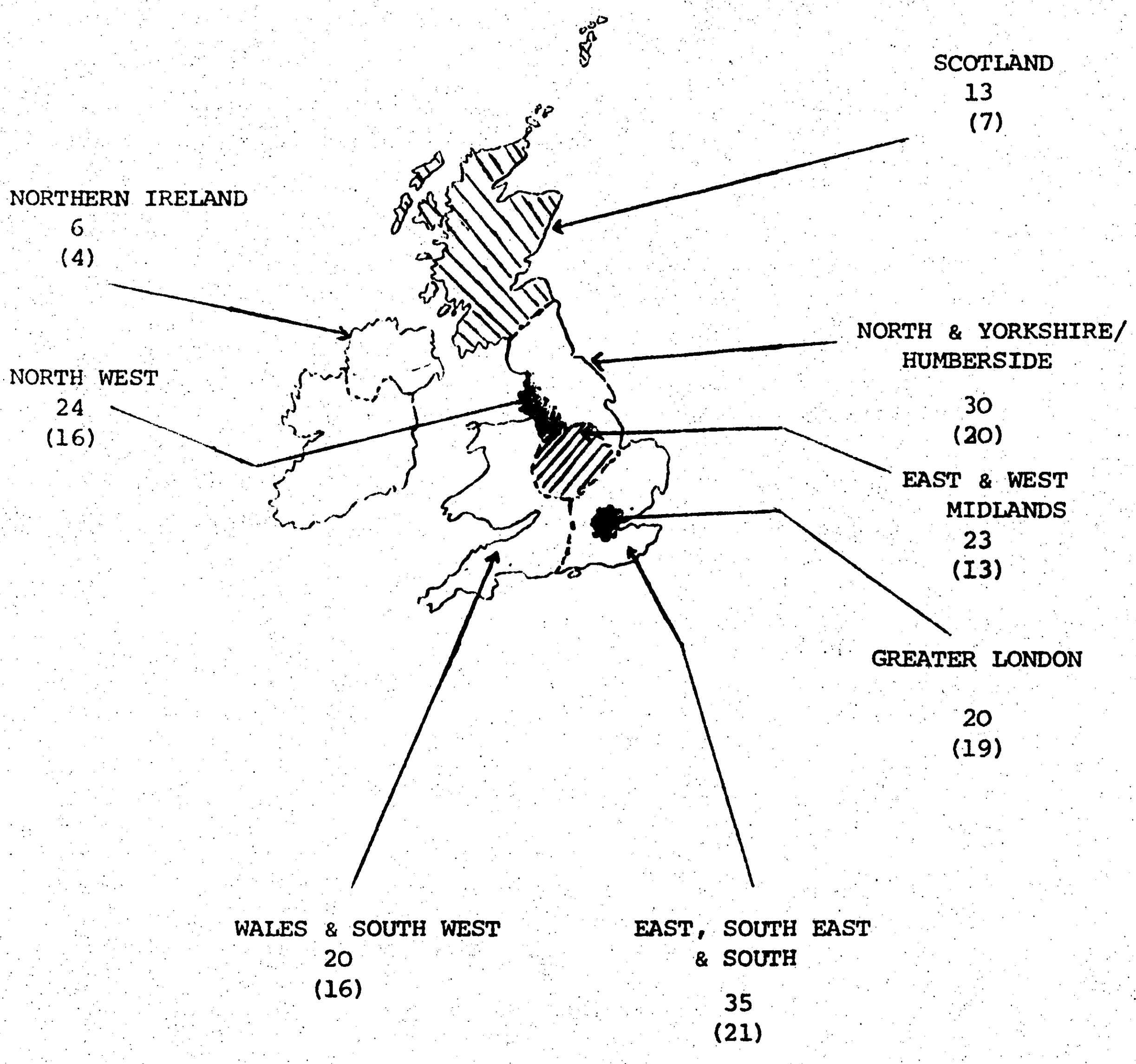

Figure 5.2: The Regional Distribution of Ethical Wholesalers Registered with the National Association of Pharmaceutical Distributors

The N.A.P.D. lays down a Code of Practice (127) to be complied with by its members, with respect to the distribution of medical speciality products. This Code of Practice is reproduced as Table 5.1.

Table 5.1: Code of Practice (as applied to medical speciality products) for Pharmaceutical Wholesalers.
(Reference: N.A.P.D. (127))

1. To ensure that stocks of manufacturers' products are:

   a) Comprehensive.
   b) Maintained at a level, to be agreed in consultation with the manufacturer, which is consistent with normal stock turnover.
   c) Correctly rotated.

2. To forward orders for stock replacement at such times and in such volume as to ensure maintenance of comprehensive stocks having regard to the delivery service provided by the manufacturer.

3. To ensure that orders to meet special demands, either for delivery to the wholesaler or direct to the customer, are kept to the minimum, consonant with the need to provide the requisite service to the customer.

4. Where a member has a pre-launch arrangement with a manufacturer for his new products, to accept into stock any consignment of new products of that manufacturer on terms that the member has the right to return all or part of that consignment for credit if not sold within an agreed period.

5. To co-operate with manufacturers' representatives in reviewing stocks.

6. To ensure that a daily supply service is provided to all retail outlets; if necessary, by cooperation with another wholesaler or by other means.

7. To assist manufacturers in specific programmes of sales promotion; for example, by giving publicity to special offers through wholesalers' representatives or bulletins issued to customers.

8. To provide an information service on medical specialities with particular reference to new products.

9. When a branded product is ordered, not to substitute another manufacturer's product of similar composition without the customer's consent.

10. Not to export goods without the manufacturer's express authorisation.

11. To cooperate with manufacturers by adjusting stock levels to meet anticipated demand arising from specific sales promotion.

Table 5.1. Continued

12. To adjust stock levels in anticipation of fluctuation in demand due to seasonal conditions.

13. To place new products held by him with retail pharmacists who have agreed to accept an initial stock.

14. To provide special storage facilities which may be required by the nature of the product.

The pharmaceutical wholesaler provides a service to his customers, retail chemists and hospital pharmacists, with a delivery frequency that is second-to-none; a once, twice, three or even four times a day delivery.

Wholesalers usually operate a fleet of delivery vans which make drops to retail and hospital pharmacies along established routes.

The goods are packed into individual consignments, according to each customer's order which may consist of from, say, one to fifty items on a single order. This packing operation is carried out by the wholesalers' order pickers and packers.

It is the practice of regular customers to place orders usually once or twice a day with the wholesaler. In fact, it is common for wholesalers to phone favoured customers each day at a particular time in order to obtain their order requirements.

Within the constraints of the N.A.P.D. Code of Practice, reproduced here as Table 5.1, it is in the financial interest of the wholesaler to minimise his capital investment by holding minimum stock levels.

He is also more interested in the higher turnover lines of a manufacturer's range than the lower turnover ones, since they yield a higher proportion of his revenue, generated by a specific margin, usually 15%, of the retail price of the goods sold.

These preferences can be in direct opposition to the interests of the manufacturer. He would encourage wholesalers to carry relatively high levels of stock in order to avoid stock-outs, and hence delivery delays. In this way the manufacturer's own aggregate inventory holdings can be reduced, and the whole range of his products maintained in stock at the wholesaler level.

In order to avoid the inevitable conflicts it is essential for good relations and communications to be maintained between the manufacturers and wholesalers.

The types of orders received from hospital pharmacists vary somewhat in terms of contents and quantities of items, from those received from retail chemists. Recognising this, amongst other differences as well, some wholesaler chains appoint certain of their branches to deal specifically with hospital or retail trade.

The independent wholesaler survives as long as "High Street" chemist shops and hospital pharmacies exist nationwide in their present numbers.

"Boots" operate retail chemist shops throughout the country that are predominantly serviced by their own wholesaler branches. The volume, and diversity, of their turnover is sufficiently great to make this economically viable.

The extensive number of individual pharmacy outlets, the relatively high value of pharmaceutical products and the urgency with which these products are required, are all factors which ensure that the wholesaler retains an essential role in the national pharmaceutical distribution process.

Hospital Pharmacists

A re-organisation of the National Health Service took place in April 1974, which appointed hospitals to one of 90 Area Health Authorities in England. These, in turn, are grouped into 14 Regional Health Authorities.

The re-organised structure is represented by Figure 5.3.

Although Figure 5.3. applies only to England, partly similar arrangements apply to Wales, Scotland and Northern Ireland.

Hospital pharmacies are attached to each of the larger hospitals. Within these pharmacies, the principal pharmacist is responsible for the ordering of ethical medicines, either directly from the manufacturers or via local wholesalers.

Hospital purchases are made within certain guidelines specified by each of the Regional Health Authorities. For instance, contract purchasing agreements require the hospital pharmacist to order certain products from a particular manufacturer, with whom a contract price is previously arranged by the Health Authority. The orders may be placed through a local wholesaler, as appointed by the manufacturer, as part of the contract agreement.

The proportion of contract purchases in hospitals' total turnover of ethical medicines is sufficiently great for manufacturers, and wholesalers, to place great emphasis on obtaining hospital contracts through tender and negotiation.

One effect of contract purchasing is that only one brand of a generic type of medicine, e.g., oxytetracycline, is stocked by a hospital pharmacy.

The hospital pharmacist, unlike his retail counterpart, has the authority to alter a doctor's prescription from one brand to another, within the same generic category, without the doctor's

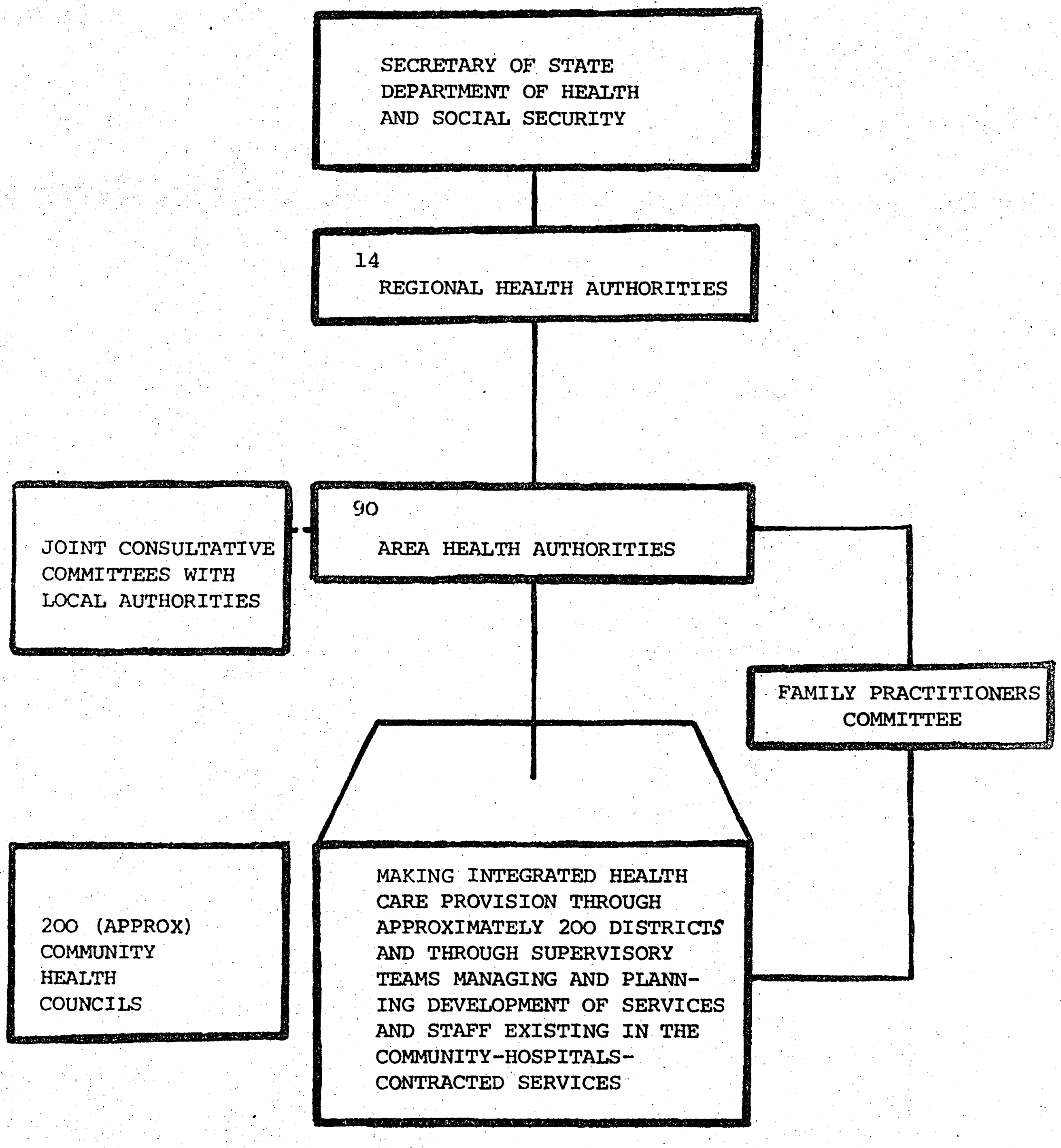

Figure 5.3: Re-organisation of the National Health Service for England.
(Source: Long Range Planning, Dec. 1974, p.35(112))

expressed permission. In fact, hospital doctors write a high proportion of their prescriptions generically, allowing the hospital pharmacist to select the particular brand, which should usually be the one on contract (130).

Hospital pharmacists traditionally obtain a larger proportion of their ethical medicines directly from the manufacturer, than do retail chemists. In recognising this preference, pharmaceutical manufacturers often retain direct hospital accounts, even though they are discouraging, or even eliminating, direct retail custom. Indeed some manufacturers continue to accept direct orders from hospitals, simply passing the orders straight through to the appointed wholesaler nearest to that customer.

Hospital pharmacists can expect to receive at least a daily delivery frequency from their local wholesaler if they order through him.

Retail Chemists

There are approximately 12,000 retail pharmacies in Great Britain (73).

About 10% of this number are part of the "Boots" organisation, who own the largest chain of retail dispensaries in the country. Other smaller chains operate, usually in local areas, but do not approach the number of "Boots" establishments. "Boots" accounts for from 15 - 20% of the total ethical turnover, by value, amongst retail pharmacies in Great Britain.

The predominant pattern of retail chemist distribution in Great Britain is that of individually owned/managed businesses serving several local doctors in each vicinity.

As a rule, the retail pharmacist relies on a number of local wholesalers for his daily supplies of ethical medicines. A once, twice, three or even four times, a day delivery from a wholesaler enables a retailer to minimise his stock holdings. This service is essential for the retail chemist's survival, since the high value of many ethical products would soon force him to invest a disproportionately high amount of capital in inventory holding.

A retail chemist can also purchase ethical medicines directly from the manufacturer, at a reduced cost. However, in doing so, the chemist would expect to wait longer for their receipt than if he ordered them via his local wholesaler. Additionally, the value of the chemist's order might have to be sufficiently high to meet any minimum order size restrictions imposed by the manufacturer.

Certain pharmaceutical manufacturers encourage direct ordering by retail chemists, others tolerate it, but a growing number oppose the practice. Many manufacturers in this latter category have curtailed all their retail chemists accounts, and now insist that all orders be placed through appointed wholesalers.

The breakdown of ethical turnover for retail outlets in Great Britain is as follows: (Source *)

Boots 15 - 20% by value

Other Retail Chemists:

a) Direct from Manufacturers 10% by value
b) via Wholesalers 70-75% by value

A.C. Nielsen (133) shows the increasing dependence of independent chemists on wholesalers, based on findings for twenty product classes.

The proportion of the total number of deliveries to retail chemists made via wholesalers increased steadily from 41% in 1961 to 68% in 1973. This last figure is lower than that indicated above (*). There are probably two reasons for this difference:

i) the continuing increase in the wholesalers' share of the business from 1973 to 1975;

ii) the differing proportions depending on whether they are based upon business value or on number of deliveries. It may be expected that chemists would tend to purchase higher value items from wholesalers, rather than from manufacturers, in order to reduce their capital investment in inventory. The outcome would be a resulting higher percentage made on a value basis than on a number of deliveries basis.

The retail chemist is not restricted by any overriding contract agreements with manufacturers, as is the hospital pharmacist; nor is he confronted with as great a proportion of generic prescribing as in a hospital.

He must dispense exactly what the doctor prescribes unless he has the expressed permission, usually as a result of a phone call, of that prescribing physician.

A high proportion of the prescriptions dispensed by most retail chemists will originate from local doctors. As a result, the order requirements, and stocks, of the local retail pharmacy will reflect the doctors' prescribing habits.

This advantage of being in a position to predict demand, is not enjoyed, to the same extent, by chemists operating in city centres where many of the customers are visitors, or who reside in outlying areas. Similarly, if a doctor temporarily departs from his practice, say for a holiday, leaving a locum doctor as a replacement, the nearby pharmacy has to be alert for a probable change in certain of the medicines prescribed. The retail chemist must then stock up and order accordingly when the new prescribing pattern becomes apparent.

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* Company source for medical statistics who wish to remain anonymous

A number of retail chemists within a district sometimes group together to combine their purchases and so obtain improved discount terms. As a chemist buying group they are supplied by manufacturers, traditional wholesalers or cash-and-carry operators. The services of the latter are availed of by about a third of independent chemists, usually only for topping up on product categories such as baby foods (133).

The manager of a branch pharmacy (e.g. Boots) will obtain the major portion of his supplies through the company's wholesale depots. However, he usually has the freedom, within limits, to purchase medicines from other local wholesalers or directly from the manufacturers.

Doctors

There are approximately 26,000 prescribing physicians and surgeons in Great Britain. Between them they account for about 350,000,000 prescriptions written each year. (*)

20% of this total number of prescriptions are written generically, rather than using a manufacturer's own brand name.

A doctor may operate from a hospital, a general practice, a consultancy, a clinic, etc. His prescribing habits can vary depending on this operational environment. For instance, it is recognised that hospital doctors prescribe a considerably higher proportion of generic prescriptions than do doctors in general practice. NEDO (130) notes that medical teaching methods (carried out in hospitals) are partly responsible for this inbalance. It may be that as the purchase contracts negotiated by Regional Health Authorities restrict hospital prescribing to one brand only for certain groups of drugs, the hospital doctor finds it more acceptable to simply specify the generic name.

Robinson (146) considers general practitioners to be, as a group, more cost-conscious than hospital staff, since the Executive Councils of the National Health Service may call upon them to explain the reasons for any high expenditure on drugs they have prescribed, relative to their local area's average prescribing cost per patient. Cooper (47) points out that this form of control is merely a psychological threat, usually foundering on the rock formed by the doctor's complete clinical right to prescribe whatever he considers to be in the best interests of his patient.

It is recognised by pharmaceutical manufacturers that a drug's sales are, in the main, determined by the extent to which the manufacturer succeeds in gaining doctors' acceptance of his product. The doctor is therefore the customer of the manufacturers in that it is he who makes the purchasing decision between their various branded products. Cooper (47) believes that their choice is made on therapeutic grounds:

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*Company source for medical statistics who wish to remain anonymous.

> ".... The doctor does not weigh up in his mind the relative prices and effectiveness of two alternative drugs and prescribe what on balance appears to him as the less costly; he makes his choice with the patient's well-being in mind and chooses what he considers to be the best drug therapeutically. All other considerations are purely secondary. No doctor has refused a patient a needed drug on the grounds that it was too expensive ...."
> (Reference: Cooper (47)).

However, the above assertion may be true only when all range of drugs are readily available.

One of the most significant features of the product-market situation for pharmaceuticals is that each medicine prescribed by the doctor is usually required straightaway by his patient. In general the patient's health cannot afford to wait for a pharmacist, wholesaler or manufacturer to alleviate the effects of a prolonged stock-out situation. In such circumstances, product availability is likely to be an important factor in the future medicine selections by doctors. The doctor would usually be informed of a stock-out situation by either the pharmacist, or the return of his patient.

Patients

At one time or other, everybody usually has to go to the doctor, or into hospital.

A visit to a doctor often results in the patient being prescribed a treatment which can only be obtained from a dispensing pharmacist. The choice of chemist is usually left to the patient, who chooses to suit his, or her, convenience.

Patients in hospitals, unless they be out-patients, do not have to collect their own treatments from hospital pharmacists. Hospital staff will transfer the prescription to the pharmacy and pick up the dispensed medicines.

Patients will sometimes feed back information to a doctor concerning the availability of the prescribed product at local chemists. If unavailable there, the patient would probably inform the doctor, if the chemist himself has not already done so.

The patient is the eventual consumer of the pharmaceutical products to whom all distribution effort in the supply channels is directed. However, the patient makes no purchase decision, as such; he merely receives and consumes whatever medicines are prescribed for him by his doctor.

2. The Logistics Contribution to the Marketing Mix

Cannon (29) states that:

> ".... The process of making goods physically available is a crucial element in the marketing mix with important implications for all other aspects...." (Reference: Cannon (29))

The marketing mix is a term used to describe the proportional allocation of resources by a company in the furtherance of sales of its product range.

Cannon (29) goes on to conclude that a real choice exists to the company between a policy conceived as essentially distributive and an advertising, or promotional, policy.

In an analysis of companies' marketing systems, Stasch (159) considers the physical distribution subsystem alongside the personal selling and advertising subsystems.

Stasch judges the contribution made by the physical distribution subsystem to be one of two alternatives. It can either:

i) merely facilitate sales by making the products available in a satisfactory condition and in sufficient time,

or,

ii) act as a demand stimulant in order to increase sales or to increase the company's market share.

Smith (155) deems that a company's distribution policy may, at times, constitute a form of promotion in itself, at least within the trade, i.e., the choice of which distribution channels to use for the supply of a product can result in demand stimulation, not only for that one product but for others in the company's range.

Smith goes on to say that a manufacturer may sometimes feel little need to worry about his distribution policies for an "exclusive miracle" drug. However, the distribution system which he uses in such a case can determine the future cooperation that he may expect to receive from wholesalers and retailers, when such cooperation might then be essential to the success of his business operations.

In extolling the advantages of air freight for overseas distribution, Jackson and Brackenridge (92) consider that:

> ".... in competitive markets today, distribution is an important part of the marketing mix, with the basic elements of product performance and price...."
> (Reference: Jackson and Brackenridge (92))

There is further evidence from other sources that logistics can be regarded as a contributor to the marketing mix. For instance, Kotler (103) notes the increasing attention being paid to the "demand aspect" of physical distribution system design. He points out that each component physical distribution decision can affect company sales.

For instance, warehouse locations are a promotional tool, in that they give confidence to local buyers with respect to better availability and company service; inventory level policies affect product availability, and hence sales volume; packaging and handling procedures, insofar as they affect the incidence rate of damaged goods, can affect the number of customers; the modes of transportation employed, insofar as they can mean faster, or slower, arrival of goods, can affect buyer satisfaction and sales revenue.

In addition, Mercer (119) points to there now being real evidence that distribution must be regarded as a selling pressure. He relates a company's market share with both distance between the manufacturer and the customer, and with competitors' locations.

However, on the other hand, it might appear from some writings that logistics is a non-contributor to the marketing mix of the pharmaceutical manufacturer. For example, Cooper (47) states that:

> ".... Demand (for ethical pharmaceutical products) responds to the incidence of sickness, the quality of therapy available to treat it, and to sales promotion, but very little else ..." (Reference: Cooper (47))

Product innovation, rather than price, is the main competitive force in the pharmaceutical industry, and leads to fierce inter-firm rivalry with rapid interchanges between the market leaders. The market concentration among companies serving the world pharmaceutical markets is very low (32).

Maybe, however, the logistics contribution to the marketing mix is rather played down by authors writing about the pharmaceutical industry. Most of these see the supply of products, through channels as depicted in Figure 5.1, as merely facilitating the sales achieved through "doctor-acceptance" of the products.

Undoubtedly, the therapeutic value of products and the sales promotional efforts afforded to them, will directly affect demand.

Constantin (46) considers the contribution that logistics management can make to the creation of demand for the company's products. He breaks down the marketing mix into a balance of four policy factors:

a) selection of channels of distribution,
b) customer service considerations,
c) promotional effort,
d) pricing policies.

According to Constantin, the influence of logistics management policy is going to be felt most in relation to a) amd b), and less in relation to c) and d).

Elsewhere , (177), it is noted that company management have generally ignored the revenue generating possibilities created by improved distribution service, due largely to a failure to recognise the importance of this service to the overall company performance.

In addition, though, logistics can contribute somehow to the level of demand for a company's products through indirect effects on doctors, and other members of the distribution channel. These indirect effects may be broadly classified under the heading of customer goodwill.

For example, Hutchison and Stolle (90) warn that the cooperation and response to future promotional efforts from customers might suffer if a manufacturer's present level of distribution service to them is low.

Also, Jackson and Brackenridge (92), in supporting the claims of air freight as a mode of transport which provides a high speed and flexible distribution service to improve product availability in overseas markets, state that:

> ".... in many markets constantly good product availability is essential not only to exploit the market and to maintain customer loyalty but also to establish a good reputation to improve sales in the future ....." (Reference: Jackson and Brackenridge (92)).

The Effect of Stock-Outs

It can be envisaged that the influence of customer goodwill will be felt to a degree that is going to vary with the ease of product availability.

If no stock-outs are being experienced, then the logistics contribution to the marketing mix may be negligible. However, if a product, or a range of products, is in short supply and frequently unavailable, then the logistics contribution can be absolutely critical.

In the stock-out situation, one, or more, of three consequences can result:

1) a back-order (or extraction)
2) a lost sale
3) a lost customer (Reference: Walters (176))

At best, a stock-out results only in a back-order having to be raised, which implies that the sale is delayed; at worst, it results in a lost customer, i.e., no further prescribing of that product by the doctor concerned.

The effect of a stock-out on a company is difficult to evaluate in quantitative terms. Garnett and Smith (69) attempt to do this by generating the cost of a stock-out. They envisage a stock-out, not as losing sales revenue, but rather as incurring an additional cost to the business operation. The authors include a term for this incurred cost in the development of their total cost minimisation model.

The total costs of the logistics system may be considered in terms of the following equation:

Total Logistics Costs, $TC = F + V(x)$

where F = Fixed Logistics Cost
V = Variable Logistics Cost/Unit of Sales Volume
X = Number of Units of Sales Volume

(Reference: Grabner and Robeson (74))

This equation exposes the fact that a stock-out situation, which results in reduced X, results in a less than proportional reduction in TC. If sales volume falls by 20%, total logistics costs will be reduced by less than this percentage. This demonstrates how the consequences of a stock-out situation in terms of lost sales revenue will normally never be outweighed by a corresponding reduction in total logistics costs, unless the stock-outs are part of a planned company policy.

Based on single and repeated stock-out situation models, Walter and LaLonde (173) develop linear equations for calculating the expected monetary values of stock-outs, measured in terms of revenue differences.

The Effect of Product Substitutability

There are two factors that the manufacturer must consider in the pharmaceutical marketing situation:

1) the patient needs medical treatment and is not (or, rather, the doctor is not) prepared to accept delay or forego treatment;

2) the fierce competitive rivalry between manufacturers offering substitute products for doctors' consideration.

Walters (175) lists four factors, relevant in determining whether an industry, or a company, is sensitive, or not, to distribution service's influence on demand, and sales revenue. These factors are:

i) Product substitutability - the customers' brand loyalties

ii) Product dependability - importance of the reliability of the distribution service.

iii) Complementary products - products of a company helping to sell each other.

iv) Cost of customer enquiries - the concern of customers regarding service levels as a proportion of salesmen's time spent in answering queries.

As long as the therapeutic value of substitute products is equivalent doctors are not, generally, going to mind which brand is used in treating a patient, viz., the increasing trend towards generic prescribing.

The patient is unlikely to mind, either, unless the treatment is continuous, e.g. treatment for diabetics, where a considerable degree of brand loyalty can be built up by sufferers.

The pharmacist is remunerated for the medicine which he dispenses. He is therefore unlikely to be overconcerned as to which brand of medicine is prescribed. The pharmacist's main concern is that whatever brand is prescribed is one which, either he has in stock or, he can make quickly available, so that the patient does not have to take the prescription elsewhere.

Although the hospital pharmacist's turnover is not threatened by rival pharmacists, it is in his interests to dispense those medicines for which the hospital has a contract agreement, negotiated by its Regional Health Authority. Any such agreements not only guarantee a fixed contract price, but also guarantee the hospital with regular supplies of the product concerned. Any failure to meet such an agreement will obviously jeopardise the granting of any future contracts, and imply a "lost customer" situation for the manufacturer.

The wholesaler, in turn, is unlikely to be too concerned over which manufacturer's product the doctor prescribes, or to which pharmacy, within a vicinity, the patient takes his prescription; the business will probably come through him anyway.* The wholesaler is mainly concerned that he can supply whichever pharmacy orders the product, whatever brand it is.

The primary concern and responsibility for ensuring that a branded product is readily available to the patient lies with the manufacturer of that product. It is his revenue which is directly affected as a result of the competition with other manufacturers, offering substitute products to his own.

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* This is not strictly true since some retail chemists may be better customers of a wholesaler than others. These effects are likely, however, to balance out.

3. Customer Service as a Measure of Logistics Effectiveness

The previous section examined the logistics contribution to the marketing mix. The company's management of its logistics operations can contribute to the sales revenue generated by the company to an extent dependent upon the prevailing product/market situation.

This contribution can be made either directly, where an apparent logistics contribution to demand relationship exists in the short-term view or, indirectly, through effects on customer goodwill and customer relations measured in the long-term.

The preceding section indicated that the logistics effort of the pharmaceutical manufacturer can make its contribution felt more in indirect ways than in terms of a direct effect upon level of demand.

The term "customer service" is used to describe this contribution as it affects the customer and influences his level of cooperation and goodwill towards the manufacturer.

From a fundamental basis of taking a systems approach to analyse the logistics system, an operational model for decision-making by logistics management was developed in Chapter 3. This model utilised the procedure of cost-effectiveness analysis, and Chapter 3 presented a step-by-step procedure for carrying out such an analysis. It was proposed that this procedure is particularly suitable for assessing the impact of an alternative proposal upon the operations of the logistics system (of a pharmaceutical manufacturer).

Using a cost-effectiveness analysis, the decision-making model predicts the consequences, or outcomes, to be expected from each alternative, i.e., what the total logistics costs are, and to what extent each objective of the logistics system is attained. A criterion can be used to judge the effectiveness of the logistics system's performance. This was termed a performance criterion.

Only when the effectiveness of the logistics system is represented on a common basis and, preferably, in quantitative terms, can the costs be weighed against effectiveness and the alternative proposals be thereby assessed.

There is considerable evidence available in the literature to suggest that customer service can be used as a criterion of the logistics system's performance, or in other words, to be used as a measure of logistics effectiveness. Some of this evidence is now discussed as follows:

Cunningham and Hardy (49) attempt to evaluate the effectiveness of distribution systems. After reviewing some literature on distribution systems, they conclude that:

> "....The approaches so far have not dealt with the underlying question: what level of service and of what kind is it necessary for the channel system to deliver, and what effect do varying levels of service have on the

output which will pass through the distribution channel? ...."
(Reference: Cunningham and Hardy (49)).

In another review of logistics literature, Stephenson and Willett(160) find that most of the operational models which they reviewed attempt to define the relationship between customer service and logistics costs in a limited manner, in that they prescribe a minimum cost distribution system capable of delivering some pre-determined standard of customer service.

Stephenson and Willett warn that this pre-determination of a level of service means that the demand consequences (the effects on revenue) are not really treated as a variable, where it would be more realistic to recognise that different levels of service are capable of producing different demand responses from a firm's customers.

A further warning is sounded by Parker (140) who notes that the prevailing practice in the organisation of physical distribution systems is for alternative proposals to be weighed up, and decisions reached which result in the greatest efficiency and least cost in the performance of each particular function. Due regard must however be paid to the effects of those decisions on the cost and performance of other related functions. Interrelations between the costs of logistics functions were discussed in the previous chapter.

Bowersox et al (19) state that the performance of the physical distribution system is measured by two standards:

i) the level of customer service;
ii) the total cost required to attain that service level.

In recognising these two standards Lawrence (108) proceeds to recommend that decisions affecting physical distribution systems should be based on the total performance of the system over a prescribed period of time. Hence the total performance of the system is measured by these two standards acting as performance criteria, bearing in mind Parker's (140) warning as to the necessity of considering interrelated effects on cost and performance.

Having carried out a physical distribution survey amongst 26 companies across a broad range of industries in the U.S.A., Neuschel (132) finds that only a few of these companies are doing a thorough job in determining customer service needs and their cost implications. Neuschel suggests that the reason for this neglect is maybe that the majority of companies do not recognise customer service as being a measure of logistics effectiveness that is, in some way, proportionally related to the total logistics cost.

Neuschel warns that companies who neglect viewing their logistics system in this way do so at their own cost. He states that:

> "....The economic importance of the relationships between distribution and other functions is underlined again and again in the survey findings. Several executives cited small changes in customer service policies, such as faster delivery, that substantially increased transportation costs .... In a consumer goods company, where many products must be included in a single shipment, poor manufacturing planning and scheduling wrought havoc with distribution costs and service.....Recognising the complex interrelationships of these and related factors is clearly a critical step in any organised approach to improving the cost-effectiveness of the distribution function. Lacking such a perspective, management can hardly hope to make the right cost-versus-advantage trade-offs to arrive at optimal solutions."
> (Reference: Neuschel (132)).

The illustration of delivery time, or lead time, mentioned above as a specific measure of customer service is also taken up by Pettit (141). He uses the term "derived demand" to represent that proportion of sales revenue dependent in some way upon service level. He views times and costs as being interchangeable to a large extent in distribution systems and, because of this, it is important to get the time-cost ratio correct in terms of total lead time to the customer, from order to delivery, and to weigh this against considerations of reliability, nomination of day and time, etc., as well as against the costs involved.

Lead time may not be the only customer service criterion to be taken into account. For instance Hutchison and Stolle (90) recognise that customer service can have both direct and indirect effects upon sales revenue, which may or may not be easy to measure in benefit terms.

In the previous section, indirect effects are considered as generally contributing towards customer goodwill.

Hutchison and Stolle state:

> ".... Although the indirect effects of the level of customer service may be difficult to measure, it is no less important to consider them, for they can have a major impact on company profits...."
> (Reference: Hutchison and Stolle (90))

Howard and Schary (89) generate a safety stock investment to customer service level relationship in order that different costs of investment may be compared on the basis of the service levels which each provides. In other words, when the inputs to the logistics system are considered as investment in inventory, the outputs from that system are measured as levels of customer service.

Lee (110) measures effectiveness of a logistics system from another point of view. In analysing the decision rules for a multiple product logistics system, with particular regard to the production control-inventory control interface, Lee expresses a measure of effectiveness for this system as a shortage charge, or incurred excess costs as a result of stock-outs, i.e. back order costs, lost sales (see reference: Walters (176), in previous section). In fact this shortage cost is the inverse of a revenue attributable to customer service.

A specific reference to measuring the effectiveness of logistics systems of the pharmaceutical manufacturer is to be found in a report in Traffic Management (167), dealing with the logistics operations of Abbott Laboratories (U.S.A.), a multinational pharmaceutical manufacturing company. Here it states that Abbot Laboratories is placing great emphasis upon the role of its customer service section in working with the regional distribution centres in order to improve order cycle performance and other service-related factors.

4. Identifying the Criteria of Customer Service

The previous section presented literary evidence to support the contention that customer service can be used as a measure of logistics systems' effectiveness.

The same approach will now be taken in this section to help identify those criteria of customer service which can be used as appropriate measures of the effectiveness of logistics systems of pharmaceutical manufacturers.

It was indicated in the previous section that lead time could well be such an appropriate measure, having as it does an indirect effect upon the sales revenue of the pharmaceutical manufacturer. However, it is intended, in this section, to consider other possible criteria of customer service, to expand the lead time criterion into its component characteristics, and finally to relate these to the particular customers' service requirements.

Review of Service Criteria Selections

A number of authors' works were reviewed from literature concerned with identifying those criteria of customer service appropriate to consumer goods markets, such as pharmaceuticals.

The results of this literature review are summarised in tabular form in Table 5.2., where an author's recognition of a service criterion is indicated by an *. Fifteen appropriate service criteria are isolated from the literature reviews; service criteria more appropriate to industrial markets, e.g. technical advice and information, and after sales service, are omitted.

Three of the six references comprising Table 5.2. rank their identified service criteria in terms of relative importance. Their rankings together with additional fourth and fifth references, are shown in Table 5.3. The fourth and fifth references of Cunningham and Roberts (50) and Ballou and DeHayes (10) are omitted from Table 5.2, since their results are drawn from empirical studies made on industrial markets rather than consumer goods markets.

It should be noted that, in Table 5.3, the customer service criteria of order processing time, order preparation time and delivery time (numbers 1, 2 and 3, in Table 5.2) are collectively grouped under the heading of lead time duration. The lead time is seen here as the length of time that the customer waits for delivery of the goods from the moment he places his order.

In addition, in Table 5.3, the individual service criteria of compatability of physical despatch method, scheduled deliveries, compatability of load unitisation and convenient ordering quantities (numbers 7, 8, 9, and 10 in Table 5.2) are collectively termed delivery flexibility. The fuller implications of the meaning of this collective service criterion will be brought out later on in this section.

Customers' Lead Time

Tables 5.2 and 5.3. serve to highlight the association of lead time with customer service in consumer goods markets.

This lead time, sometimes referred to as order cycle time, can be considered as being composed of the durations of the following activities:-

Lead time (to the customer) =
Time for order to be received by the manufacturer +
Time for order to be processed by the manufacturer +
Time for order to be prepared by the manufacturer +
Time for delivering goods to the customer.

Each of these durations is additive towards the total lead time to the customer. The manufacturer (or wholesaler, if ordered indirectly) is solely responsible for the first three, while the last is affected by the operations of other members of the distribution channel.

Criteria of Customer Service	Stephenson and Willett (160)	Cunningham and Hardy (49)	Walters (175)	Hutchison and Stolle (90)	Bowersox et al (18)	Christopher and Wills (39)	Flaks (64)
1. Order Processing Time	*		*	*	*	*	*
2. Order Preparation Time	*		*	*		*	*
3. Delivery Time	*		*	*	*	*	*
4. Lead Time Consistency	*	*	*	*	*	*	*
5. Inventory Reliability, e.g. omission rate, back orders	*	*	*	*			*
6. Order Size Constraint			*	*			
7. Compatibility of Physical Despatch Method						*	
8. Scheduled Deliveries						*	
9. Compatability of load Unitisation						*	
10. Convenient Ordering Quantities						*	
11. Delivery Frequency	*						
12. Means of Order Placement	*						
13. Order Accuracy	*						
14. Claims	*						
15. Order Condition on Receipt	*						

Table 5.2. Tabular Summary of Authors' Identifications of Customer Service Criteria

Numbering from Table 5.2	Criteria of Customer Service	Stephenson and Willett (160)	Cunningham and Hardy (49)	Christopher and Wills (39)	Cunningham and Roberts (50)	Ballou and DeHayes (10)
1,2,3	Lead Time Duration	1=		2=		2
4	Lead Time Consistency	1=	1	1	1	1
5	Inventory reliability, e.g. omission rate, back orders		3			
7,8,9, 10	Delivery Flexibility			2=		
11	Delivery Frequency		2			
12	Means of Order Placement	1=				

Table 5.3. Tabular Summary of Authors' Rankings of Customer Service Criteria

Both Tables 5.2 and 5.3 indicate that lead time has a number of aspects, or characteristics, that may have differing relevance to customer service.

Three of these (lead time duration, lead time consistency, and lead time flexibility) are considered to be of particular relevance to the pharmaceutical logistics system's effectiveness, and are now discussed, in turn, in greater detail.

Lead Time Duration

In most of the literature reference to lead time normally assumes it to mean duration, or speed, from point of manufacture to point of receipt by customer, or, more fully, from point of order to point of receipt by customer.

The meaning of lead time duration, and of the other lead time characteristics, can be better explained by considering a hypothetical manufacturer - customer situation.

Table 5.4. tabulates the results of a lead time analysis carried out over a one month period for a customer who has ordered 100,000 items of goods from a manufacturer during that period.

The first column lists the lead times (in days) in order of increasing duration for which items were received, expressed as $t \pm x$, where $x = 1,2,3,4,5,6,7$ or 8 days. For instance if $t = 10$, then the range of lead times experienced by that customer would range from 2 days $(10 - 8 = 2)$ to 16 days $(10 + 6 = 16)$

The second column lists the total numbers of separate items found to have been received with lead times corresponding to those listed down the first column.

The remaining three columns will be referred to when the other two lead time characteristics of consistency and flexibility are next discussed.

The lead time durations, in the data given in Table 5.4, obviously vary according to which item is being considered, over a range of 14 days, It is usually the average lead time duration over a specified period that is of interest to managers or analysts.

It is important to note that the average lead time for the case of Table 5.4. does not equal t days, although the majority of items were received in a lead time duration of t days.

The true average lead time duration is equal to the sum of each of the lead times (column 1 in Table 5.4) multiplied by the number of items received in each of these lead times (column 2), all divided by the total number of items received during the period (= 100,000).

The answer will be an average lead time duration of some figure slightly less than t days.

Lead time (t ± x) Days	Number of items received in lead time t ± x	Percentage of items received in lead time t ± x	Number of items received in lead time t ± x or less	Percentage of items received in lead time t ± x or less
t - 8	25	0.025	25	0.025
t - 7	100	0.100	125	0.125
t - 6	500	0.500	625	0.625
t - 5	1000	1.000	1625	1.625
t - 4	3000	3.000	4625	4.625
t - 3	3500	3.500	8125	8.125
t - 2	4000	4.000	12125	12.125
t - 1	15000	15.000	27125	27.125
t	55000	55.000	82125	82.125
t + 1	12000	12.000	94125	94.125
t + 2	3000	3.000	97125	97.125
t + 3	2000	2.000	99125	99.125
t + 4	800	0.800	99925	99.925
t + 5	60	0.060	99985	99.985
t + 6	15	0.015	100000	100.000
t + 7	0	0.000	100000	100.000
-	100,000	100.000		

TOTAL ITEMS ORDERED DURING THE MONTH = 100,000

Table 5.4. A Lead Time Analysis of a Hypothetical Series of Transactions Between Manufacturer and Customer over a Period of One Month

Lead Time Consistency

This second characteristic of lead time is ranked first as a criterion of customer service by all four of the references included in Table 5.3.

Lead time consistency is that critical service criterion which determines the levels of safety stock required to achieve a predetermined service policy on item availability at the point of ordering. A small decrease in lead time consistency can lead to a considerably disproportionate increase in safety stock investment.

A typical response from a customer service manager working for a pharmaceutical manufacturer might be -

> "Knowing our average lead time doesn't help us much for it's knowing how bad the longest lead times are that counts. These will be the black spots and the cause of customer complaints".

The concept of lead time consistency can be made clearer by referring again to the hypothetical lead time analysis set out in Table 5.4. The figures in column 2 can be converted into percentages of the total number of ordered items and a distribution curve constructed of these percentages against lead time duration.

Figure 5.4 represents this distribution curve for the hypothetical example, indicating the probability of lead time being $t \pm x$ days.

Referring back again to Table 5.4. the level of lead time consistency can be read off from column 5, as the percentages of items received in lead time $t \pm x$, <u>or less</u>, e.g., 94.125% items received in lead time (t +1) days or less.

If the curve in Figure 5.4. is a 'normal' distribution curve, then it is possible to completely define the curve knowing only its mean, or average, lead time and the standard deviation.*

Lead Time Flexibility

Table 5.3 includes delivery flexibility as a term which encompasses four identified criteria of customer service:

- Compatibility of physical despatch method
- Scheduled deliveries
- Compatability of load unitisation
- Convenient ordering quantities

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* Then, ± one standard deviation accounts for 68.3% of occasions when items are ordered; ± two standard deviations accounts for 95.4%; ± three standard deviations accounts for 99.7% etc.

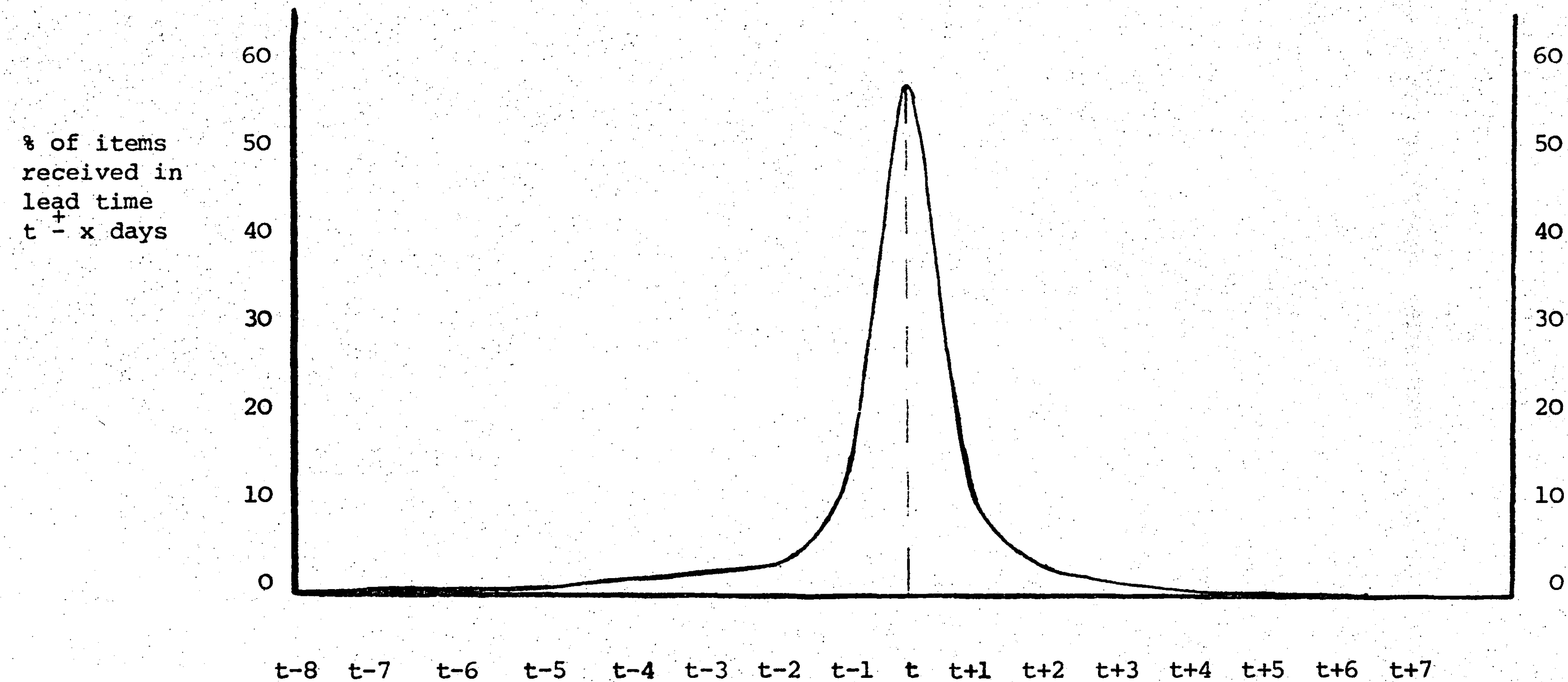


Figure 5.4: Distribution Curve Showing Probability of Lead Time Being $t \pm x$ days for the Hypothetical Case

As Christopher and Wills (39) point out:

> "...If the way in which the company physically despatches its products can be made more compatible with the way in which the customer likes to receive them, then a further advantage may be gained. Selling the product in convenient order quantities, delivery on nominated days, unitising the product in a way most suited to the customer's handling system, these are ways in which distribution service can be offered through delivery flexibility."
> (Reference: Christopher and Wills (39))

The pattern of distribution for all leading pharmaceutical manufacturers is punctuated by small, urgent orders which may often be required in a life-or-death situation. In such cases, the manufacturers have to provide an accelerated lead time, requiring a measure of flexibility from the functions within the logistics system.

Other Service Criteria

Other criteria of customer service are listed in Table 5.2, besides those reflecting directly upon lead time. Some do, however, have indirect connections with lead time, and are inherent in one or other of the lead time characteristics.

For instance, delivery at scheduled times is often the method employed by suppliers to provide an increased level of lead time consistency. In the same way delivery frequency is a reflection of lead time duration.

Also the customer is sensitive to inventory reliability, as it affects the number of back orders required for out of stock products, since this reflects on the lead time consistency.

The other service criteria are, in differing degrees, relevant to the pharmaceutical manufacturer and his customers.

Imposing an order size constraint is an increasing practice amongst manufacturers, but not so amongst wholesalers. The constraint is never usually great enough to seriously discourage orders, only to enable the manufacturer to recoup his administrative costs in merely processing the order.

Compatability of physical despatch method, and load unitisation, are less important as criteria of customer service to the pharmaceutical industry than they are to most other industries. The low bulk, and regular physical form, of the products generally makes for palletisation and relatively easy handling throughout the distribution channel.

Convenient ordering quantities are associated with order size constraint. The high value of medicines, and the large number of small independent retail chemists operating throughout the country results in an emphasis on ordering quantities being made convenient for the customer rather than for his larger supplier. Since most retail chemists, and hospital pharmacists, only operate through a few local wholesalers their ordering requirements are, by necessity sufficiently large not to seriously hamper their suppliers' operations.

A retail chemist, or a hospital pharmacist, can place orders by telephone, mail or through manufacturers' representatives. The former means is the commonplace, especially for orders through wholesalers. To customers with whom he does a large and regular trade, the wholesaler will usually phone up each day to obtain the customer's daily order requirements. This service procedure can also apply between wholesaler and manufacturer except that the ordering frequency is once every week, or two weeks, usually, rather than daily.

Order accuracy, order condition on receipt, and claims are very important to the pharmaceutical industry as they are to most other industries. However, the vital need for accuracy and undamaged condition of medicines on receipt can be set against the inherently fast response usually obtainable from suppliers within the industry. The widespread practice of ordering more than necessary to meet immediate requirements usually surmounts the occasional setbacks experienced in incorrect receipts, broken bottles,etc. The majority of problems regarding order accuracy, for wholesalers, stems from the manufacturers' practice in branding their products by similar-sounding names and in similar-looking packs, leading to errors in telephoned order receipts and order picking.

5. Customers' Particular Service Requirements With Respect to Lead Time

It would seem that the institutional grouping of customers into hospital pharmacists, wholesalers and retail chemists might also be a natural classification for service requirements, with respect to the chosen lead time characteristics of duration, consistency and flexibility.

Retail chemists require a fast lead time service in order to minimise their inventory holdings of large numbers of different medicines. As a service to them, wholesalers operate van deliveries once, twice, three or even four times a day.

This service accounts for both the criteria of delivery frequency and lead time duration. When a retail chemist places an order with a wholesaler early on in the morning, he expects same day, or next day, delivery.

Although an order placed directly with a manufacturer cannot be expected to be delivered in such a short lead time, as with a wholesaler, the retail chemist is still seeking as fast a service as possible.

Hospital pharmacists probably seek much the same service requirements, in terms of lead time, as do retail chemists. They are, however, closer to the "life-or-death" situation than the retail chemist and medicines may be required that much more urgently in such circumstances. Also, as a tradition, many hospital pharmacists prefer to maintain close ties with the pharmaceutical manufacturers, especially those on contract, than do retail chemists.

Wholesalers expect to have to carry fairly substantial stocks of most available products. To them, however, inventory must represent a very high level of investment.

There are three major components of inventory:

a) In-transit
b) Cycle
c) Safety

The wholesaler is usually most concerned with b) and c).

The lead time consistency that a manufacturer gives to a wholesaler will, to a large extent, determine his necessary level of safety stock holding. Cycle stocks will be determined by customers' ordering patterns and demand fluctuations, which are unlikely to vary unduly.

Inconsistency in manufacturers' lead times can result in wholesalers having to carry excessive safety stocks. These act as a buffer against late delivery so that the wholesalers' own service levels to their customers can be maintained.

Lead time flexibility is a criterion of service that can affect all three categories of customer: wholesalers, retail chemists and hospital pharmacists. In "life-or-death" situations, suppliers must be ready to lay on emergency delivery arrangements, e.g., express parcels rail service, passenger train service, hired cars, air freight, etc. In less critical situations, a customer may forget to place his order on time, and place it later, maybe by only a matter of hours. The flexibility of the service he is offered can be assessed by whether his supplier is still able to deliver that order at the same time as if the order had been placed at the normal time, e.g. if a wholesaler places an order with a manufacturer on a Monday, instead of the previous Friday (as normally accepted), whether he can still obtain receipt of that order on the following Thursday, if he so desires.

Summary

This chapter has been concerned with the consideration of customer service as being a measurable output, in terms of effectiveness, of the operations of the logistics system.

It commenced by extending the flowchart of the logistics system of the pharmaceutical manufacturer, constructed in the previous chapter, to include the distribution channels and customer institutions of the home market for pharmaceuticals. As a result three main customer groups were identified: wholesalers, hospital pharmacists and retail chemists. The special role of doctors (both hospital and general practice) and patients was also reviewed.

In supporting the claim that the output of the logistics system could make a contribution to the marketing mix of the manufacturer, customer service was proposed as being a suitable output, which could be measured and related to the operations of the logistics system, and to its total cost. The effects of stock outs and of product substitutability were particularly discussed in relation to the market for ethical pharmaceuticals.

A literature review identified a number of possible criteria of customer service which could be used as specific measures of the logistics system's effectiveness.

Customers' lead time was defined, and three characteristics of this lead time (duration, consistency and flexibility)were deemed as being those most appropriate for measuring the effectiveness of the pharmaceutical manufacturer's logistics system. The meaning of each of these lead time characteristics was explained with reference to a hypothetical example of orders placed/goods delivered between manufacturer and customer over a month. The data were presented in terms of a lead time analysis.

The relevance of other service criteria to the pharmaceutical situation was also considered.

From a broad analysis carried out on each of the customer types' particular service requirements, with respect to lead time, it may be possible to recognise certain relationships. For instance, it would appear that the duration of lead time is particularly important to retail chemists and hospital pharmacists, wishing to keep down their investments in inventory levels.

To wholesalers, though, lead time consistency may be a more important criterion in helping to reduce the levels of safety, or buffer stock. To some extent, lead time flexibility is a relevant criterion to each of the three customer types.

In reviewing the service considerations of the customer groups of the pharmaceutical manufacturer, this chapter proposed how a measure of effectiveness could be made of the operations of the logistics system of the pharmaceutical manufacturer. Such a measure of effectiveness is essential in order that the performance of the system can be assessed against the total logistics cost, as derived from the analysis in Chapter 4. The balance of costs versus effectiveness can then be used in the form of an operational decision making model, as outlined in Chapter 3.

The next chapter will hypothesise a means whereby the total number of interactions within the logistics system can be reduced to provide a practicable means of deriving a total logistics cost for the system. It will also elaborate on the findings of this chapter and hypothesise a number of relationships between the lead time customer service criteria and the customer groups.

Chapter 6

Research Suppositions: Heuristics to Simplify the Cost-Effectiveness Analysis of the Logistics System

Introduction

The logistics system of a pharmaceutical manufacturer was reviewed in some detail in Chapter 4. It was concluded that unless some means of reducing the number of relevant interactions is used, the complexity of the logistics system analysis will be formidable. This applies not only to an analysis with a view to deriving a total logistics cost but also to assessing a measure of effectiveness for the logistics system.

In introducing the systems approach as a basis for logistics analyses, it was suggested in Chapter 3 that a heuristic, or some form of hybrid, model could be used to reduce the complexity of problem solving. In this research a model, or a form of procedural guideline, is being sought that will reduce the complexity of the logistics system analysis by reducing the interactions within the system down to a manageable number. Only then can a logistics system analysis, as outlined in this research,have practicable application for logistics management.

It is intended in this chapter to first provide evidence that some form of heuristic model is suitable for the task of reducing the complexity of the logistics system analysis.

This logistics analysis is considered in two parts (in accordance with previous chapters): the cost analysis and the effectiveness analysis of the logistics system.

For the cost analysis, the logistics system propounded in Chapter 4 will be detailed further into a composite of component activities, each incurring a cost that contributes towards the total logistics cost. In order to reduce the extremely large numbers of interactions that could occur between these activities, heuristic guidelines will be suggested, expressed as research suppositions. The foundation of these suppositions will lie in the assumption that material changes its form, place and time utility as it flows through the logistics system, from raw materials acquisition to finished product delivery to the customer.

A similar basis will be used in the effectiveness analysis of the logistics system when the logistics functions will be viewed as a composite of time-incurring activities. Again, research suppositions will be postulated to act as heuristic guidelines in reducing the complexity of the effectiveness analysis.

It was suggested in the previous chapter that the customers of the pharmaceutical manufacturer may be classified according to pre-determined lead time characteristics. The nature of these characteristics, and the service requirements of the customers, will be looked at in more detail, and guidelines suggested to relate the two.

1. The Heuristic Model

In Chapter 3, it was shown that the logistics system may be represented by one of three major types of models: formalist, simulation and heuristic. The heuristic model was considered particularly suitable for reducing the complexity of problem solving.

In reviewing the scope of the logistics system, it was concluded in Chapter 4 that the prolific number of possible interactions between logistics functions must be reduced. Only then can a practicable analysis of the logistics system be carried out with a view to deriving the total logistics cost for any configuration of that system.

It is proposed that a heuristic model, of some kind, is the appropriate means for reducing the number of interactions to be included in an analysis of the logistics system of a pharmaceutical manufacturer.

Table 6.1 summarises the conclusions of Stasch (158) regarding the suitability of the types of model to the analysis of the logistics system.

In analysing the logistics system of the pharmaceutical manufacturer with a view to deriving a total logistics cost, it is the first two characteristics, as listed in Table 6.1, that are most relevant, i.e., capability to realistically represent the logistics system and the data quantity requirement in so doing. Heuristic models fall into the middle ranking against each characteristic, and probably represent the only practical approach to an initial analysis of the logistics system.

Later in this chapter the analysis will be extended to include the customer service considerations identified in the previous chapter. Then the third characteristic of Table 6.1 (the capability of realistically representing customer demand) will be introduced.

Since heuristic models are basically only guidelines used to aid decision-making in any number of situations, the type of heuristic employed can be correspondingly diffuse.

It is envisaged that the kind of heuristic model required for the logistics system analysis, in the terms so far set out in this research, will be akin to the heuristic modes used by Kuehn and Hamburger (104). In tackling quite a different problem, that of determining the geographical pattern of warehouse locations which will be most profitable to a company, they lay down three principal guidelines, for reducing the problem-solving complexity. These are as follows:

> "1. Most geographical locations are not promising sites for a regional warehouse; locations with promise will be at, or near, concentrations of demand .....

Characteristic of the logistics system analysis	Rank 1	Rank 2	Rank 3
1. Realistic representation of the logistics system.	S	H	F
2. Data requirement demand.	F	H	S
3. Realistic representation of customer demand.	S	← F H →	
4. Capability of analysing the multi-product, rather than the single product, situation.	← H S →		F
5. Capability of evaluating alternatives.	← H F →		S

Key: F = Formalist Model; H = Heuristic Model; S = Simulation Model

Table 6.1: Tabulation of Model Types' Applicability to the Analysis of the Logistics System

(Reference: Stasch (158))

2. Near optimum warehousing systems can be developed by locating warehouses one at a time, adding at each stage of the analysis that warehouse which produced the greatest cost savings for the entire system .....

3. Only a small subset of all possible warehouse locations need to be evaluated in detail at each stage of the analysis to determine the next warehouse site to be added ....."

(Reference: Kuehn and Hamburger (104))

In employing these heuristic guidelines to their warehouse location problem, Kuehn and Hamburger are seeking a solution which can be described in terms of acceptability characteristics, rather than an optimum solution.

Although used to solve quite a different problem to the analysis of a logistics system, Kuehn and Hamburger's heuristics do share one common feature: the objective of reducing the total number of possible alternatives.

For the logistics system analysis a heuristic model needs to be developed which can reduce the number of interactions to be considered therein, in deriving a total logistics system cost.

2. Cost Analysis of the Logistics System

The previous two chapters portrayed the logistics system of the pharmaceutical manufacturer as a flowchart for the movement of materials, orders and information between the logistics functions, and the customer institutions. Chapter 4 analysed the logistics system of the manufacturer in terms of the total logistics cost. Chapter 5 extended the analysis of the logistics system with regard to its overall effectiveness measured in terms of customer service criteria.

Here the analysis of the logistics system of the pharmaceutical manufacturer is first studied in terms of its total cost.

The Logistics Functions as a Composite of Cost-Incurring Activities:

It was shown in Chapter 4 how the components of the logistics system, the logistics functions, can be regarded as its cost centres, each directly contributing towards the total logistics cost.

From a survey of the literature on logistics cost analyses, a number of cost centres were suggested, in Chapter 4, for inclusion in the logistics system analysis. These are:

Purchasing
Materials Handling
Storage and Warehousing
Order Picking
Packaging
Transportation
Documentation
Order Processing
Inventory Control
Production Scheduling
Information Feedback
(Quality Control)

These cost centres were selected on a basis of their relative magnitude with respect to:-

either, a) making a direct contribution to the total logistics cost, e.g., Transportation costs;

or, b) making an indirect contribution to the total logistics cost, through their operations' effects upon cost centres not specifically included in the above list, e.g., Production Scheduling's effect on manufacturing cost, Inventory Control's effect on inventory investment, Purchasing's effect on cost of raw materials.

This initial step in logistics cost analysis can be followed up by dividing the selected cost centres into component activities, i.e., those activities that describe the varied nature of each cost centre's operations.

In selecting the relevant activities, the research work of Dicer (56) is of some help. He lists the logistics system activities for each of eight sub-systems: Traffic, Storage and Warehousing, Packaging, Materials Handling, Documentation and Information Flow, Inventory Control, Production Scheduling, and Location and General Management.

Dicer analyses the international logistics situation, for a broad cross-section of U.S. industries, from a systems point of view. He terms the logistics functions the sub-systems of the logistics system, and the logistics activities the components of these sub-systems.

The choice of cost centres for this research, as previously listed, differs from Dicer's selection in three main respects. These are:-

i) Location (and General Management) as a cost centre is omitted here, for the case of a pharmaceutical manufacturer, since location decisions tend to be made at a strategic, rather than at an operational level, and hence the decision on facility location is likely to be made in respect of political factors overriding the economics of the purely logistics considerations.

ii) Purchasing is included as a cost centre in the analysis of the logistics system of a pharmaceutical manufacturer since its activities affect the quantities and times, as well as the costs, of raw materials and packaging components entering the materials flow path. The original definition of business logistics, in Chapter 1, included raw material acquisition as an integral part of the total logistics concept.

iii) Quality Control is tentatively included in the list of cost centres for this research, as it was noted in Chapter 4 that its influence on the operations of other logistics functions may or may not significantly affect their costs. There is little factual evidence to support the case one way or the other. Walker (171) contends the following:

> "Although the large (drug) firms take the position that effective quality control is very expensive, and constitutes a large part of the final cost of a drug, available evidence does not support this argument ....."
>
> (Reference: Walker (171))

It can probably be supposed that the impact of Quality Control, in rejecting materials from the production processes or from outside suppliers, is only likely to have a significant effect upon the operations of the other logistics functions when the rejection rate is unpredictably high or it affects particularly sensitive materials. In normal situations the effects of Quality Control should be relatively minimal.

For this reason, this logistics system analysis omits Quality Control as a cost centre, with the proviso that it may have to be included when the materials rejections exhibit an abnormal rate, or pattern.

Dicer (56) selects his activities (48 in total) following a comprehensive survey which he made of the logistics literature up to 1969. These selected activities apply to manufacturing companies with international trade interests across a broad cross-section of industries. The selection approach used by Dicer can be explained in his own words:

> "..... Each function should be treated as a subsystem and the point of contact or interaction is between the individual activities within the different functions rather than between the functions themselves.
>
> In order to handle this problem in building the logistics model, it is best to start at the lowest subsystem level practical and to build these subsystems individually before attempting to relate them to each other and to a larger system ....."
>
> (Reference: Dicer (56))

It is proposed that Dicer's list of subsystem activities be used as the basis for identifying the composite of cost-incurring activities within the logistics system of the pharmaceutical manufacturer.

Dicer's list is altered somewhat to suit the logistics operations of pharmaceutical manufacturers; the amended list is represented in Table 6.2. This list includes eight logistics cost centres divided into a total of 42 component activities.

The previously identified number of eleven cost centres (excluding Quality Control) is reduced to eight by incorporating the following:

i) Order Picking and Packaging as 'Order Preparation and Packaging.'

ii) Documentation, Order Processing and Information Feedback as 'Documentation and Order Processing'.

The amendments made to Dicer's rather generally described activities are mainly to specify the component activities in more detail, with respect to the features of a pharmaceutical manufacturer's logistics system. These features were identified and discussed in numerous sections of the preceding chapters.

Table 6.2: List of Activities Comprising the Logistics System for the Pharmaceutical Manufacturer

Logistics Cost Centre	Ref.	Component Activities Description
A. TRANSPORT	A1	Selecting the mode of transport for each shipment.
	A2	Scheduling the transport for each shipment.
	A3	Selecting the types of carriers, and the specific carriers in each type, to provide the required mode of transport.
	A4	Ascertaining the proper classification descriptions, packing requirements, rates etc., on each shipment.
	A5	Supervising the physical receipt and shipping of the freight, including weighing and measuring where necessary.
	A6	Consolidating and pooling to take advantage of carload rates, containerisation etc., on shipments.

Logistics Cost Centre	Ref.	Component Activities Description
	A7	Arranging for adequate insurance of the shipment during transit.
	A8	Tracing and checking on the progress of exported goods; checking of import arrivals and arranging for special services.
	A9	Purchasing, leasing, operating and controlling of company vehciles.
	A10	Determining the use of foreign freight forwarders to handle traffic activities, and the extent of their duties.
	A11	Managing rate negotiations, adjustments, new classifications, litigation, legislation, etc., for the firm.
	A12	Routing of shipments at home and abroad, and selecting points of international entry and exit.
B. STORAGE AND WAREHOUSING	B1	Designing internal warehouse and operations: layout, size, type of shelving, aisle width, degree of automation, etc.
	B2	Selecting external loading bay design and operation: layout, size, height, degree of automation, outside storage arrangements, etc.
	B3	Selecting and using public and/or leased warehouses.
	B4	Selecting and using foreign trade zone facilities.
	B5	Designing and operating special storage arrangements, e.g., refrigeration, high security storage, etc.
	B6	Maintaining and protecting the physical condition of the inventory during storage.

Logistics Cost Centre	Ref.	Component Activities Description
C. ORDER PREPAR-ATION AND PACKAGING	C1	Picking goods from the warehouse shelves to make up customers' orders.
	C2	Designing packaging methods: disposable, or returnable, pallets, shrink wrapping machinery, lease, or own, containers, etc.
	C3	Selecting the primary packs: type, size, material, etc.
	C4	Selecting the outer pack: type, size, degree of standardisation, material, etc.
	C5	Packaging operations with the outer packs, i.e., parcelling up orders for despatch to customer.
D. MATERIALS HANDLING	D1	Selecting and operating equipment to move materials between warehouses and production areas on a single site.
	D2	Selecting and operating equipment to handle materials within the warehouse.
E. DOCUMENT-ATION AND ORDER PROCESSING	E1	Preparing and handling of shipping documents, e.g., bills of lading, freight contracts, freight bills, insurance policies, etc.
	E2	Preparing and handling of government documents, e.g., export declarations, certificates of origin, import licenses, etc.
	E3	Preparing and handling of financial documents, e.g., invoicing and credit control.
	E4	Receiving and processing of customers' orders.
	E5	Preparing and handling of internal control information, e.g., inventory levels, production schedules, operating budgets, etc.

Logistics Cost Centre	Ref.	Component Activities Description
	E6	Auditing and arranging for payment of freight bills, customs duty, insurance premiums, etc.
	E7	Receiving and following up on customer complaints, loss and damage claims, overcharge claims, return of unsold goods, etc.
	E8	Managing and controlling of minimum order size, ordering frequency, etc.
F. INVENTORY CONTROL	F1	Managing and controlling inventory levels of raw materials and packaging components.
	F2	Managing and controlling inventory levels of production intermediates.
	F3	Managing and controlling inventory levels of finished goods.
G. PRODUCTION SCHEDULING	G1	Determining which product to produce in a multi-product operation.
	G2	Determining the batch sizes, or the number of batches in a campaign, to produce.
	G3	Determining the dates for beginning and completing each production run at every process stage.
H. PURCHASING	H1	Determining the quantities of each raw material and packaging component to be purchased from outside suppliers.
	H2	Determining when outside supplies of raw materials and packaging components are to be delivered.
	H3	Determining from which outside suppliers to purchase the raw materials and packaging components.

Activity Interactions:

It was stressed in Chapter 4 that a derivation of the total logistics cost, if based upon an analysis of the logistics system in its entirety, involves the consideration of a large number of possible interactions, between logistics cost centres.

If the components of the cost centres, the logistics activities, are also considered to interact individually with each other, then this large number of possible interactions becomes a multitude. For instance, if each of the 42 activities listed in Table 6.2 were to interact in tandem with every other one; then there would be 861* interactions. The task of handling such a number is quite formidable in terms of analysis time, volume of information required and expense.

Dicer (56) reduces the number of possible activity interactions in his logistics research down to about half (from 1128** down to about 550) by flowcharting the pattern of activities that make up the decision-making process for each subsystem.

Ideally, according to Dicer, all of a system's activities should be considered simultaneously when making a logistics decision. In practice, however, this is usually impossible.

The logistics subsystem, or department, manager must apply an iterative, rather than a simultaneous, decision-making procedure, selecting first what he sees as being the key activity. He then bases his decisions, concerning the other activities, on this key.

The iterative procedure commences with the key activity decision, working down the hierarchical decision chart in a step-wise manner basing each subsequent decision on the previous one.

Dicer charts the decision-making process for each one of his eight subsystem groups, classifying in hierarchical order, their component activities as "general policy", "key", "primary support" and "secondary support".

---

* $\frac{n(n-1)}{2} = \frac{42 \times 41}{2} = 861$

** $\frac{n(n-1)}{2} = \frac{48 \times 47}{2} = 1128$

This basis for structuring component activities is not applicable to the logistics cost analysis of this research study.

This non-applicability highlights a main difference between the terms of reference of this research and that of a number of other logistics analysts, e.g., Bowersox (17), Shycon and Maffei (150) and Kuehn and Hamburger (104). The distinction hinges on whether the logistics analysis is based upon modifications made to the company's existing system, or whether a new system design is under review.

The logistics analysis of this research study is to be made concerning the decision of whether or not to implement a proposed operational change originating from any one of the logistics system's departments,or cost centres, within the company. Dicer's approach is not based on a consideration of the existing system. His flowcharts of the decision processes are able to identify 'key' activities since they aim at one overriding decision: the optimum design of a new logistics system.
When the logistics system itself is assumed to be fixed, or existing, the effects of a change acting within the constraints of the system are required to be evaluated. It is then that the component activity directly corresponding to the proposed change becomes the key activity in any decision-making flow sequence.

However, one of the research objectives is to construct a framework within which the effects of an alternative proposal, arising from any logistics department, can be assessed. Therefore every component activity is potentially a key one. It is not possible to devise a decision-making flow sequence of logistics activities that would suit each assessment.

Some other basis is required to identify the relevant interactions to be included in a cost analysis of the logistics system.

A Basis for Reducing the Number of Activity Interactions:

A logistics system exists in any company in order to operate and control the flow of material through it. For a pharmaceutical manufacturer, raw materials are converted into finished goods through a series of conversion stages; the flow through each stage being the concern of logistics management.

Faced with a multitude of possible interactions to be included in an analysis of this flow, it is suggested that the basis of utility theory might provide a guide to reducing the complexity of the problem.

As Fishburn (62) suggests:

> "..... Preferences between decision alternatives can be characterised in terms of several factors relating to the alternatives. These factors may be regarded as utilities ....."
>
> (Reference: Fishburn (62))

In the context of the logistics system, logistics activities can be said to provide utility to the materials as they flow through the system. In this connection it is stated (81) that:

> "..... logistics functions create time and place utility
> - production creates form utility
> - marketing creates ownership utility ....."
>
> (Reference: Henn (81))

Since marketing, as an operative function, is excluded from the logistics system, the materials flowing through the system can be said to change utility with respect to time, place and form.

If materials progressively increase their time, place and form utilities, then the value to the manufacturer of those materials can be likewise said to progressively increase. Some examples of of how the activities of logistics functions can change a material's utility, and hence its value, are as follows: Production and Packaging activities can change a material's form utility; Materials Handling and Transportation activities can change a material's place utility. The material's value in each example will also change. By implication, the changes will represent an increase in value since the material will have progressed that much nearer the finished goods state.

Additionally, as each activity takes a finite time to complete, a material's time utility will change continuously from raw materials acquisition to receipt of the finished goods by the customer. As before, the material's value will progressively increase as the time utility changes along the path of the material flow.

If a material's value to the manufacturer is progressively increasing as its utility is changed by each logistics activity, then the costs to the manufacturer are also progressively increasing. Changes in form, place and time utility are the result of logistics activities. These activities incur costs in the form of expenditure on such items as labour charges, capital investment in equipment and facilities, raw material and packaging component costs, equipment running charges, capital investment in inventory and general overhead expenses.

Although the nature of the costs may be varied, one general conclusion can be drawn:

> as logistics costs they are incurred whenever a material changes its form, place or time utility.

It is supposed that this conclusion can provide a basis for reducing the number of activity interactions to be included in a cost analysis of a pharmaceutical manufacturer's logistics system.

The logistics system flowchart as drawn in Chapter 4 is now reconstructed to show the materials flow path between a succession of conversion points. This reconstruction is shown as Figure 6.1

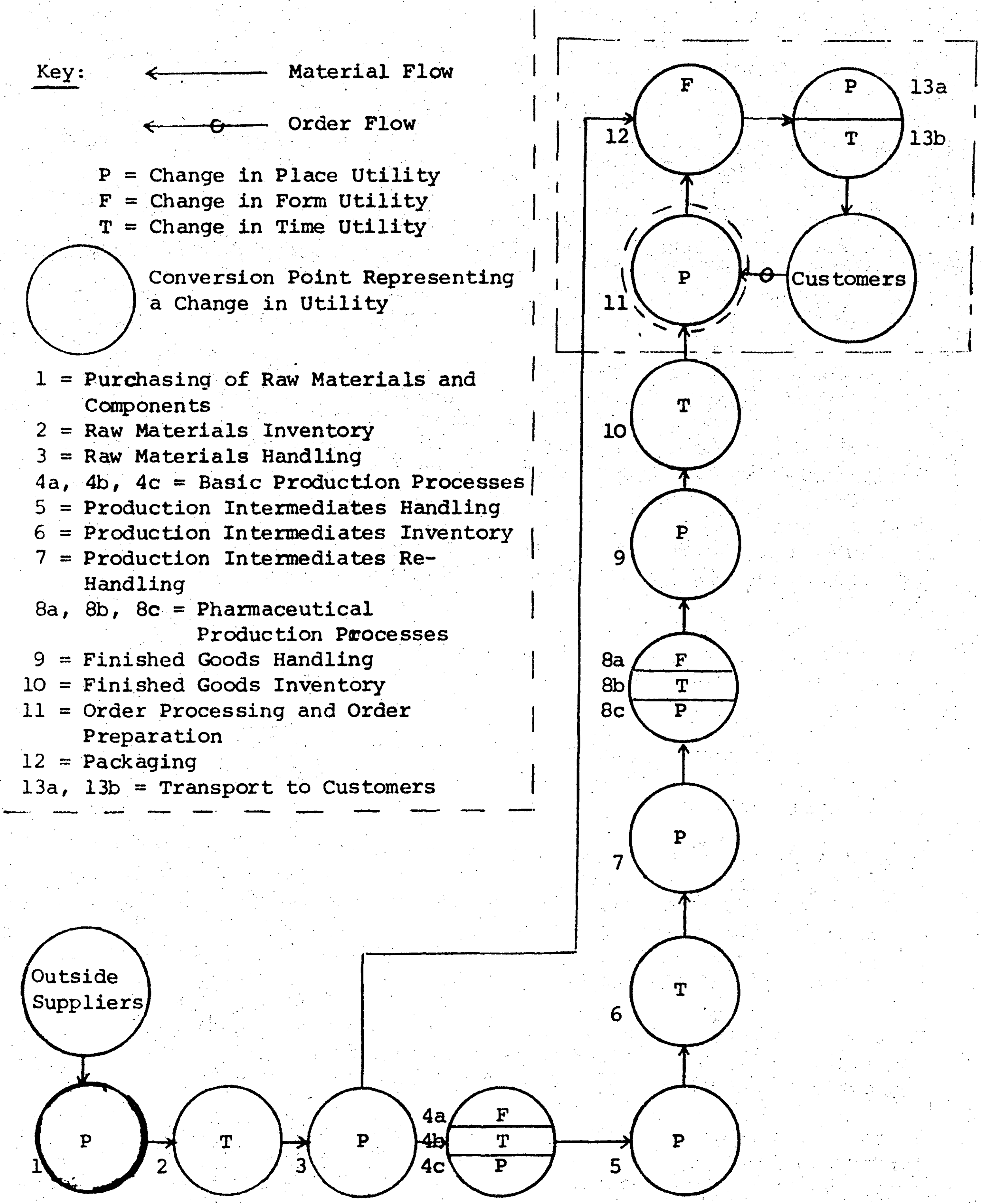


Figure 6.1: Materials Flow Path Within a Pharmaceutical Manufacturer's Logistics System

The conversion points are represented as circular nodes, connecting the material flows. At each node material is converted, either with respect to its form, place or time utility, and logistics costs are thereby incurred. These conversions are indicated by the letters F, P and T, respectively, marked within the circles.

Node number 11 is shown with a dashed outer circle. This outer circle represents the order processing operation, which translates orders into information; the inner circle of node 11 is a solid line depicting the order preparation function. The order flow back from the customers is only included in Figure 6.1 to provide continuity.

It will be noted that nodes numbered 2, 4b, 6, 8b, 10 and 13b, are allotted a change in time utility, T, despite the earlier observation that a material's time utility changes continuously along the materials flow path. These six nodes are shown as specifically denoting a time change since they are the ones involving capital investment in inventory holding, e.g., safety stocks, cycle stocks, transit stocks, work-in-process. When material exists purely as inventory, in one form or another, its form and place utility cannot be said to be changing, only its time utility.

The inherent changes in time utility made to the material by each of the logistics activities will be dealt with later on in this chapter.

Each component activity of the logistics system listed in Table 6.2 incurs a cost, through its operations, that can contribute to the total logistics cost.

By logically extending the earlier statement that logistics costs are incurred whenever material changes its form, place or time utility, each component activity can be assigned to one or more of the conversion points of Figure 6.1. The cost effects of an activity will correspond to its conversion point(s) with respect to its type of utility change, P, F or T.

Table 6.3 is constructed to tabulate each component activity of the logistics system (as referenced in Table 6.2), denoting its appropriate conversion point(s) and utility change(s).

In compiling Table 6.3 great care is taken to only assign those conversion points to each activity, where the effects of that activity act directly on the particular utility change.

Component Activity of the Logistics System (Ref.)	Conversion Point(Node) Nos.	Type of Utility Change		
		F	P	T
A1	13a		*	
A2	13b			*
A3	13a		*	
A4	13a		*	
A5	13a		*	
A6	13a		*	
A7	13a		*	
A8	13a		*	
A9	13a		*	
A10	13a		*	
A11	13a		*	
A12	13a		*	
B1	2,6,10			*
B2	10			*
B3	2,6,10			*
B4	13b			*
B5	2,6,10,13b			*
B6	2,6,10,13b			*
C1	11		*	
C2	12	*		
C3	8a	*		
C4	12	*		
C5	12	*		
D1	1,3,5,7,9		*	
D2	2,6,10,11		*	*
E1	13a,13b		*	*
E2	13a,13b		*	*
E3	11		*	
E4	11		*	
E5	2,4b,6,8b 10,13b			*
E6	13a		*	
E7	11,13a		*	
E8	11		*	
F1	2			*
F2	6			*
F3	10,13b			*
G1	4a,8a	*		
G2	4c,8c		*	
G3	4b,8b			*
H1	1		*	
H2	1		*	
H3	1		*	

Table 6.3: Tabulation of the Conversion Points and Utility Changes in the Material Flow Path Corresponding to Each Component Activity of the Logistics System

Some of the designations may appear to be misdirected. For instance, activity B6 ("Maintaining and protecting the physical condition of the inventory during storage") may not seem to affect the time utility which is changed during warehouse storage. However B6 does serve to act on the warehouse storage function, which exists in the material flow sequence to change time utility (see Figure 6.1).

It may also be argued that activity A6 ("Consolidating and pooling to take advantage of carload rates, containerisation, etc. on shipments") would be more likely to affect the change in form utility, through external packaging requirements, than to affect changes in place and time utilities, corresponding to the transportation of finished goods to the customer. In this case, however, the effect on form utility is an indirect one, albeit a significant effect, since the activity A6 acts directly on the logistics system only through the final transportation function, represented in Figure 6.1 as conversion point 13a/13b.

The materials flow path of Figure 6.1 and the tabulation of conversion points, utility changes and component activities given by Table 6.3 provide a framework for reducing the number of activity interactions to be included in the total cost analysis. However, the interactions' effects on logistics costs, have to be first considered with respect to the corresponding changes in form, place and time utility.

Research Suppositions: A Heuristic Procedure to Aid the Calculation of the Total Logistics Cost:

It can be intuitively presumed that the closer two component activities are to each other in the material flow path, as linked through their designated conversion points, the stronger is likely to be their interactive effect on logistics cost. The material flow path is as depicted by Figure 6.1; the designated conversion points are those as listed in Table 6.3.

The above presumption can form a link between the logistics system analysis framework of Figure 6.1 and Table 6.3, and the formulation of a necessary heuristic procedure to aid the calculation of the total logistics cost.

To this end, the following research suppositions are proposed to provide some guidance as to the relative measure of interactive effects in terms of their contribution to total logistics costs:

- If an activity appropriate to a conversion point(s) is operationally changed, then its cost effects on the type of utility represented by that point(s) will be reflected most by the other activities appropriate to the same conversion point(s).

- The changed activity's cost effects on the types of utility not represented by the appropriate conversion point(s) will be felt most by activities corresponding to the nearest conversion point(s) on the material flow path.

These two suppositions represent heuristic procedural guidelines that may possibly provide a basis for reducing the number of activity interactions to be included in a cost analysis of the pharmaceutical manufacturer's logistics system.

It should be noted that they assume that all logistics activities are capable of acting upon each type of utility (form, place and time) to a certain extent, at least.

The following examples should serve to illustrate their application:

i) A change in activity C1 ("Order picking of finished goods from warehouse shelves to make up customers' orders") will exhibit the most important interactions with activities corresponding to conversion point number 11 for changes in place utility; to conversion point number 12 for changes in form utility; and to conversion point number 10 for changes in time utility.

ii) A change in activity F2 ("Managing and controlling inventory levels of production intermediates") will show the most important interactions with activities corresponding to conversion point number 6 for changes in time utility; to both conversion points numbers 5 and 7, equally, for changes in place utility; and to conversion points numbers 4a and 8a, equally, for changes in form utility.

iii) A change in activity D1 ("Selecting and operating equipment to move materials between warehouses and production areas on a single site") will exhibit the most important interactions with activities corresponding to conversion points numbers 1, 3, 5, 7 and 9, equally, for changes in place utility; to conversion points numbers 2, 4b, 6, 8b and 10, equally, for changes in time utility; and to conversion points numbers 4a and 8a, equally, for changes in form utility.

In example i) activity C1 is 'coincident' with conversion point 11 (from Table 6.3) and 'once-removed' from conversion points 10 and 12 (from Figure 6.1).

Similarly, for example ii), activity F2 is 'coincident' with conversion point 6, 'once-removed' from conversion points 5 and 7, and 'twice-removed' from conversion points 4a and 8a.

Again, in example iii) activity D1 is 'coincident' with conversion points 1, 3, 5, 7 and 9, and 'once-removed' from conversion points 2, 4a, 4b, 6, 8a, 8b and 10.

Table 6.4 is a re-tabulation of the information in Table 6.3. It shows the total number and references of each component activity corresponding to each conversion point.

Conversion Point		Total number of component activities	Component Activity References
Number	Type of Utility Change		
1	P	4	D1, H1, H2, H3
2	T	7	B1, B3, B5, B6, D2, E5, F1
3	P	1	D1
4a	F	1	G1
4b	T	2	E5, G3
4c	P	1	G2
5	P	1	D1
6	T	7	B1, B3, B5, B6, D2, E5, F2
7	P	1	D1
8a	F	2	C3, G1
8b	T	2	E5, G3
8C	P	1	G2
9	P	1	D1
10	T	7	B1, B3, B5, B6, D2, E5, F3
11	P	6	C1, D2, E3, E4, E7, E8
12	F	3	C2, C4, C5
13a	P	15	A1, A3, A4, A5, A6, A7, A8, A9, A10, A11, A12, E1, E2, E6, E7.
13b	T	7	A2, B5, B6, E1, E2, E5, F3

Table 6.4: Tabulation of the Component Activities of the Logistics System and the Utility Changes in the Material Flow Path Corresponding to Each Conversion Point.

Table 6.4 will be used later in the thesis (in Chapter 8) to ascertain the number of interactions resulting from application of the research suppositions to the analysis of empirical data.

3. Effectiveness Analysis of the Logistics System

The previous section studied the logistics system of the pharmaceutical manufacturer in terms of its total cost. In this section the effectiveness analysis of the logistics system will now be discussed.

In the previous chapter, it was shown that the effectiveness of a logistics system can be measured with respect to customer service criteria. In particular, the service criteria of lead time duration, lead time consistency and lead time flexibility were selected. These were considered to be appropriate in linking the logistics operations of a pharmaceutical manufacturer to his three main groups of customers: wholesalers, hospital pharmacists and retail chemists.

The Logistics Functions as a Composite of Time-Incurring Activities:

It was previously supposed that logistics costs are incurred whenever a material changes its form, place or time utility within the logistics system. These utility changes were represented as conversion points along a materials flow path, Figure 6.1, beginning with the acquisition of raw materials and packaging components and ending with the delivery of finished goods to the customer.

In as much that every conversion, or component activity corresponding to each conversion, takes a finite time to occur, it can be presumed that materials are continually changing their time utility as they flow through the system.

In previously considering the cost analysis of the logistics system, changes in time utility were restricted to those involving the material state when it acts purely as an inventory, in one form or another.

It may be presumed that each of the logistics system activities listed in Table 6.2 can be considered to represent a change in time utility. Each activity requires a specific time for its completion. In line with utility theory, it can be said that the value of the material progressively increases with each activity's completion along the material flow path.

Just as logistics activities may be distinguished on the basis of their either contributing directly or indirectly to the total logistics cost, it may be supposed that they can be similarly distinguished with respect to the material's total residence time within the logistics system. In order to make this distinction clear it is convenient to consider the component activities listed in Table 6.2 as being, either i) activities requiring a time duration for their completion, or ii) activities which are essentially <u>decisions</u> having direct implications on the timing and duration of other activities.

For instance, activity A1 ("Selecting the mode of transport for each shipment") is a decision taken by the Transport function. As a decision it can be made in a very short time by one man. However, its implications on transit time duration can be very great; there is a big difference in journey times between air and sea freight. On the other hand activity E1 ("Preparing and handling of shipping documents") has an actual duration time; it is, in itself, an operation rather than being a decision.

Activity Interactions:

Since each component activity of the logistics system incurs a time duration as well as a cost, either directly or indirectly, the number of possible activity interactions in the effectiveness analysis is the same as in the cost analysis of the logistics system.

Therefore, comments made previously on activity interactions in the cost analysis of the logistics system apply similarly here. The same conclusion can also be reached that some basis is now required to identify those relevant interactions to be included in an effectiveness analysis of the logistics system.

A Basis For Reducing the Number of Activity Interactions:

The earlier stated proposition that utility theory can provide a guide to reducing the complexity of the logistics system analysis implies that logistics activities progressively incur time, as well as costs, since one of the utility factors is time, itself.

Time through the logistics system may be regarded in one of two ways, regardless of whether or not the activity in question is classed as a decision or an operation:

either, a) contributing towards the duration of the customers' lead time,

or, b) contributing towards the total residence time of the logistics system.

This distinction can best be illustrated by reference to Figure 6.1.

The 'square' formed by the material and orders flow through the conversion points numbers 11, 12, 13a/b and the node representing 'Customers', is that containing logistics activities which contribute towards the customer's lead time. These activities will include both operations and decisions, as previously distinguished.

The remaining portion of the materials flow, linking conversion points numbers 1 to 10 and including the node representing 'Outside Suppliers', contains logistics activities (both operations and decisions) which contribute towards the total residence time for material within the logistics system.

The components of time, a) and b), can be neatly related to the distinction drawn, in Chapter 1, between the scope of 'physical distribution management' and of 'materials management'. The logistics activities comprising the customer lead time square would be within the scope of physical distribution management; those remaining logistics activities would be within the scope of materials management.

It should be noted that the logistics activities associated with time component a) also contribute towards the residence time of materials for the total logistics system.

It can be recognised that all logistics activities incur a time duration, as well as a cost. Then, the list of logistics activities (Table 6.2), and their association to the conversion points (Table 6.3) portrayed in the materials flow path of the logistics system (Figure 6.1), can apply equally well to the effectiveness analysis of the logistics system as it did to the cost analysis. They can similarly provide a framework for reducing the number of activity interactions to be included in the total effectiveness analysis.

However, as with the previous cost analysis, the interactions' effects on the customer's lead time have first to be considered with respect to their effects on the changes in form, place and time utility.

Research Suppositions: A Heuristic Procedure to Aid the Derivation of the Customer's Lead Time

Again, it can be intuitively presumed that the closer two component activities are to each other in the material flow path the stronger is likely to be their interactive effect with respect to customer's lead time, or the total residence time of material within the logistics system. In other words, a change in the operations of a logistics activity will cause greatest disruption, leading either to delay or accelerated throughput, in those activities most adjacent to it on the materials flow path of the logistics system.

The following research suppositions are proposed, as a follow-on to the suppositions postulated earlier for the cost analysis:

- If an activity appropriate to a conversion point(s) is operationally changed, then the time effects on the type of utility represented by that point(s) will be reflected most by the other activities appropriate to the same conversion point(s).

- The changed activity's time effects react, on the types of utility not represented by the appropriate conversion point(s), most by affecting the duration of activities corresponding to the nearest conversion point(s) on the materials flow path.

It is anticipated that these two suppositions will only hold true within the confines of each of the two sections of the materials flow path, as previously identified. These are: a) the customer's lead time square formed by the conversion point numbers 11, 12, 13a/b and the node marked 'Customers', and b) the remaining portion of the materials flow path from the node marked 'Outside Supplies' to that representing conversion point number 10.

These suppositions represent the heuristic procedural guidelines that may possibly provide a basis for reducing the number of activity interactions to be included in an effectiveness analysis of the pharmaceutical manufacturer's logistics system.

The chosen measure of effectiveness is customer service, and in particular the customer's lead time as a criterion of customer service. The association of specific lead time criteria with categories of customers will be examined in the next section.

First, though, the following <u>examples</u> should serve to illustrate the application of these two research suppositions:

i) A change in the duration of activity A5 ("Supervising the physical receipt and shipping of the freight .....") will exhibit the most important time interactions with activities corresponding to conversion points numbers 12, 13a and 13b, equivalent to changes in form, place and time utility, respectively, within the customer's lead time square of Figure 6.1.

ii) A change in the timing of activity H2 ("Determining when outside supplies of raw materials and packaging components are to be delivered") will exhibit the most important time interactions with activities corresponding to conversion points numbers 1, 2 and 4a, equivalent to changes in place, time and form utility, respectively, within the portion of the materials flow path, outside of the customer's lead time square.

In example i) activity A5 is 'coincident' with conversion points 13a/b (from Table 6.3) and 'once-removed' from conversion point number 12 (from Figure 6.1). It should be noted that all conversion points are within the customer's lead time square of Figure 6.1

For example ii) activity H2 is 'coincident' with conversion point number 1, 'once-removed' from conversion point number 2, and 'three-times removed' from conversion point number 4a. All conversion points are within the portion of the materials flow path outside of the customer's lead time square.

As before, Table 6.4 will be used later in the thesis to ascertain the number of interactions as a result of applying the research suppositions to the analysis of empirical data.

4. Classification of Customers with respect to Lead Time Characteristics.

The previous section put forward heuristic procedures to reduce the number of activity interactions and, hence, simplify the derivation of the lead time experienced by the customer. This lead time is the response of the manufacturer's logistics system to a customer's order.

It is proposed that the measure of this response can be taken as the measure of the effectiveness of the logistics system. However, as seen in the previous chapter, this lead time response can be considered in a number of different ways; these are termed lead time characteristics.

Lead Time Characteristics:

In Chapter 5, the three lead time characteristics, that are particularly relevant to the pharmaceutical industry, were identified as being lead time duration, lead time consistency and lead time flexibility.

It was seen as being essential to a logistics analysis that the customer service considerations extend beyond that of, merely, lead time duration. Deriving one lead time to one customer for one order (or one product) does not say much as to the customer service achievement in a consumer goods situation.

If all the lead times to all the customers for all the orders (or individual products) are derived from the logistics system analysis, then a lot more information is available on customer service. This is not only due to being able to predict a more accurate average lead time duration, because of the greater quantity of data available, but that now it is possible to examine the lead time information with respect to the overall consistency and flexibility.

However, deriving an overall average duration, an overall consistency and an overall flexibility from the range of forecasted lead times, may not even be sufficient as a satisfactory measure of customer service. It may be desirable to obtain a value for these lead time characteristics in respect of each group of customers (or, possibly, even each customer) and each class of products. It may be that only then can the effectiveness of a logistics system configuration be predicted with sufficient accuracy to judge whether an alternative proposal should be implemented or not.

Classification of Customers:

In discussing the particular service requirements of each of three main groups of customers of the pharmaceutical manufacturer, in Chapter 5, it was suggested that there would appear to be differing requirements with respect to lead time criteria. As Christopher and Wills (39) remark:

> "Often the criterion adopted for grouping customers or accounts is by the volume of business placed, in other cases the criterion may be the type of company, in other cases geographical. However it may be more appropriate to attempt to define segments of customers according to their service needs. Not all customers will have the same requirements for service, whether in terms of lead times, flexibility, or whatever....."

(Reference: Christopher and Wills (39))

The following research suppositions are proposed in order to identify a particular lead time criterion with a particular type of customer:

- Lead time consistency is a primary criterion of customer service for pharmaceutical wholesalers.

- Lead time duration is a primary criterion of customer service for retail chemists.

- Lead time flexibility is a primary criterion of customer service for hospital pharmacists.

It is assumed in all these suppositions that each of the three lead time characteristics is important to all categories of customer. They imply, though, that a particular characteristic is dominant, above the others, for each of the customer groups.

The main reasons behind each of the three assertions are as follows:

- Pharmaceutical wholesalers are being increasingly served by scheduled deliveries from manufacturers, indicating that this practice may be a response to the wholesalers' desire for lead time consistency.

- Retail chemists, through necessity, have to maintain low levels of inventory on a wide variety of products. Their dependence on frequent deliveries from wholedalers (once, twice or, even, three times a day) indicates that lead time duration may be their primary concern.

- Hospital pharmacists have to maintain relatively low levels of inventory on a wide range of products, as do retail chemists. However the 'life-or-death' urgency of some hospital requirements could mean that lead time flexibility is the chief concern of hospital pharmacists.

In attempting to assess the support for these suppositions in the remainder of the thesis, two features of the situation, referred to several times earlier, have particular importance. These are a) the effect of stock outs, and b) the classification of products.

Each of these is now discussed in turn.

Effect of Stock-Outs:

The effects of stock-outs upon customers was discussed at various times in previous chapters. For instance, in Chapter 2, stock-outs were classified as being long term, short term, localised or widespread. The resultant effect on sales revenue was particularly examined. Attention was also drawn to how stock-outs can affect the operations of the logistics system and, as a consequence, incur excessive costs.

The interrelationships between components of the logistics system and stock-outs can be readily outlined by reference to the materials flow path of the logistics system, Figure 6.1

The customer's'lead time square', represented by conversion points 11, 12, 13a/b and the Customers, corresponds to those logistics activities which contribute directly to the customer's lead time. If there is a delay in carrying out one of these activities, then a corresponding delay may be directly reflected on the lead time duration.

The remainder of the materials flow path accounts for those logistics activities that do not contribute directly to the customer's lead time. Rather, they indirectly affect customer's lead time through the incidence of stock-outs. These activities act within the logistics system to either help prevent stock-outs at the point of finished goods inventory (conversion point number 10) or, at least, to ensure that the number and frequency of stock-outs conform to a pre-determined stock-out policy. For instance a policy of 95% item availability is frequently laid down. This would mean that one item in every twenty is unavailable for immediate preparation and despatch at the point of finished goods inventory. Such a policy does not imply anything, however, as to the duration of the stock-out, whether it be long-term or short-term.

The activities corresponding to conversion points outside of the customer's lead time square on the materials flow path can be said to form a'stock building sequence'.

In determining the lead time for a particular product contained within a certain customer's order, it is not realistic to assume that the product will automatically be in stock. If such an assumption were true, then it would simply be necessary to only consider the contributory durations of activities within the customer's lead time square, e.g., total customer's lead time = order receipt duration + order processing duration + order preparation and packaging duration + transport duration.

However, in the real world, 100% item availability can never be relied upon, and the contributory durations of the remainder of the logistics activities must be calculated if a lead time profile is to be built up on a range of products over a period of time.

Classification of Products:

Pharmaceutical products may be classified under all number of groupings, e.g., by value, by turnover, by dates of introduction, by therapeutic application. Walker (171) illustrates the latter by listing 12 major groups, divided into 40 minor groupings, on the basis of the type of drug with respect to its therapeutic application.

For the pharmaceutical industry, it is useful to be able to segregate products from amongst the large number in existence. It would seem to be appropriate to segregate according to the interests concerned. For members of the pharmaceutical distribution channel the following bases might be applicable:

Manufacturers:	Therapeutic application Degree of substitution by competitive products Product value
Wholesalers:	Manufacturers Turnover
Retail Chemists) Hospital Pharmacists) :	Product value Turnover Therapeutic application

and, in addition:

Doctors:	Therapeutic application Degree of substitution

These suggested groupings will be useful later in testing the research suppositions proposed in this chapter.

Summary

This chapter commenced by proposing that a heuristic model, of some kind, would be a suitable means for reducing the number of interactions to be included in an analysis of the logistics system of a pharmaceutical manufacturer. It was demonstrated that heuristics are appropriate with respect to two characteristics: capability to realistically represent the logistics system and the quantity of data required.

The analysis of the logistics system was reviewed under two headings: cost and effectiveness.

In viewing the logistics system as a collection of cost centres, the cost analysis considered these to be further divided into component logistics activities. The research work of Dicer (56) was largely used as the basis for selecting these activities. The result is a list composed of eight logistics cost centres divided into a total of 42 component activities, relevant to the pharmaceutical manufacturer. Interactions amongst pairs of these would result in a total of 861 to be considered in a logistics system analysis.

In attempting to find a basis for reducing the number of activity interactions, in the context of this research, utility theory was used as a guide. On this basis, it was presumed that logistics costs are incurred whenever a material changes its form, place or time utility.

The logistics system flowchart of Chapter 4 was reconstructed to represent the materials flow path within a pharmaceutical manufacturer's logistics system. This is based on a succession of conversion points, where a change in form, place or time utility occurs, each point being associated with a number of the logistics activities which contribute towards the total logistics cost.

In order to aid the calculation of this total logistics cost, two research suppositions were put forward. These provide heuristic guidelines necessary to reduce the number of activity interactions to be included in a cost analysis of the logistics system. These suppositions define the intuitive presumption that a changed activity will have greatest cost effects on activities closest to it, as represented on the materials flow path.

The effectiveness analysis of the logistics system was founded on the same assumed basis as the cost analysis. Instead of viewing the logistics functions as a composite of cost-incurring activities, they are seen as a composite of time-incurring activities. Each activity will incur, either directly or indirectly, a specific time duration, which can either contribute towards the duration of the customer's lead time, or contribute towards the residence time of material within the logistics system. A customer lead time square was identified on the material flow path to indicate those activities which contribute towards the duration of the customer's lead time.

The number of possible activity interactions was again seen as formidable.. Two further suppositions based on the same principles as before, were put forward. These again provide heuristic guidelines necessary to reduce the number of activity interactions to be included in an effectiveness analysis of the logistics system.

The final part of the chapter proposed that customers could be classified according to their service requirements with respect to lead time characteristics. Three suppositions were put forward concerning the service requirements of pharmaceutical wholesalers, hospital pharmacists and retail chemists. Two features of the situation, the effect of stock-outs and the classification of products, were also discussed.

The next chapter will be concerned with devising a fieldwork approach in order to collect empirical data from respondents. This data will later be analysed so as to test each of the research suppositions postulated in this chapter.

Chapter 7

The Empirical Research Design

Introduction

The previous chapter proposed seven research suppositions which were designed to act as heuristic guidelines in reducing the number of interactions to be included in a decision making model of the logistics system.

Cost and effectiveness analyses of the pharmaceutical manufacturer's logistics system were derived from taking a systems approach to the basic decision making problem of the logistics manager, viz, assessing the merits of an operational proposal, alternative to that being carried out, when interactive effects upon total logistics cost and customer service levels have to be taken into account.

It was considered necessary to test these hypotheses against empirical data obtained from pharmaceutical manufacturers and their customers. In order to do this the empirical research work needs to be designed so as to suit the principal research objectives.

There is no single ideal research design that can be universally applied. The details of the design have to be carefully matched to not only the research objectives but to the constraints imposed both by the available time and finance of the investigator.

A review of empirical research designs used in practice in logistics investigations should be valuable in establishing some sort of classification of these designs. This will aid the recognition of their specific advantages and limitations, so helping in the task of preparing a detailed formulation of the empirical research plan for each of the intended surveys.

Unless a system of sequential sampling is used, the sample size of each respondent group must be predetermined. The size of each sample is usually a compromise between the resource limitations of the study itself and the level of confidence that can be attached to conclusions drawn from the responses of a certain sample size.

The effectiveness of any sample can be increased with respect to its size by making it more representative of the population. This can be done by ensuring that the selection process is as random as possible, and that each possible respondent (if comparable with respect to size, contribution to business value, etc.) has an equal chance of being chosen.

1. Restatement of the Research Objectives

In selecting a research design for the empirical work of this study, it is recognised that the design should primarily suit the research objectives.

The research objectives were outlined in Chapter 1. They involve the testing of the suppositions proposed in the previous chapter, where those suppositions result from an attempt to logically simplify the cost and effectiveness analyses of the logistics system of the pharmaceutical manufacturer. The suppositions provide a systematic means of reducing the numbers of interactions to be included in such analyses, when applied to the assessment of alternative logistics proposals.

Briefly restated they are as follows:

- If an activity appropriate to a conversion point(s) is operationally changed, then its effects, in respect to both cost and time, on the type of utility represented by that point(s) will be reflected most by the other activities appropriate to the same conversion point(s).

- The changed activity's effects, in respect to both cost and time, on the types of utility not represented by the appropriate conversion point(s) will be felt most by activities corresponding to the nearest conversion point(s) on the material flow path.

- Lead time consistency is a primary criterion of customer service for pharmaceutical wholesalers.

- Lead time duration is a primary criterion of customer service for retail chemists.

- Lead time flexibility is a primary criterion of customer service for hospital pharmacists.

In order to meet the research objectives, it is proposed that the empirical research investigation be directed in three areas:

1) The manufacturer's logistics system
2) The service preferences of the customer groups
3) The effect of stock-outs upon eventual sales revenue

2. Empirical Research Techniques

Elliott and Christopher (59) note the presence of the common ground that exists in the realm of method or technique between all research projects.

> "....Most marketing research involves obtaining information from human beings, either directly as respondents to an interview or questionnaire, or indirectly through their behaviour, such as purchasing patterns...."
>
> (Reference: Elliott and Christopher (59), p.2)

Within this common ground, though, it is possible to make a classification of research techniques.

Classification

Elliott and Christopher (59) classify techniques of data collection by first making a basic distinction as to whether they are reactive or non-reactive. Their categorisation is reproduced as Figure 1.

Reactive techniques involve the empirical data being collected as a result of interaction between the investigator and the respondent. Non-reactive, or normative, techniques result in the empirical data being collected by the investigator without the assistance of a respondent.

In the absence of the opportunity to either observe at close hand or to use existing material, the investigator is restricted to using reactive techniques. Elliott and Christopher (59) do,however, sound the following warning concerning reactive research methods.

> "...in reactive research the investigator can manipulate the situation to yield the desired data but cannot be sure how far the data are purely the product of the respondent and how far they are influenced by his manipulation...."
>
> (Reference: Elliott and Christopher (59), p.22)

An extended classification of the "reactive-ask questions" grouping in Figure 7.1 is provided by Green and Tull (75), and shown as Figure 7.2. In this they recognise two basic characteristics of interviews between investigator and respondent: whether the interview is structured or unstructured, and whether the approach taken by the investigator is direct or indirect.

A structured interview could be the verbal administration of a questionnaire, or at least an interview planned around a prepared list of questions. On the other hand, an unstructured interview could, at an extreme, be considered as a 'depth' interview, where the respondent determines the direction and content of the interaction with the interviewer acting as a verbal mirror.

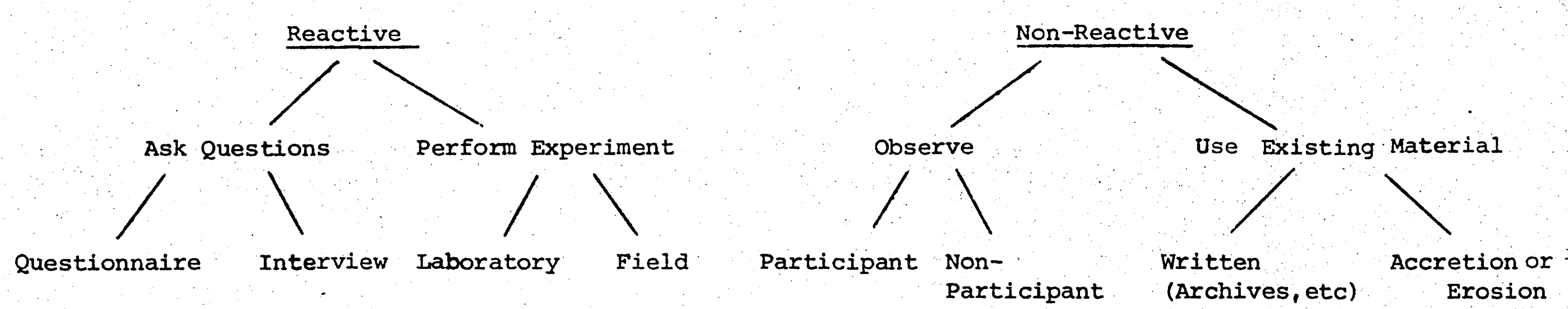


Figure 7.1. Categorisation of Techniques of Data Collection. (Reference: Elliott & Christopher (59) p.22)

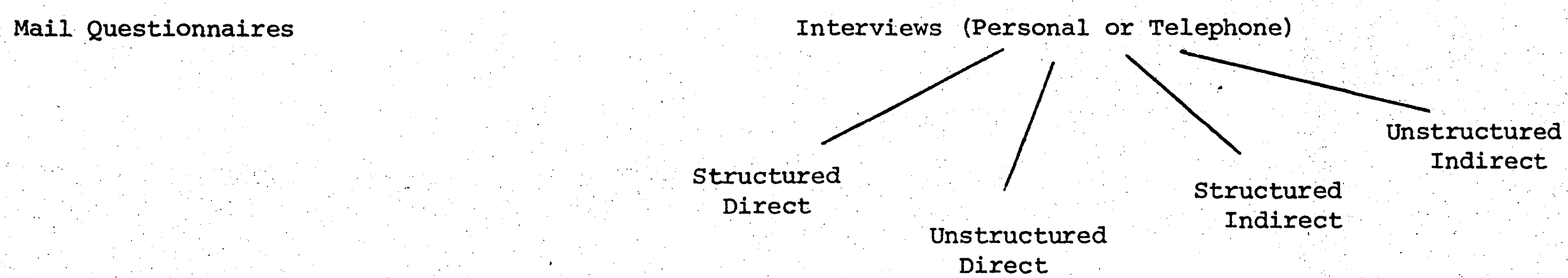


Figure 7.2. Categorisation of Means of Obtaining Information from Respondents (Reference: Green and Tull (75))

The distinction drawn between the direct and indirect approach is probably best explained in Green and Tull's own words:

> "...Psychologists have long recognised that direct questionning of patients is frequently of little value for diagnostic purposes. The patient is usually unable and often unwilling to give accurate answers to direct questions. To solve this problem, a number of techniques have been devised to obtain information by indirect means. Most of these techniques employ the principle of projection. That is, the subject is given a non-personal, ambiguous situation and asked to describe it. The person giving the description will tend to interpret the situation in terms of his own needs, motives and values. The description, therefore, involves a projection of characteristics of personality to the situation described...."
>
> (Reference; Green and Tull (75), p.147)

Taking Green and Tull's structural classification one step further the graph of Figure 7.3 is drawn to show the declining amount of structure from the example of the mailed questionnaire down to the example of the depth interview.

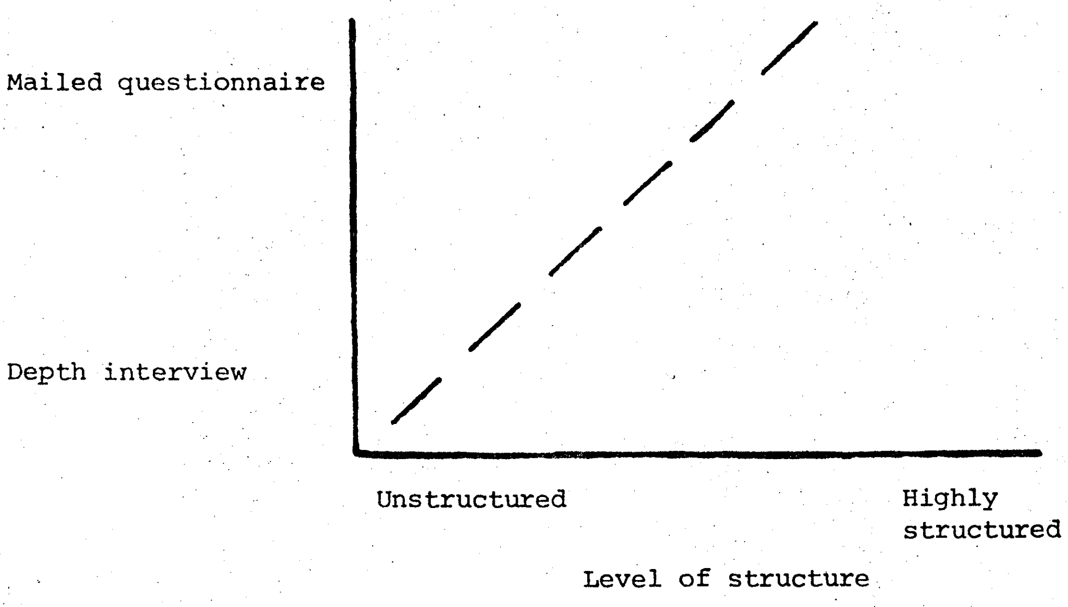


Figure 7.3. Possible Relationship of Extent of Structure to Examples of Research Techniques

Figure 7.3 can be alternatively depicted as a funnel-shaped profile as in Figure 7.4. Here the narrowing funnel represents the declining variety, or latitude, of information. Examples of some further research techniques are linearly positioned within the intermediate region, between the extremities of the methods of mailed questionnaires and depth interviews.

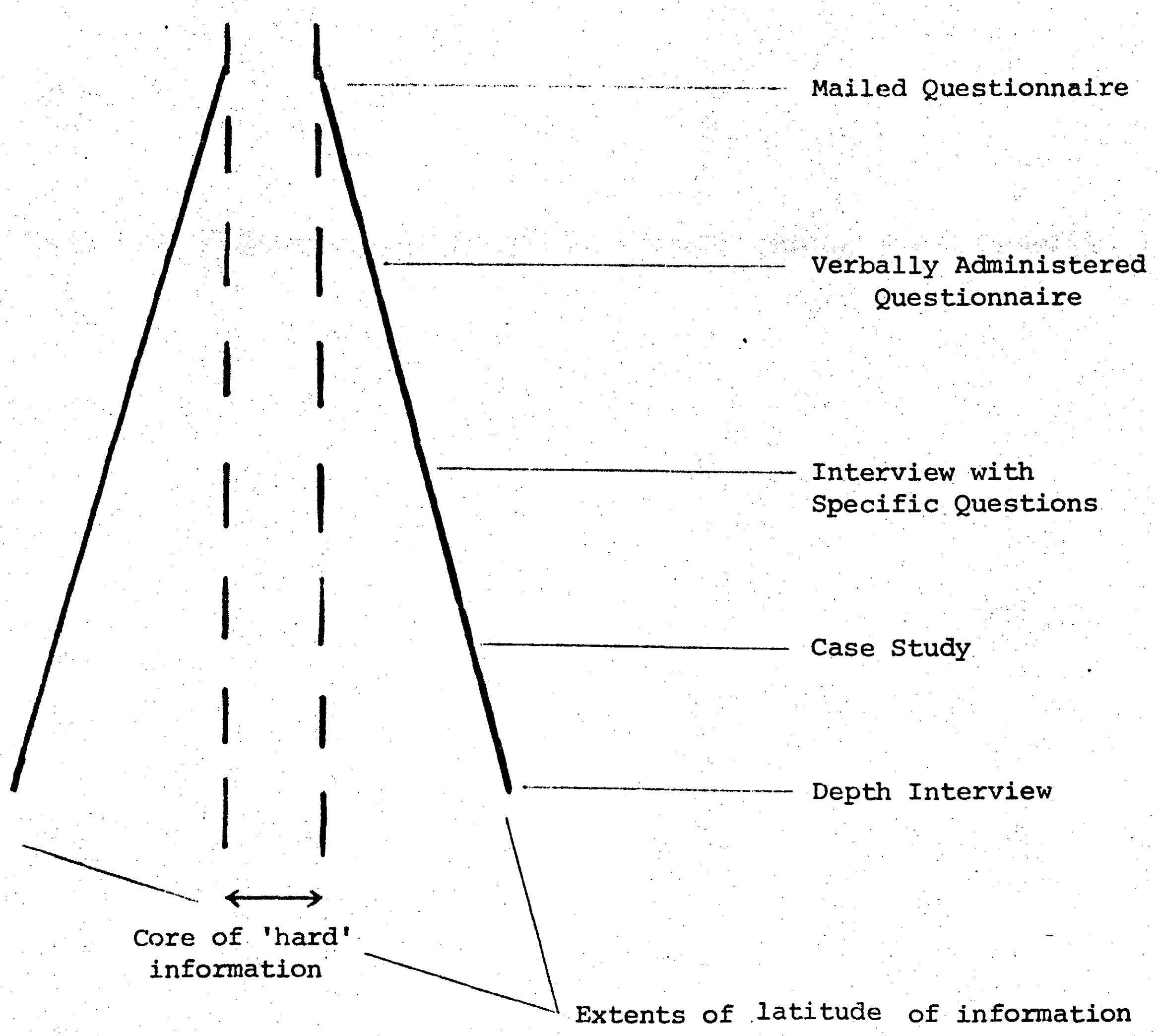
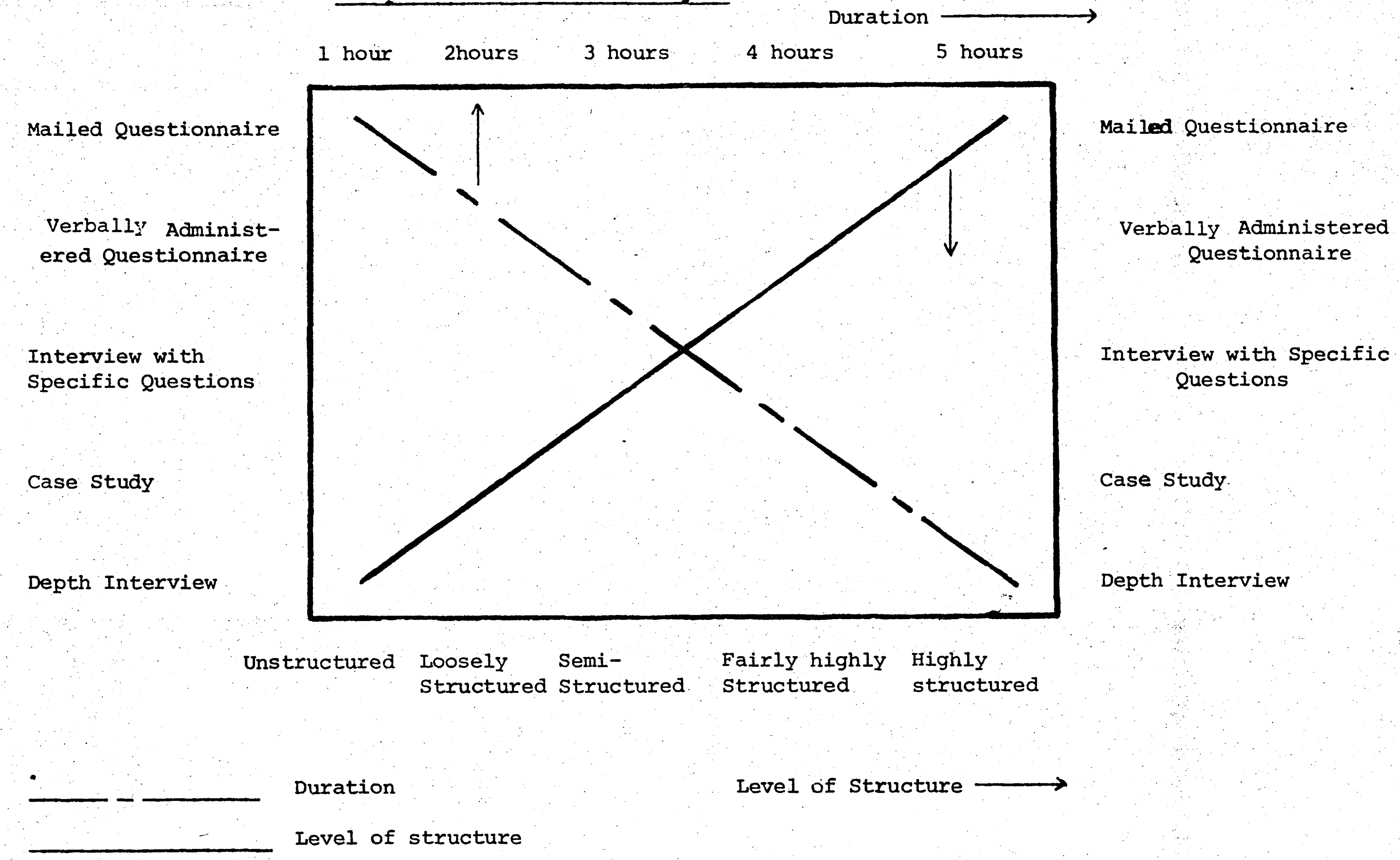


Figure 7.4. Profile Showing Latitude of Information Corresponding to Examples of Research Technique

The core of 'hard' information indicated in Figure 7.4 as being enclosed by vertical, dashed lines refers to the information obtained from a mailed questionnaire. The extension of these dashed lines down the length of the profile assumes that the eventual objective of each of the research techniques is to obtain this exact information.

It should be noted that the duration of the contact time between investigator and respondent is supposedly far greater for a depth interview than for a mailed questionnaire. If it is supposed that this duration varies inversely with the level of structure associated with the research technique, then a relationship as illustrated by Figure 7.5 might result.

Figure 7.5. Possible Relationships of Level of Structure and Duration of Contact Time to Examples of Research Techniques



The time scale used along the upper abscissa of Figure 7.5 is arbitrarily selected.

In order to further clarify these classifications some examples of research techniques being used in distribution research are now given.

Examples :

Depth Interviews: Atkins (6) pursues his research within a particular company, manufacturing industrial parts, who consider that their distribution methods require changing in the light of their falling sales and profits. In formulating an economic model and a behavioural model of the company's conditions, Atkins obtains his data through largely unstructured interviews with management personnel, and through observations of company records and accounts. Therefore Atkins makes use of both reactive and non-reactive research techniques.

Wayman (178) similarly attempts to formulate a mathematical model of a particular logistics system, that of a U.S. State's liquor distribution operation, by gathering empirical data through a series of interviews with management personnel and from reading internal reports and records. Wayman himself refers to these interviews as being unstructured and direct.

A common feature of both these examples, which use depth interviewing methods, is that the investigator is invited by the company to examine its logistics operations with access permitted to internal information and freedom to interview management personnel. The research is, in effect, an attempt to solve one company's problems.

Case Studies: The research work of Wronski (180) examines the impact of international container shipments on corporate physical distribution management by setting out to provide answers to three principal research questions: i) Is a heuristic or a systems approach being adopted? ii) Are the functions of the container being optimised? iii) Is the least cost or maximum profit test applied, or neither? Wronski attempts to answer these questions for three large companies, employing containerisation methods, by using a case study approach. He obtains information from managers of the companies concerned through means of loosely structured interviews between them and himself. Wronski then draws his conclusions as answers to the research questions, for each case, from the data collected.

Interviews with specific questions: Magrill (116) uses a comparative approach to study the marketing logistics systems of oil companies. His field study work consists of a series of interviews with managers of different companies. The research is comparative in that answers to the same specific questions are obtained from each respondent.

Dicer's (56) research into international logistics is aimed at constructing a theory instead of testing one. His research method consists of a three-phase approach: library research, personal interviews and the administration of a Delphi* questionnaire. In order to avoid merely discovering the problems facing one particular firm, Dicer structures his personal interview questions in such a way as to obtain fairly generalised responses.

The level of structure imposed in an interview can vary widely within this category. For instance the interviewer might ask the specific questions in a standard order and without variation in wording. On the other hand the interviewer might choose to put these questions in an order which seems appropriate to the progress of the interview, and in such a manner as to hopefully draw out the maximum response from that particular respondent.

Verbally administered questionnaires: Walson and Terry (172) ask managers from a variety of companies to indicate which distribution methods, from a list of alternatives, would be more likely to fulfill the achievement of a stated factor, or objective. This information is obtained by the authors through methods of interview and questionnaire response. Initially, in order to narrow down the number of relevant objectives, Walson and Terry carry out loosely structured interviews. Later, in order to provide the responses to specific questions, the interviews become highly structured and direct. The interviews take on the form of a verbally administered questionnaire.

An example of market research into pharmaceutical purchasing is provided by Wills (179). He attempts to classify the prescription drug, in the U.S. market, within a contemporary consumer goods classification system, by determining the consumer buying habits of prescription pharmaceuticals. His field study consists of telephone interviews to a random selection of households. These interviews take the form of a verbally administered questionnaire which is fairly highly structured.

The technique of a verbally administered questionnaire used in the above two examples, implies that the interviewer uses a standard list of questions, which are generally asked in a standard order and without variation in wording. Elliott and Christopher (59) draw a distinction between this technique and the preceding one (interviews with specific questions) in that, there, specified probes can be added which allow the interviewer to seek fuller information in cases where the response appears to be insufficient or doubtful in other ways. Without these probes the technique becomes a verbally administered questionnaire.

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* The Delphi method is referred to as an "anonymous debate-by-questionnaire" by Helmer (80). Its use provides the benefits of a committee-type approach without the resulting social compromise.

Mailed questionnaires: This technique, where no personal contact is usually made, is widely used for a variety of purposes, especially in market research. An example of the technique in practice is provided by Walters (174) who used the Delphi method to forecast the logistics implications of future changes in grocery retailing. He sent out questionnaires, on a four-round basis, to selected respondents within the grocery business.

The method of mailing questionnaires provides great versatility at relatively low cost. The questionnaire can be prepared and posted to people in any location at usually the same cost per person. The respondent may remain anonymous and therefore confidential information can be imparted that might otherwise be withheld. The respondent is also able to answer the questionnaire in his own time.

A major drawback to the technique is the usually anticipated high rate of non-response. Typically, those people who are indifferent to the topic being researched will not respond, (Green and Tull (75),p.158). The usual response rate to a mailed questionnaire is of the order of 20 to 40 per cent (75). However Walters (174) was able to substantially increase his response rate by making preliminary contact, by a letter, telephone call or even a visit, with the respondents before sending them the questionnaires.

An additional problem with mailed questionnaires lies with the expected bias of the results. Presumably the people responding tend to do so because they have stronger feelings about the research subject than do the non-respondents. It is therefore necessary in any mailed questionnaire survey to obtain a measure of this bias by contacting a sample of the non-respondents by other means, e.g. a telephone interview.

3. The Proposed Research Design

It can be assumed that the proposed research techniques will not be in the non-reactive category, and hence will be of the reactive type. The previous chapters of the thesis particularly highlight the lack of available information and data pertaining to the distribution of pharmaceutical products. Two main reasons for this neglect are suggested. These are:

1) the natural reluctance of pharmaceutical manufacturers to publish detailed cost information (if it is available anyway)

2) the lack of attention paid to distribution as a service-related factor in pharmaceutical marketing, compared to, say, levels of promotional activity and pricing policies.

In selecting from amongst the reactive research techniques so far presented, the following points have to be borne in mind:

a) It can be expected that fairly limited contact times will be permitted by all types of respondents: manufacturers, wholesalers, hospital pharmacists, retail chemists and doctors. This is due both to the pressure of their work and the fact that this research has origins external to the respondents, c.f., Atkins (6) and Wayman (178), where a company itself initiated the research study.

b) The size of the sample. Personal interviews, unless by telephone, may be ruled out with respect to cost and time available if the sample size is too large, or the locations of the respondents too varied.

c) It is no good precisely structuring a survey if afterwards it is realised that the information obtained is either insufficient or irrelevant to the research objectives. In this research it is initially necessary to identify the relevant logistics activities and customer service criteria of the manufacturers.

d) It must be decided whether an indirect or a direct approach is to be taken in the interview or questionnaire. For instance, Dicer (56) takes an indirect approach in structuring his interview questions in such a way as to get generalised responses. In justifying an indirect approach he says:

> ".... To simply ask a line manager what he sees as the restrictions on his specific activity would be of little value in that the reply would reflect the constraint, or constraints, foremost in the mind of that manager at that particular time...."
>
> (Reference: Dicer (56), p.52)

e) The desire, expressed in Chapter 1, to draw conclusions from this research that would have general application to the logistics management of any pharmaceutical manufacturer and, hopefully, would extend to manufacturers in other industries.

The consideration of factor a) virtually eliminates depth interviews as a viable research technique for this study.

The combination of factors a) and e) also tends to discourage taking a case study type approach, in addition to depth interviews.

The relevance of factor c) will depend to some extent on whether a nationwide or a local survey is to be made. It can be argued that since distribution is a major part of logistics and that distribution performance is related to distance, then a localised survey is obviously limited if its results are to be extrapolated to a complete coverage of the home market.

The total number of pharmaceutical manufacturers, with manufacturing and distribution facilities in this country is far less than the number of pharmaceutical wholesalers, and many more times fewer than the numbers of retail chemists, hospital pharmacists and doctors.

Whilst it is considered to be a feasible proposition to personally interview a representative selection of the total number of pharmaceutical manufacturers, it is decidedly impossible to do the same for the other categories of respondents. A mail questionnaire approach therefore seems obligatory for the empirical surveys on wholesalers, hospital pharmacists, retail chemists and doctors.

The consideration of factor c) would point to the desirability of carrying out an initial survey of all respondent categories. However, due to the sample size, this is only really feasible with the manufacturers; a pilot test of the mailed questionnaire could be carried out on a limited number of the possible respondents in the other categories. Since the initial survey with manufacturers must allow a certain latitude of discussion, and since depth interviews and case studies are ruled out, a technique using a semi-structured interview with specific questions seems to be indicated. (see Figures 7.4 and 7.5)

A degree of indirectness would seem desirable in all the approaches, as long as the desired information is clearly obtained and not obscured, in the light of Dicer's (56) earlier warning.

It is proposed that the following overall research plan be adopted:

<u>Manufacturers</u> - a two-stage survey. The initial survey is to consist of semi-structured personal interviews with logistics managers of selected respondent companies. The follow-up survey is to consist of a verbally administered questionnaire to the same logistics managers with questions designed to test the research suppositions relating to the cost and effectiveness analyses of the logistics system.

<u>Wholesalers, Hospital Pharmacists and Retail Chemists</u> - a mail questionnaire to cover a nationwide sample of each customer category. The questions are designed to test the research suppositions relating to the service preferences of customers. A pilot questionnaire is first forwarded to a number of the possible respondents to assess its suitability.

<u>Doctors</u> - a mail questionnaire approach to cover a nationwide sample. The questions are designed to assess the effect of stock outs upon sales revenue. Again, a pilot questionnaire is first posted to a number of the possible respondents to assess its suitability.

In all the mail questionnaire surveys, a reminder is sent out to all the initial non-respondents. Later a telephone interview approach is used on a number of the non-respondents in each category in order to obtain a measure of bias, if any, between them and the respondents.

The research techniques, and the questionnaire and interview designs are now described in detail for each respondent category.

4. Manufacturers Survey

The manufacturers survey is carried out in two stages:
i) the initial survey and ii) the major survey.

Initial Survey

Leading pharmaceutical manufacturers with operations in this country were first approached by posting a letter to them (see Appendix A, Exhibit 1). This letter requests information on their product ranges, the type of facilities and their location, and on their general distribution methods, as well as seeking their further cooperation in the research project.

Following this accumulation of background information on the companies and the industry as a whole, and knowing which companies were likely to offer assistance, the initial surveys were commenced.

Interview Procedure

The principal objectives of the initial survey are to:

i) Find out the general operating conditions, and identify the main logistics activities that contribute towards a total logistics cost, of pharmaceutical manufacturers.

ii) Ascertain the service levels achieved by manufacturers in the distribution of ethical pharmaceutical products to their customers.

iii) Operations information that is useful in the design of the final survey. Examples of such information are included in the list of Appendix A, Exhibit 3.

Appendix A, Exhibit 2 shows the preliminary letter written to each logistics manager.

Personal interviews were carried out with the logistics manager, or nearest equivalent (e.g., distribution manager, materials manager), of each company. The discussion was semi-structured around the interview framework of questions presented as Appendix A, Exhibit 3. The duration of the interviews was found to vary between three-quarters of an hour and four hours, dependent upon the time available to the respondent and the quantity of ensuing discussion.

In some cases more than one respondent in each company was seen, e.g., order processing manager, warehousing manager, customer service manager, production controller, purchasing manager (besides the logistics manager).

Sample of Respondents

The sample of pharmaceutical manufacturers was not selected to any particular pattern, except to include as many of the larger ones operating in Britain as possible. The members list of the Association of the British Pharmaceutical Industry (4) provides the source of the selections. Here there are listed 89 firms, but no more than 40% of these are thought to have manufacturing facilities in this country.

34 companies were initially approached by sending them the letter as in Appendix A, Exhibit 1. Of these, 17 are included in a list of the 20 largest pharmaceutical manufacturers in Great Britain prepared in a report by the National Economic Development Office (130). In this report it is noted that, in 1969, those 20 companies accounted for approximately 70% of total sales in Britain.

Of the 34 companies initially approached, 28 were prepared to offer their further cooperation in the research project, 25 of this number were selected for the initial survey, i.e., a personal interview with the company's logistics manager as described in the previous section.

It is appropriate at this stage to consider a problem to which Dicer (56) draws attention. This concerns the effect that a manager's position in the firm's hierarchy can have upon his response during the interview.

> "....The problems that are seen by each manager as critical will vary with the level that he occupies within the structure of his organisation. It was evident during the interviews that the lower one went down the management ladder, the narrower became the view of the person being interviewed. It continued to the point where the traffic manager of the firm could visualise only those interactions which would have an impact on the transportation of the goods and found it difficult to see as important constraints that would affect packaging or warehousing for the firm...."
>
> (Reference: Dicer (56), p.53)

As far as possible, interviews for this research were carried out with managers of comparable position within the companies. Too low a level of management might produce a narrow outlook, as Dicer warns; too high a level of management might mean a lack of knowledge of the operational details so essential for formulating a model that is to aid operational decision making.

The results of the initial survey are summarised by tabulating the answers to 20 specific questions as shown in Appendix A, Exhibit 4.

Major Survey

This consists of a verbally administered questionnaire to the logistics managers of pharmaceutical manufacturers, with questions designed to test the first four research suppositions proposed in the previous chapter.

The details of the major survey are now discussed under two headings: the questionnaire design and interview procedure, and the sample of respondents.

Questionnaire Design and Interview Procedure

The questionnaire is shown as Appendix A, Exhibit 5.

Question numbers one to three ask each manager to consider, in turn, six proposed changes within their company's logistics system. Since these changes are not directed specifically at any particular company's operations, the respondents must interpret them as being hypothetical proposals. The managers were asked to rank those logistics activities, from the listed selections, whose costs are most likely to be affected by the change in question.

Six changes are proposed, each directly related to one activity amongst the total of 42 presented in Table 6.2 of the previous chapter. The six changes are:

Change A: "Using road freight instead of rail for all shipments over 10 lb. weight to customers in North England and Scotland."

Change A directly relates to component logistics activity A1 which corresponds to conversion point number 13a on the materials flow chart as Figure 6.1, Chapter 6.

Change B: "Installation of a shrink wrapping machine on the packaging line for all goods to home customers. Primarily this will reduce packaging labour costs."

Change B directly relates to component logistics activity C2 which corresponds to conversion point number 12 on the materials flow chart of the logistics system (Figure 6.1)

Change C: "Imposing an increased minimum order size of £50 value per order from any customer."

Change C directly relates to component logistics activity E8 which corresponds to conversion point number 11 on the materials flow chart of the logistics system.

Change D: "Decrease by 25% the aggregate inventory levels of product intermediates and bulk products held at all stages of production."

Change D directly relates to component logistics activity F2 which corresponds to conversion point number 6 on the materials flow chart.

Change E: "Decrease by 2 weeks supply the inventory levels of each product in packed form ready for despatch."

Change E directly relates to component logistics activity F3 which corresponds to conversion point numbers 10 and 13b on the materials flow chart.

Change F: "Purchase larger than normal quantities of some raw materials to obtain substantial bulk buying discount terms."

Change F directly relates to component logistics activity H1 which corresponds to conversion point number 1 on the materials flow chart.

These six changes are selected as corresponding to an even spread of conversion points along the materials flow path, and as representing proposals of current concern to logistics management of pharmaceutical manufacturers (Question number 20 of Appendix A Exhibit 4: "Results of the Initial Survey")

The types of utility directly affected by the changed activities are as follows:

Change A (activity A1)	-	Place utility
Change B (activity C2)	-	Form utility
Change C (activity E8)	-	Place utility
Change D (activity F2)	-	Time utility
Change E (activity F3)	-	Time utility
Change F (activity H1)	-	Place utility

Utility changes are obtained from Table 6.3 in Chapter 6.

For each changed activity the total number of remaining logistics activities (41 in each case) are presented to each respondent in three groups corresponding to question numbers 1, 2 and 3. Question 1 represents the first group containing 13 activities which directly affect time utility via their appropriate conversion points (see Tables 6.3 and 6.4, Chapter 6). Question 2 represents the second group containing 25 activities which directly affect place utility via their appropriate conversion points. Question 3 represents the third group containing 5 activities which directly affect form utility via their appropriate conversion points.

Question numbers 4 to 9 ask each manager to consider, in turn, a further six proposed hypothetical changes within their company's logistics system. In question numbers 5, 7 and 9 the managers are asked to rank those logistics activities, from the listed selections, whose timing, duration or schedules are most likely to be affected by the change in question.

Six changes are proposed, each directly related to one activity amongst the total of 42 presented in Table 6.2, Chapter 6. The six changes are:

Change G: "Deciding to service all wholesaler customers in Britain with a scheduled van delivery calling once a fortnight."

Change G directly relates to component logistics activity A2 which corresponds to conversion point number 13b on the materials flow chart of the logistics system, Figure 6.1 in Chapter 6.

Change H: "Deciding to reduce aisle width within the warehouse in order to increase the storage capacity of the existing warehouse without need to expand or build/ rent additional warehouse."

Change H directly relates to component logistics activity B1 which corresponds to conversion point numbers 2, 6 and 10 on the materials flow chart of the logistics system.

Change I: "Deciding to use a public warehouse in the Midlands as an addition to present warehouse capacity at the plant. It will be used for storing finished goods for distribution to home customers."

Change I directly relates to component logistics activity B3 which corresponds to conversion point numbers 2, 6 and 10 on the materials flow chart of the logistics system.

Change J: "Speeding up the order processing operation so that all orders received during a morning are transmitted to the warehouse by 3 p.m. that day. Previously orders would take a whole day to be processed."

Change J directly relates to component logistics activity E4 which corresponds to conversion point number 11 on the materials flow chart of the logistics system.

Change K: "Deciding to begin a long production run of the highest turnover product of the company 2 weeks early due to a seasonal upsurge in demand".

Change K directly relates to component logistics activity G3 which corresponds to conversion point numbers 4b and 8b on the materials flow chart of the logistics system.

Change L: "Deciding to bring forward deliveries of raw materials and components to meet earlier, than originally planned, production schedules."

Change L directly relates to component logistics activity H2 which corresponds to conversion point number 1 on the materials flow chart of the logistics system.

As before, these six changes are selected as corresponding to an even spread of conversion points along the materials flow path, and as representing proposals of current concern to the logistics management of pharmaceutical manufacturers (Question number 20 of Appendix A, Exhibit 4:"Results of the Initial Survey")

The types of utility directly affected by the changed activities are as follows:

Change G (activity A2)	-	Time utility
Change H (activity B1)	-	Time utility
Change I (activity B3)	-	Time utility
Change J (activity E4)	-	Place utility
Change K (activity G3)	-	Time utility
Change L (activity H2)	-	Place utility

These utility changes are obtained from Table 6.3 in Chapter 6.

For each changed activity the total number of remaining logistics activities are presented to each respondent in three groups corresponding to question numbers 5, 7 and 9. Question 5 represents the first group containing 7 activities which directly affect time utility via their appropriate conversion points (from Tables 6.3 and 6.4, Chapter 6). Question 7 represents the second group containing 15 activities which directly affect place utility via their appropriate conversion points. Question 9 represents the third group containing just one activity which directly affects form utility via its conversion point.

Certain of the component logistics activities listed in Table 6.2 of the previous chapter were in Chapter 6 termed decisions which have a direct impact upon the timing and duration of logistics activities, e.g. activity A1, which is a decision made by the transportation department. In terms of time, the decision itself can be made almost instantaneously by one man. However, its impact upon duration of transit time can be very great; there is a big difference in journey times between air and sea freight. On the other hand, activity E1 (preparation and handling of shipping documents) has an actual duration time; it is an operation rather than a decision.

Table 7.1 lists each component logistics activity, appropriate to the type of utility which it directly affects, and denotes whether it constitutes an operation or a decision. In certain cases, the activity can be regarded as being both an operation and a decision, e.g., activity D2: "selecting and operating equipment to handle materials within the warehouse."

With respect to each change in type of utility, two questions are asked in the second section of the questionnaire. The first requests the respondent to identify which of the logistics activities, denoted in Table 7.1 as decisions, might be affected by the change in question. The second then asks him to rank activities, denoted as operations, whose timing,duration or scheduling could be affected as a result of both the change and those decisions identified in the previous question.

In this way, Question 4 is coupled to Question 5, Question 6 to Question 7, and Question 8 to Question 9.

It was realised that a verbal administration of the questionnaire (Appendix A, Exhibit 5) in its entirety, would be too time-consuming. A compromise had to be made whereby some of the comprehensiveness of the survey is sacrificed in order to make it more manageable.

It was decided to put forward each change (A to L) to the respondent and ask him to indicate which departments were likely to be affected by each one. The departments were named on cards and placed in front of the respondent. They are:

Transportation
Order Picking and Packaging
Order Processing and Documentation
Inventory Control
Storage and Warehousing
Materials Handling
Production Scheduling
Purchasing

When identifying a department, the respondent was asked to specifically indicate the affected activities within that department, and finally to rank these activities for each considered change. In this way the respondent could fairly quickly identify the relevant effects without being confronted by as many as 25 possible alternatives for each considered change within each question.

Using the interviewer's format shown in Appendix A, Exhibit 6, the number of overall questions put to each respondent are essentially reduced from 54 (6 changes for each of the 9 questions) down to 12 (the total number of changes).

The time of the formal administration of the questionnaire, in this form, was found to be about 40 minutes.

Time Utility

Component Logistics Activity No.	Operation O	Decision D
A2	O	
B1		D
B3		D
B5	O	D
B6	O	
D2	O	D
E1	O	
E2	O	
E5	O	
F1		D
F2		D
F3		D
G3		D

Place Utility

Component Logistics Activity No.	Operation O	Decision D
A1		D
A3		D
A4		D
A5	O	
A6	O	
A7	O	
A8	O	
A9	O	D
A10		D
A11	O	
A12		D
C1	O	
D1	O	D
D2	O	D
E1	O	
E2	O	
E3	O	
E4	O	
E6	O	
E7	O	
E8		D
G2		D
H1		D
H2		D
H3		D

Form Utility

Component Logistics Activity	Operation O	Decision D
C2		D
C3		D
C4		D
C5	O	
G1		D

Table 7.1: Division Between Operations and Decisions for Activities Directly Affecting Time, Place and Form Utilities

Sample of Respondents

Not all of the 25 companies originally approached in the initial survey were considered suitable as respondents to the final survey since they did not have manufacturing facilities in this country. 16 of these companies were selected for participation in the final survey, all of which did have manufacturing facilities in this country.

It is estimated that 36 pharmaceutical companies registered with the Association of the British Pharmaceutical Industry have substantial manufacturing facilities for producing ethical pharmaceutical products in Britain. This number can be considered to be the population of companies from which the sample of 16 was drawn.

From the results of the initial survey and discussions, it appeared that the companies seemed to differ to quite a large extent on two main characteristics. These are:

a) the extent of their manufacturing and distribution operations;

and b) the extent of imposed limitations on customer groups, e.g. some manufacturers will only accept orders from wholesalers, whilst others will distribute to any recognised customer group.

Tables 7.2 and 7.3 show the comparisons between the sample and the population on the basis of these two characteristics.

From the apparent proportional similarity between the sample and the population it is suggested that a representative sample of pharmaceutical manufacturers was drawn for inclusion in the final survey.

Relative extent of pharmaceutical manufacturers' customer limitation policies in Great Britain		Number of manufacturers	
Relative Grading	Description	Population	Sample
1	Wholesalers only	0	0
2	Wholesalers and large hospitals (or Regional Hospital Auth.)	4	2
3	Wholesalers and all hospitals	6	3
4	Wholesalers, hospitals & selected retailers, or retail buying groups	2	1
5	Wholesalers, hospitals & retailers	24	10
	Totals	36	16

Table 7.2. Relative Extents of Pharmaceutical Manufacturers' Customer Limitation Policies in Great Britain for Population and Sample

Relative extent of pharmaceutical manufacturers' manufacturing and distribution operations in Great Britain		Number of Manufacturers	
Relative Grading	Description	Population	Sample
1	Extensive basic/pharmaceutical production plants in more than one location, with two or three major warehouses.	2	1
2	Extensive basic/pharmaceutical production plants in one location with only pharmaceutical production at other location(s). One or two major warehouses.	4	3
3	Extensive basic/pharmaceutical production plants at one location only, with one or two major warehouses.	8	4
4	Less extensive basic/pharmaceutical production plants at one location only, with only one warehouse.	10	5
5	Extensive pharmaceutical production (only) processes at more than one location, with one or more major warehouses.	7	2
6	Extensive pharmaceutical production (only) processes at only one location, with only one warehouse.	3	1
7	Limited pharmaceutical production at only one location with only one warehouse.	2	0
	Totals	36	16

Table 7.3. Relative Extents of Pharmaceutical Manufacturers' Manufacturing and Distribution Operations in Great Britain for Population and Sample.

5. The Method of Paired Comparisons

The method of ranking, used previously, is considered unsuitable for use in the mailed questionnaires to customers because of the inherent complexity of the resulting questions and required responses. If the alternative selections are presented as sets of pairs, it should be easier for the respondent to answer, even though the number of required responses will increase.

In terms of the levels of the lead time criteria, the method of paired comparisons (described fully by David (52)) is based around the six groups of conditions, as follows:

1. HIGH speed
   MEDIUM consistency
   MEDIUM flexibility

2. MEDIUM speed
   HIGH consistency
   MEDIUM flexibility

3. MEDIUM speed
   MEDIUM consistency
   HIGH flexibility

4. LOW speed
   MEDIUM consistency
   MEDIUM flexibility

5. MEDIUM speed
   LOW consistency
   MEDIUM flexibility

6. MEDIUM speed
   MEDIUM consistency
   LOW flexibility

There are 15* possible pairings amongst the six groups:

1	vs	2	HIGH speed	vs	HIGH consistency*	
1	vs	3	HIGH speed	vs	HIGH flexibility*	
2	vs	3	HIGH consistency	vs	HIGH flexibility*	
1	vs	4	HIGH speed	vs	LOW speed	x
1	vs	5	HIGH speed	vs	LOW consistency	
1	vs	6	HIGH speed	vs	LOW flexibility	
5	vs	6	LOW consistency	vs	LOW flexibility*	
2	vs	4	HIGH consistency	vs	LOW speed	
2	vs	5	HIGH consistency	vs	LOW consistency	x
4	vs	5	LOW speed	vs	LOW consistency*	
3	vs	4	HIGH flexibility	vs	LOW speed	
3	vs	5	HIGH flexibility	vs	LOW consistency	
2	vs	6	HIGH consistency	vs	LOW flexibility	
4	vs	6	LOW speed	vs	LOW flexibility*	
3	vs	6	HIGH flexibility	vs	LOW flexibility	x

Only the comparisons marked* should show any variations in response if the three service criteria are valid components of desired customer service. The others compare either a high level with a low level of one component, or high with medium against low with medium levels of two components, e.g. the fifth pairing of high speed against low consistency can be considered as high speed with medium

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* $n \frac{(n-1)}{2} = 6 \frac{(6-1)}{2} = \frac{6 \times 5}{2} = 15$

consistency against medium speed with low consistency. In this example the former condition, 1, should be preferred.

In recognition of the disparity between high and low levels of one component, the three pairings involved (marked x) are dropped from the questionnaire and dummy preferences are inserted into the analysis.

This leaves 12 comparisons which are included in the customers' questionnaires, as detailed in the following section.

6. Wholesalers Survey

In order to test the research supposition postulated earlier concerning the service preferences of wholesalers, a mailed questionnaire was administered to selected wholesaler respondents.

Questionnaire Design

The questionnaire to pharmaceutical wholesalers is shown as Appendix B, Exhibit 2, and the covering letter enclosed with each questionnaire as Appendix B, Exhibit 1.

In the questionnaire, several of the questions are included in order to obtain general information about the wholesaler respondents: location, type of customers, size, spread of delivery service, type of service received from manufacturers.

The primary aim of this questionnaire, with respect to testing the research supposition, is to investigate the wholesalers' preferences for alternative levels of distribution service.

In Question 9, the respondent is asked to consider the distribution service offered by each of six hypothetical manufacturers, A to F. The levels of distribution service are chosen to represent a balance between lead time consistency, lead time duration and lead time flexibility. The levels of each characteristic are graded as being high, medium or low according to the reference of the previous section describing the method of paired comparisons.

The respondent is asked to make twelve preferences between each of the paired comparisons.

Sample of Respondents

The total number of member firms registered with the National Association of Pharmaceutical Distributors is 16 (127). Many of these members are branches of one of the five main wholesaler chains operating in different regions of Great Britain.

In order to select a representative sample of possible respondents from this population, it was decided to select every other company (including branches) from the members list of the N.A.P.D. (127), excluding one of the major wholesaler chains who had refused to cooperate.

A total of 74 wholesaler companies were sent the mailed questionnaire with a covering letter. A further copy of the questionnaire with a reminder letter (Appendix B Exhibit 5) was sent to any initial non-respondent. The correspondence was all addressed to "The Manager".

A telephone interview survey of a number of the outstanding non-respondents was later made in order to assess any measure of bias between the respondents and the non-respondents.

The questionnaire was initially piloted to managers of three wholesaler companies by means of a verbal administration. Their comments enabled the questionnaire to be modified slightly into the final design ready for sending to the remaining companies.

7. Hospital Pharmacists Survey

In order to test the research supposition postulated earlier concerning the service preferences of hospital pharmacists, a mailed questionnaire was administered to selected hospital pharmacist respondents.

Questionnaire Design

The questionnaire to hospital pharmacists is shown as Appendix B, Exhibit 3, and the covering letter enclosed with each questionnaire as Appendix B, Exhibit 1.

In the questionnaire, several of the questions are included in order to obtain general information about the hospital pharmacist respondents: proportion of items on contract, buying patterns, ordering frequency, speed of delivery service received from wholesalers.

The primary aim of this questionnaire, with respect to testing the research supposition, is to investigate the hospital pharmacists' preferences for alternative levels of distribution service.

In Question 6, the respondent is asked to consider the distribution service offered by each of six hypothetical wholesalers, A to F. In Question 7, the respondent is likewise asked to consider the distribution service offered by each of six hypothetical manufacturers, 1 to 6.

The levels of distribution service are chosen to represent a balance between lead time consistency, lead time duration and lead time flexibility. The levels of each characteristic are graded as being high, medium or low according to the reference of the earlier section describing the method of paired comparisons.

In each of Questions 6 and 7, the respondent is asked to make twelve preferences between paired comparisons.

Sample of Respondents

In order to select a representative sample of possible respondents from the hospital pharmacist population in Great Britain, it was decided to select one hospital from every other District Health Authority listed in The Hospitals Year Book 1975 (91). Several District Health Authorities usually come under one Area Health Authority which in turn is part of a Regional Health Authority. The reorganisation of the National Health Service in England was previously shown as Figure 5.3.

For Scotland, Wales and Northern Ireland, one hospital was selected from every other Area Health Authority which approximately corresponds to the District Health Authority of England. Again, these are listed in the Hospitals Year Book 1975 (91).

Several hospitals are usually listed as belonging to each District or Area Health Authority. The one with the largest number of beds was selected in each case, excluding those hospitals for the treatment of mental illness. This basis ensures that the chosen hospitals are large enough to possess a hospital pharmacy.

A total of 138 hospital pharmacists were sent the mailed questionnaire with a covering letter. A further copy of the questionnaire with a reminder letter (Appendix B, Exhibit 5) was sent to all initial non-respondents. The correspondence was addressed to "The Principal Pharmacist" of each selected hospital.

A telephone interview survey of a number of the outstanding non-respondents was later made in order to assess any measure of bias between the respondents and the non-respondents.

The use of the Hospitals Year Book, and the listed hospitals for each Regional/Area/District Health Authority, as a basis for selecting hospitals should provide for a fairly even distribution of respondents in correspondence to the density of population across the country.

The questionnaire was initially piloted to the first twenty possible respondents on a postal basis. Their response and comments enabled the questionnaire to be modified slightly into the final design ready for sending to the remaining pharmacists.

8. Retail Chemists Survey

In order to test the research supposition postulated earlier concerning the service preferences of retail chemists, a mailed questionnaire was administered to selected retailers.

Questionnaire Design

The questionnaire to retail chemists is shown as Appendix B, Exhibit 4, and the covering letter enclosed with each questionnaire as Appendix B, Exhibit 1.

In the questionnaire, several of the questions are included in order to obtain general information about the retail chemist respondents: delivery service received from wholesalers, ordering practice with respect to purchases from wholesalers and manufacturers, size of business.

The primary aim of this questionnaire, with respect to testing the research supposition, is to investigate the retail chemists' preferences for alternative levels of distribution service.

In Question 4, the respondent is asked to consider the distribution service offered by each of six hypothetical wholesalers, A to F. In Question 9, the respondent is likewise asked to consider the distribution service offered by each of six hypothetical manufacturers, 1 to 6.

The levels of distribution service are chosen to represent a balance between lead time consistency, lead time duration and lead time flexibility. The levels of each characteristic are graded as being high, medium or low according to the reference of the earlier section describing the method of paired comparisons.

In each of Questions 4 and 9, the respondent is asked to make twelve preferences between paired comparisons.

Sample of Respondents

In order to select a representative sample of possible respondents from the retail chemist population in Great Britain, it was decided to make the selections using the "Yellow Pages" of the Telephone Directories under the heading "Chemists, Dispensing". Using the Yellow Pages ensures that a fairly representative sample is obtained across the whole of the country in proportion to the density of population.

The method of selection was as follows: first, the total number of retail chemists listed in the Yellow Pages was estimated. In this case the estimate was 13,040. It was decided to send questionnaires to about 200 respondents. To ensure a proportional representation, every 13,040 ÷ 200 = 65th name was chosen as listed in the Yellow Pages of Telephone Directories numbers 101 to 304.

A total of 207 retail chemists were sent the mailed questionnaire with a covering letter. A further copy of the questionnaire with a reminder letter (Appendix B, Exhibit 5) was sent to all initial non-respondents. The correspondence was addressed to "The Manager" of each selected retailer.

A telephone interview survey of a number of the outstanding non-respondents was later made in order to assess any measure of bias between the respondents and the non-respondents.

The questionnaire was initially piloted to two retail chemists on a verbal basis. Then it was piloted by mailing to the first twenty respondents. Their response and comments enabled the questionnaire to the modified slightly into the final design ready for sending to the remaining chemists.

Boots are by far the largest retail organisation for pharmaceuticals in Britain. They account for more than 10% of all individual outlets. They are supplied in the main by their own wholesaler, and manufacturing, network. Their managers are, however, allowed a certain latitude in obtaining goods either directly from other manufacturers or from local wholesalers.

22 of the selected 207 retail chemists are Boots outlets.

9. Doctors Survey

In order to investigate the effects of stockouts upon sales revenue, a mailed questionnaire was sent out to selected doctors.

Questionnaire Design

The questionnaire to doctors is shown as Appendix C, Exhibit 2, and the covering letter enclosed with each questionnaire as Appendix C, Exhibit 1.

The primary aim of this questionnaire is to investigate the doctors' prescribing practices in the face of a stock out situation for four product categories:

a) Specialist medicines with very few comparable substitutes, urgently required for patient's welfare.

b) Specialist medicines with very few comparable substitutes, although the patient's health will not suffer if he waits until the next day for his medicine.

c) Medicines with many comparable substitutes, urgently required for patient's welfare.

d) Medicines with many comparable substitutes, where the patient's health will not suffer if he waits until the next day for his medicine.

Sample of Respondents

In order to select a representative sample of possible respondents from the population of doctors in Great Britain, it was decided to again make the selections using the "Yellow Pages" of the Telephone Directories under the heading "Physicians and Surgeons". Using the Yellow Pages ensures that a fairly representative sample is obtained across the whole of the country in proportion to the density of population.

The method of selection is similar to that used for retail chemists. Again a desired number of 200 recipients, divided into the estimated total number of doctors, 24,000, resulted in every 120th.name being chosen.

A total of 201 doctors were sent the mailed questionnaire with a covering letter. These included doctors and consultants working both in general practice and in hospitals.

Summary

In recognising that the empirical research design should primarily suit the research objectives, these were restated in terms of the earlier proposed research suppositions.

A classification of the empirical research techniques from the literature was next made on the basis of whether they are reactive or non-reactive, structured or unstructured, direct or indirect. Some researchers' empirical research designs were reviewed as examples of their placing in these classifications. Five categories of reactive research technique were identified: depth interviews, case studies, interviews with specific questions, verbally administered questionnaires, and mailed questionnaires.

In the context of this research work, an empirical research design was proposed for surveying pharmaceutical manufacturers, pharmaceutical wholesalers, retail chemists, hospital pharmacists and doctors. This overall research plan was essentially based upon the consideration of five factors, that represent practical constraints.

The manufacturers survey was carried out in two stages: initial and final.

The initial survey of 25 manufacturers was mainly concerned with identifying component logistics activities, ascertaining service levels to customers, as well as gaining general background information on the companies' operations.

The final survey consisted of a verbally administered questionnaire to the logistics managers of 16 of the pharmaceutical manufacturers. The questions asked the managers to consider a number of proposed changes to the logistics operations of their companies, and to select and rank those logistics activities which they thought would be most affected by the change in question. Their responses are intended to test the first four research suppositions postulated in the previous chapter.

The surveys to wholesalers, hospital pharmacists and retail chemists are all of the mailed questionnaire type. Their primary aim is to test the final three research suppositions concerned with the service preferences of each of these customer types. The method of paired comparisons was used as a basis for assessing the preferences of each respondent with respect to three service criteria: lead time consistency, lead time duration, and lead time flexibility.

In all three surveys, reminders were sent to each initial non-respondent, and a telephone interview carried out on a number of outstanding non-respondents with the intention of assessing any bias between non-respondents and respondents.

The chosen samples consisted of 74 wholesalers, 138 hospital pharmacists and 207 retail chemists.

The survey to doctors, also a mailed questionnaire, is aimed at primarily assessing the doctors' "brand loyalties" in the event of a stock-out situation. Ethical pharmaceutical products are categorised into four groups for this purpose. A total of 201 doctors, both hospital and general practice, were selected as recipients of the mailed questionnaire.

In this chapter the empirical research designs were discussed in terms of the following: the detailed questionnaire designs, the means of administeration and interview procedures, the generation of the samples of each category of respondents from their total populations.

The empirical research designs were justified by reference to classifications presented in the literature, to the research objectives and to practical constraints and conditions imposed by both the investigator and the potential respondents.

The next chapter will analyse the responses from each of the surveys, primarily with respect to testing the research suppositions.

The methods of analysis will be detailed and justified as being appropriate both to the type of data obtained and to its intended interpretation.

Chapter 8

Analysis of the Results

Introduction

In selecting a systems approach to analyse the logistics system of a pharmaceutical manufacturer, certain research suppositions were proposed in Chapter 6. The object of these was to act as heuristics in simplifying the analysis by reducing the number of interactions under consideration.

In order to assess the validity of these research suppositions, and to provide information on both the manufacturer's logistics system and the distribution channels to his customers, an empirical research design was formulated in Chapter 7. This essentially consists of a verbally-administered questionnaire to logistics managers of pharmaceutical manufacturers, and a mailed questionnaire to pharmaceutical wholesalers, retail chemists, hospital pharmacists and doctors. Random selections of recipients were picked to ensure as representative a sample as possible across Great Britain, with respect to geographical location and the density of the population therein.

This chapter is intended to aggregate the responses from each category of respondents, and to analyse the answers to certain questions so as to assess the measure of support given to each of the research suppositions. Although any such empirical evidence, obtained from such a restricted survey as this, cannot be expected conclusively to prove or disprove these suppositions, the results will at least be indicative of the merits of the selected heuristics developed in this logistics system analysis.

The method of analysis will be selected to convert the ordinal data of ranked and paired comparison responses into interval scales, which will be compared in turn to the corresponding research suppositions.

In the cases of the wholesalers, chemists and pharmacists, the results of a survey amongst non-respondents will be given in order to assess any difference between their responses, obtained through telephone interviews, and the written responses of earlier respondents.

1. Analysis of Pharmaceutical Manufacturers Responses

A two stage survey of pharmaceutical manufacturers was carried out, as described in Chapter 7. The analysis of the results obtained from each stage are now set down as follows.

Initial Survey:

This consisted of semi-structured personal interviews with logistics managers of pharmaceutical manufacturing companies. Its objectives can be summarised as finding out general operating information, identifying the logistics activities and ascertaining levels of customer service.

The results of the initial survey are tabulated as Exhibit 4 in Appendix A. These aggregated summaries of the responses are in accordance with the list of types of information required that is presented as Exhibit 3 in Appendix A.

Replies to the first six questions are tabulated primarily to indicate the size, international involvement and marketing practices of the 25 pharmaceutical companies who were interviewed. From the results it can be seen that the majority of companies are multinationals, have manufacturing facilities in Britain which export to world markets, market more than 20 pharmaceutical product lines, and have diversified interests in other types of products.

The answers to the remaining questions are mostly of use in the compilation of questionnaires for the later surveys amongst manufacturers and their customers. The tabulated response to question number 8 shows that about half of the manufacturers place no restrictions on their number of accounts, whilst the other half do so to varying degrees, though only one company was distributing solely through wholesalers.

Major Survey:

This consisted of a verbally administered questionnaire to the logistics managers of pharmaceutical manufacturing companies, with questions designed to enable a comparison to be made of the responses with the first four research suppositions proposed in Chapter 6.

The results of the major survey are tabulated as Exhibit 7 in Appendix A. These are the aggregated responses to each of the questions, requesting rankings, that are included in the questionnaire (shown as Exhibit 5 in Appendix A).

The Method of Analysis:

The tabulated responses (Appendix A, Exhibit 7) are in the form known as "ordinal" data, which implies a ranking of alternatives in terms of their possession of the attribute under study (59). In this case the attribute is a measure of relative preference.

It is not possible to deduce from ordinal data the difference in preference between ranks, e.g., whether the difference between ranks 1 and 2 is the same as that between ranks 2 and 3. The data would have to be scaled as "interval" data if the distance between rankings is to be measured.

Fortunately it is possible to generate an interval scale from ranked data. Elliott and Christopher (59) illustrate the use of the method. It essentially converts the results, as presented in the form of a "proportion matrix", into a "Z-matrix", where Z is the deviation of observed values from the population mean (μ_0) when the standard deviation (σ) = 1.

Conversion of the ordinal data into interval scales should aid the testing of the research suppositions. The interval scale will show the location of each alternative and its relative distance from other alternatives. The zero point and the unit of measurement along an interval scale are arbitrarily fixed.

The aggregated rankings can first be converted into a proportion matrix by computing "p" values from the following formula,

$$p = \frac{\Sigma fR - 0.5N}{nN}$$

where f is the frequency of allocation of a rank to an activity (cell entries in the f-matrix). N is the number of respondents and n is the number of activities.

Each cell entry is multiplied by the corresponding R value to produce the fR matrix *. The fR values are summed, for each activity, to give fR and then the p values are obtained by using the previous formula.

---

* It will be noted that not all respondents have entered activities against each ranking. The R value for all non-responses is taken to be O, thus recognising the significance of a non-response by keeping N constant for each activity, but resulting in equivalent fR values of zero.

Z values are obtained from these p values using a table such as in Siegel (152), page 247.

Finally the Z values are rescaled by giving the lowest value a score of .000 and adjusting the others accordingly.

For instance the above procedure is illustrated by reference to Table 8.1 where the responses to Question 1 Change A are analysed.

N = 16 n = 13

	Activity Rank	R	A2	B1	B3	B5	B6	D2	E1	E2	E5	F1	F2	F3	G3
f-matrix	1	5	12						1						
	2	4		1	2				2						
	3	3		1				2	1						
	4	2		1			1							1	
	5	1				1									
fR-matrix			60						5						
				4	8				8						
				3				6	3						
				2			2							2	
						1									
Σ fR			60	9	8	1	2	6	16					2	
Σ fR-0.5N			52	1	0	0	0	0	8					0	
p			.250	.005					.0385						
z			-.674	-2.575					-1.774						
+2.575			1.901	0					.801						

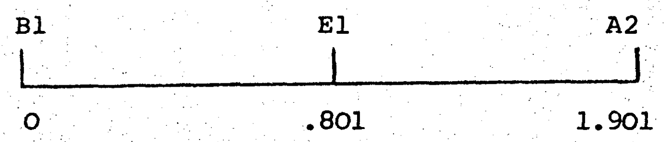
Table 8.1: Analysis to Derive Interval Scale from Ordinal Data Responses to Question 1 Change A in Manufacturers Major Survey.

The cell entries in the *f*-matrix only represent "positive" responses, i.e., the numbers of respondents who consider that an activity will be affected by a particular change. Since all respondents were able to rank as many affected activities as they wished, then those which were not identified can be considered as "negative" responses, and be assigned a value of R = O.

Therefore, in Table 8.1, activity A2 exhibits 12 positive responses (R = 5) and (N - 12 =) 4 negative responses (R = O); activity B1 exhibits 3 positive responses (R = 4, 3 and 2) and (N - 3 =) 13 negative responses (R = O); activity B3 exhibits 2 positive responses (R = 4) and (N - 2 =) 14 negative responses (R = O); etc.

N is therefore constant for each activity, and results in the exclusion of certain low response activities (e.g., activities B3, B5, B6, D2 and F3 in the case of Table 8.1) when $0.5N \geqslant \sum fR$.

From the last line in Table 8.1 can be drawn the following interval scale, where the zero point and unit of measurement are arbitrarily fixed.



In percentages the scale values become:

A2	70.4%
E1	29.6%
B1	O

The same method of analysis can be applied to each of the remaining 30 sets of responses in Exhibit 7, Appendix A. The tabular workings and resulting interval scales are presented as Exhibits 8 and 9, respectively, in Appendix A.

<u>Comparison with Research Suppositions:</u>

Four research suppositions were put forward in Chapter 6 with respect to the importance of a logistics activity's position on the material flow chart relative to that of a changed activity. These suppositions referred to both cost and time effects incurred as material flows through the logistics system.

It is now intended to compare the interval scales, previously derived, with the implications of each research supposition.

A convenient means of representing these implications is provided by a 'ring diagram' of the type shown in Figure 8.1. This is a representation of logistics activities' relative distances from the changed activity on the materials flow path, constructed earlier in Chapter 6. The case illustrated by Figure 8.1 is that for Question 1 Change A.

The centre segment of the ring diagram signifies the position of the changed activity (in this case, A1). The ring closest to the centre represents those activities which correspond to the same conversion point as the changed activity (in this case, conversion point 13 on the materials flow path corresponding to activities A2, B5, B6, E1, E2, E5 and F3, obtained from Table 6.4). These activities are termed 'coincident'.

Continuing outwards from the centre of the ring diagram the rings correspond respectively to 'once-removed' activities, 'twice-removed' activities (in this case, D2), 'three times-removed' activities (in this case B1, B3 and F1), 'four times-removed', 'five times-removed' (in this case, G3), 'six times-removed', 'seven times-removed' (in this case, F2), etc.

Ring diagrams, similar to that in Figure 8.1, have been drawn for each of the other 35 sets of manufacturers' responses (besides those for Question 1 Change A). These are shown as part of Appendix A, Exhibit 10.

The procedure for comparing each ring diagram with its appropriate interval scale is now illustrated by considering the case of Question 1, Change A. The previously derived interval scale for this case showed two activities as having numerable interactions with the changed activity, A1. These activities are A2 (70.4%) and E1 (29.6%). In Figure 8.1 both of these activities are portrayed as being within the closest ring to the centre segment, i.e., they are both coincident.

If the logistics system analysis were to only consider those activities that are coincident (A2, B5, B6, E1, E2, E5 and F3) then only seven activities would be included instead of the thirteen contained in total by Figure 8.1. In this case the activities indicated by the interval scale (A2 and E1) as having important interactive effects with the changed activity (A1) would be included with 100% representation. The complexity of the logistics analysis is reduced by considering only this restricted number of activities, yet not at the expense of discounting activities which might exhibit important interactive effects on cost, in this case, with the changed activity.

These comparisons are continued for each of the other 30 sets of manufacturers' responses and the results are shown in Appendix A, Exhibit 10. Table 8.2 represents a summary of these comparisons.

Table 8.2 is divided into four sections which correspond, in turn, to the four research suppositions earlier proposed in Chapter 6.

In addition, two lines of results are presented for each case: the first is appropriate to considering only activities within the nearest possible ring to the centre in the ring diagram, the second to both the nearest and the next to nearest possible rings.

For instance, in taking the previously illustrated case of Question 1 Change A, there is a reduction in the number of activities to be included from 13 down to 7 (7/13 = 53.9%, when considering only coincident activities. As noted before, the activities with values on the interval scale (A2 and E1) are both included amongst the seven coincident activities. Therefore there is a 100% inclusion of scale values, and a difference between this and the % inclusion of activities of +46.1% (100% - 53.9% = +46.1%). This means that no relevant activities have been excluded despite a reduction to 53.9% of the number of total possible activities.

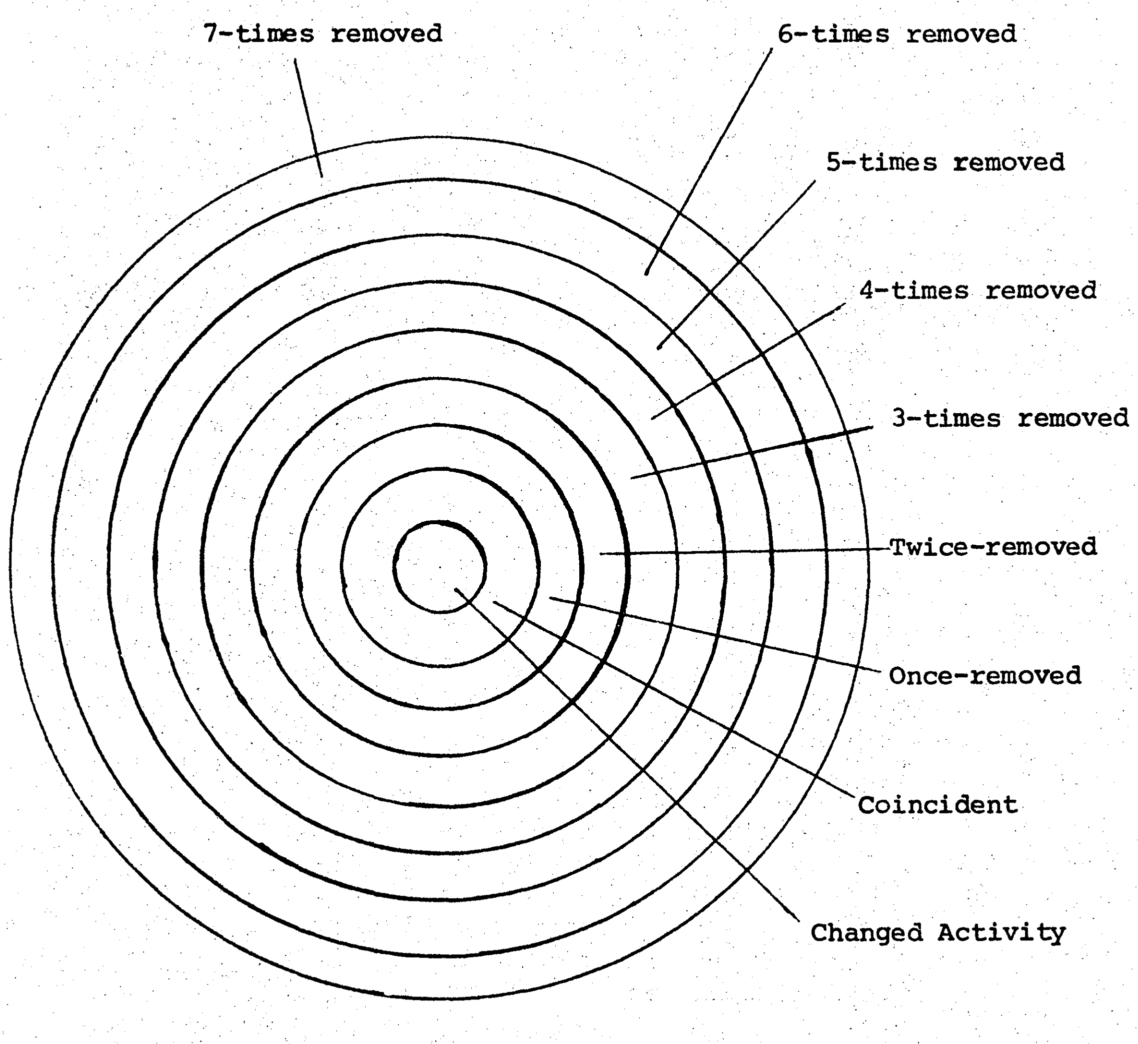


Figure 8.1: Representation of Logistics Activities' Relative Distances from the Changed Activity on the Materials Flow Path. A Ring Diagram for the Case of Question 1 Change A.

	Question	Change	Number of Possible Activities	Reduced Number of Activities	% Inclusion of Activities (a)	% Inclusion of Scale Values (b)	% Difference (b) - (a)	Number of Activities Included	Activities Excluded
Section 1	1	D	12	6	50	39.5	-10.5	3	F1,F3,G3
				7	58.3	77.1	+18.8	4	F1,F3
	1	E	12	9	75	36.8	-38.2	4	F1,F2,G3
				10	83.3	74.0	-9.3	5	F1,F2
	2	A	24	14	58.3	88.3	+30.0	6	E4,E8
				19	79.2	100.0	+21.8	8	-
	2	C	24	5	20.8	39.5	+18.7	5	A1,A3,A4,A6, A9,A11,A12,E1 H1
				20	83.3	97.2	+13.9	12	H1
	2	F	24	3	12.5	40	+27.5	2	D2
				4	16.7	100	+83.3	3	-
	3	B	4	2	50	100	+50	2	-
				4	100	100	-	4	-
Section 2	1	A	13	7	53.9	100	+46.1	2	-
				8	61.6	100	+38.4	2	-
	1	B	13	8	61.6	60.3	-1.3	3	B1,F1,G3
				11	84.6	96.5	+11.9	5	G3
	1	C	13	1	7.7	11.5	+3.8	1	A2,E1,E5,F3
				7	53.9	45.6	-8.3	3	A2,E1

	Question	Change	Number of Possible Activities	Reduced Number of Activities	% Inclusion of Activities (a)	% Inclusion of Scale Values (b)	% Difference (b) - (a)	Number of Activities Included	Activities Excluded
	1	F	13	7	53.9	100.0	+46.1	4	-
				8	61.6	100.0	+38.4	4	-
	2	B	25	20	80.0	90.5	+10.5	7	H1,H3
				24	96.0	100.0	+4.0	9	-
	2	D	25	1	4.0	13.7	+9.7	1	D1,E4,E7,G2 H1,H2
				2	8.0	28.3	+19.7	2	E4,E7,G2,H1, H2
	2	E	25	16	64.0	29.2	-34.8	3	C1,D1,E4,G2 H1,H2,H3
Section 2 continued				20	80.0	45.6	-34.4	5	C1,G2,H1,H2 H3
	3	A	5	3	60.0	*			
				5	100.0	*			
	3	C	5	3	60.0	100.0	+40.0	1	-
				5	100.0	100.0	-	1	-
	3	D	5	2	40.0	*			
				5	100.0	*			
	3	E	5	3	60.0	*			
				5	100.0	*			
	3	F	5	4	80.0	*			
				5	100.0	*			

	Question	Change	Number of Possible Activities	Reduced Number of Activities	% Inclusion of Activities (a)	% Inclusion of Scale Values (b)	% Difference (b) - (a)	Number of Activities Included	Activities Excluded
	5	G	6	5	83.3	100.0	+16.7	2	-
				6	100.0	100.0	-	2	-
	5	H	7	4 **	57.2	100.0	+42.8	1	-
	5	I	7	4 **	57.2	88.1	+30.9	4	A2
Section 3	5	K	7	1	14.3	-	-14.3	-	B6,D2
				4	57.2	100.0	+42.8	2	-
	7	J	14	4	28.6	49.5	+20.9	3	A5,A6,A9,E1 E2
				13	92.8	100.0	+7.2	8	-
	7	L	15	1	6.7	-	-6.7	-	D2
				2	13.3	100.0	+86.2	1	-
	5	J	7	3 **	42.8	80.9	+38.1	3	D2
	5	L	7	4 **	57.2	100.0	+42.8	2	-
Section 4	7	G	15	10	66.7	67.7	+1.0	7	C1,D2,E4
				14	93.3	100.0	+6.7	10	-
	7	H	15	1	6.7	72.0	+65.3	1	C1
				2	13.3	72.0	+58.7	2	-

	Question	Change	Number of Possible Activities	Reduced Number of Activities	% Inclusion of Activities (a)	% Inclusion of Scale Values (b)	% Difference (b) - (a)	Number of Activities Included	Activities Excluded
	7	I	15	1	6.7	28.4	+21.7	1	A5,A6,A8,A9 A11,C1,D1,E1
				2	13.3	47.8	+34.5	2	A5,A6,A8,A9 A11,C1,E1
	7	K	15	1	6.7	46.6	+39.9	1	D2
				2	13.3	100.0	+86.7	2	-
Section 4 continued	9	G	1	*					
	9	H	1	*					
	9	I	1	*					
	9	J	1	*					
	9	K	1	*					
	9	L	1	*					

Table 8.2: Tabulated Summary of the Comparisons Made Between Manufacturers' Responses and the Research Suppositions.

* Those cases where there has been an insufficient response for an interval scale to be drawn. One activity pre-dominant. However, for Question 9, Changes G - L, only one activity,C5,is under consideration anyway. A summary of the results in these cases is shown in Table 8.3.

** The two cases where the next closest ring of activities does not exist due to all the remaining activities being outside the customer lead time square (Question 5, Change J) or outside the stock building sequence (Question 5, Change L).

Question	Change	Is the Predominant Activity within the closest segment to the changed activity?
3	A	Yes
3	D	Yes
3	E	No
3	F	Insufficient Response
3	G	Yes

		Is activity C5 in the close vicinity of the changed activity?	Have the majority of respondents indicated activity C5?
9	G	Yes	Yes (73.3%)
9	H	No	No (46.7%)
9	I	No	No (26.7%)
9	J	Yes	Yes (73.3%)
9	K	No	No (26.7%)
9	L	No	No (20.0%)

Table 8.3: Tabulated Summary of the Comparisons Made Between Manufacturers' Responses and the Research Suppositions in Cases where an Interval Scale could not be drawn.

Looking at the second line of results for the same case, and now considering both the nearest and the next-to-nearest rings to the centre of Figure 8.1 (equivalent to coincident and twice-removed activities in this case) the number of activities are reduced from 13 down to 8 (8/13 = 61.6%). However both activities, A2 and E1 (those with values on the interval scale) are included in this number. Therefore there is again a 100% inclusion of scale values, with a difference this time of +38.4% (100% - 61.6% = +38.4%). Hence no relevant activities have been excluded despite a reduction to 61.6% of the number of total possible activities.

Obviously for this particular case, extending the research supposition to include activities within two rings instead of only the closest, has not gained any advantage since there was already a 100% inclusion of scale values. However this is not always so. Table 8.2 shows cases where the % difference value has positively increased as a result of extending the research supposition, e.g., Question 1 Change D, Question 2 Change F.

Table 8.3 summarises the results of comparisons in those cases where an interval scale could not previously be drawn, when one activity dominated the response and in Question 9 when only one activity was under consideration.

2. Analysis of Customers' Responses

Questionnaires were mailed to samples of each of the three main categories of customers: pharmaceutical wholesalers, hospital pharmacists and retail chemists. The questionnaire designs and the generation of each of the samples were discussed in Chapter 7.

The responses from each customer category are tabulated in Appendix B as Exhibit 6 (pharmaceutical wholesalers), Exhibit 7 (hospital pharmacists) and Exhibit 8 (retail chemists).

The Method of Analysis:

The paired comparison responses (corresponding to Question 9 in Exhibit 6, Questions 6 and 7 in Exhibit 7, and Questions 4 and 9 in Exhibit 8) are presented as matrices. These are still ordinal data as were the ranked responses of the manufacturers.

It is possible to generate an interval scale from paired comparison data using a method taken from Elliott and Christopher (59) and similar to that used previously on ranked data.

Each paired comparison matrix can first be converted into a proportion matrix by dividing each cell entry by N (the number of respondents).

The proportion matrix is then converted into a "Z-matrix", using a "Z-value table" as before.

The column sums of the Z-matrix, and their means (calculated by dividing by n = number of alternatives) are then found.

Finally the resulting values are rescaled by giving the lowest value a score of .000 and correcting the others accordingly.

As an example this procedure is illustrated by reference to Table 8.4 where the wholesalers' responses to Question 9 are analysed.

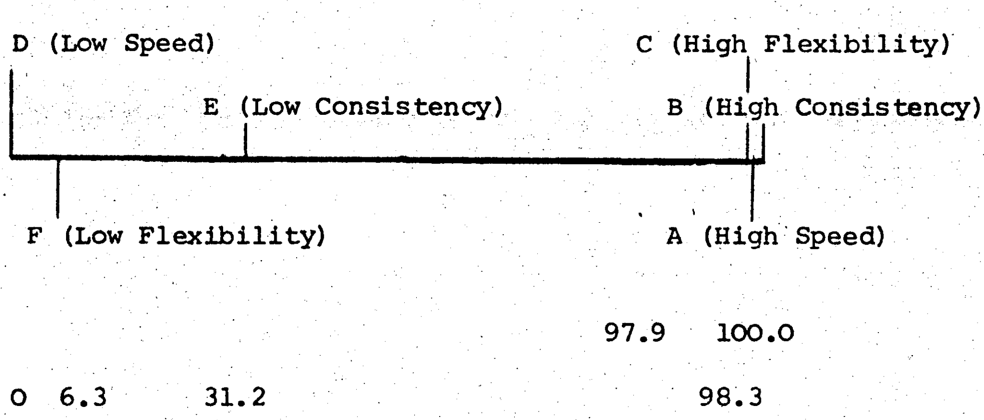
(Question 9: "I would like you to consider the situation of there being six manufacturers, (A, B, C, D, E and F) from whom you buy ethical medicines. I would like you to express your preferences between these six hypothetical manufacturers by considering each pair in turn. For the pairs listed below please mark the letter of the preferred manufacturer in the adjacent box".)

	Alternative Manufacturers	A	B	C	D	E	F
	A	.5	.632	.210	0	.053	0
	B	.369	.5	.316	0	0	.053
p-matrix	C	.789	.684	.5	0	0	0
	D	1.0	1.0	1.0	.5	.948	.421
	E	.948	1.0	1.0	.053	.5	.053
	F	1.0	.948	1.0	.579	.948	.5

		A	B	C	D	E	F
	A	.000	.336	-.807	-3.300	-1.617	-3.300
	B	-.334	.000	-.479	-3.300	-3.300	-1.617
Z-matrix	C	.803	.479	.000	-3.300	-3.300	-3.300
	D	3.300	3.300	3.300	.000	1.617	-.200
	E	1.617	3.300	3.300	-1.617	.000	-1.617
	F	3.300	1.617	3.300	.200	1.617	.000
Σ	=	8.686	9.032	8.614	-11.317	-4.983	-10.034
Mean	=	1.448	1.505	1.436	-1.886	-.831	-1.672
+1.886	=	3.334	3.391	3.322	0	1.055	.214
Nominal Scale Value (Range 0 - 100)		98.3	100.0	97.9	0	31.2	6.3

Table 8.4: Analysis to Derive Interval Scale from Ordinal Data Responses to Question 8 in Wholesalers Questionnaire.

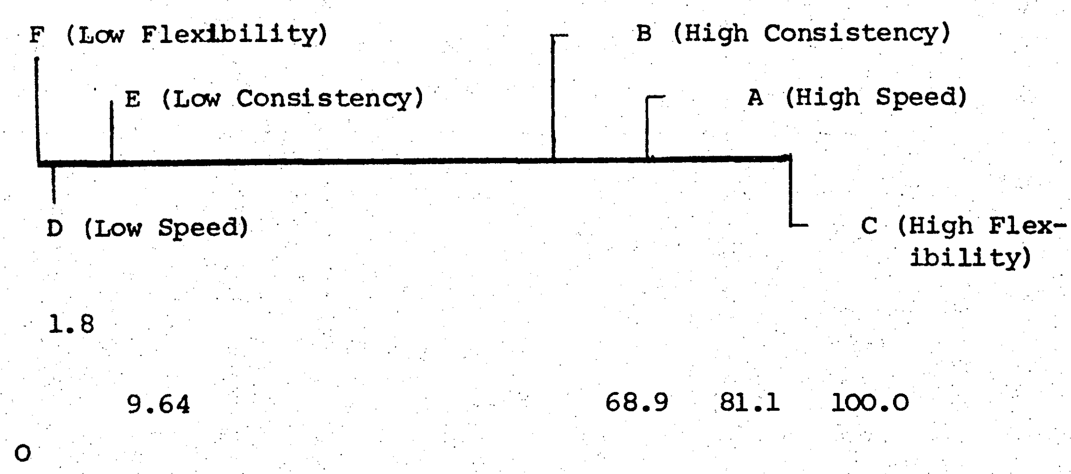
The last line of figures in Table 8.4 have been directly derived from the preceding line by scaling up to conform to a 0 - 100 range. The following interval scale may be constructed from these figures.



The same method of analysis can be applied to each of the other paired comparison responses for the customer groups of hospital pharmacists and retail chemists. The tabular workings are presented as Appendix B, Exhibit 9, from which the following interval scales may be drawn.

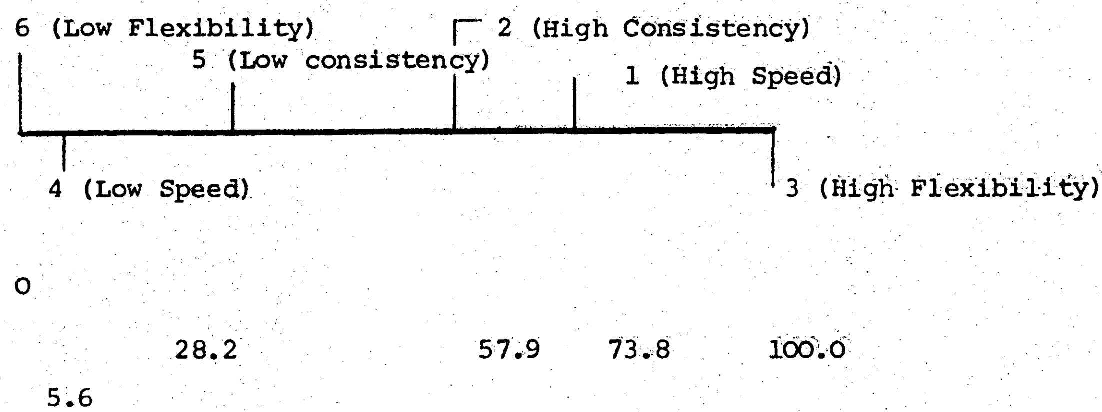
<u>Hospital Pharmacists - Distribution from Wholesalers</u>

(Question 6: "I would like you to consider the situation of there being six wholesalers (A, B, C, D, E and F) from whom you could purchase most of your ethical medicines. Assume that they each offer the same discount terms. I would like you to express your preferences between these six hypothetical wholesalers by considering each pair of wholesalers in turn. For the pairs listed below please mark the letter of the preferred wholesaler in the adjacent box.")



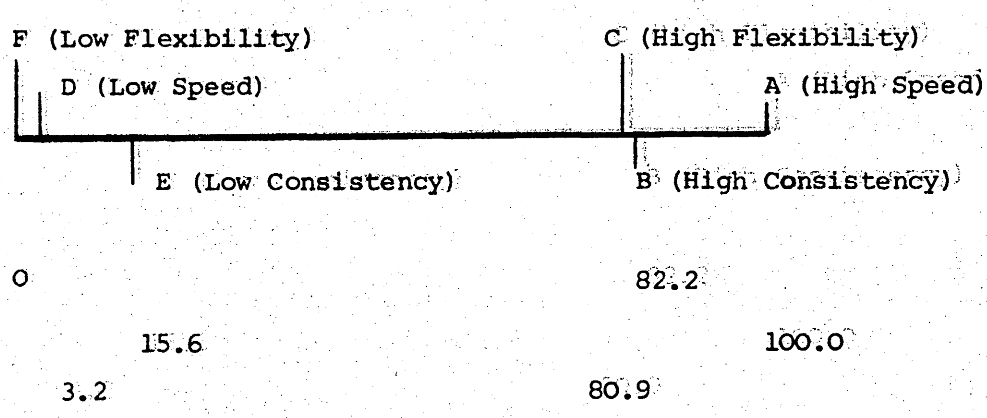
Hospital Pharmacists - Distribution from Manufacturers

(Question 7: "I would like you to consider the situation of there being six manufacturers (1, 2, 3, 4, 5 and 6) from whom you could purchase ethical medicines direct. Assume that they each offer the same discount terms. I would like you to express your preferences between these six hypothetical manufacturers by considering each pair in turn. For the pairs listed below please mark the number of the preferred manufacturer in the adjacent box.")



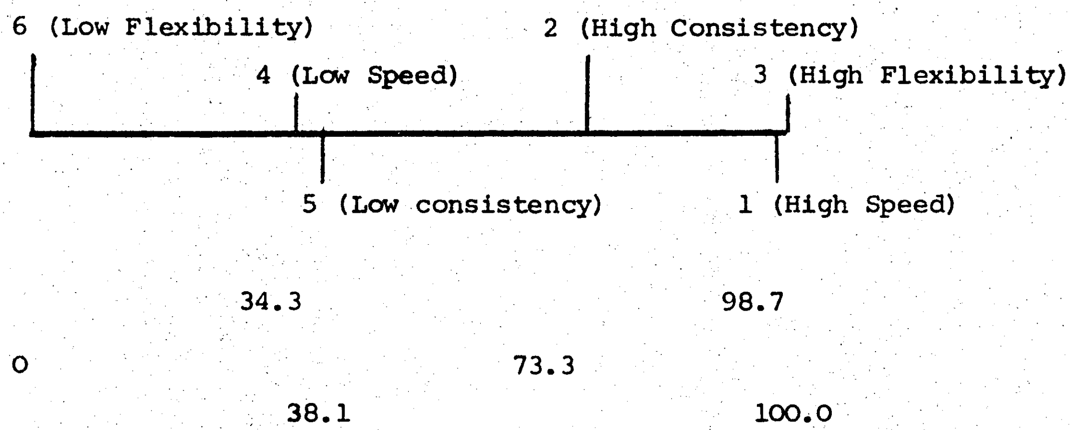
Retail Chemists - Distribution from Wholesalers

(Question 4: "I would like you to consider the situation of there being six wholesalers (A, B, C, D, E and F) from whom you could purchase most of your ethical medicines. Assume that they each offer the same discount terms. I would like you to express your preferences between these six hypothetical wholesalers by considering each pair of wholesalers in turn. For the pairs listed below please mark the letter of the preferred wholesaler in the adjacent box.")



Retail Chemists - Distribution from Manufacturers

(Question 9: "I would like you to consider the situation of there being six manufacturers (1, 2, 3, 4, 5 and 6) from whom you could purchase ethical medicines direct. Assume that they each offer the same discount terms. I would like you to express your preferences between these six hypothetical manufacturers by considering each pair in turn. For the pairs listed below please mark the number of the preferred manufacturer in the adjacent box.")



Survey of Non-Respondents:

As stated previously a survey of a number of the non-respondents in any sample is necessary to ensure that the respondents' answers are not biased.

Over the telephone several customers were asked to respond to the paired comparison questions contained in their appropriate questionnaires. However, it proved impossible to extract a complete set of preferences from the person involved. Instead they were asked to merely rank the three lead time criteria in order of relevance to themselves or to their businesses. These rankings will naturally be less reliable than those derived from the paired comparison responses, but they should serve to indicate any wide bias.

The responses are shown in tabulated form in Exhibit 10, Appendix B.

Lead time duration is shown to be the foremost criterion for pharmaceutical wholesalers, just ahead of lead time consistency with flexibility third. This result is generally in accordance with the previously derived interval scale for pharmaceutical wholesalers' service preferences, where lead time duration was found to be least preferred at low levels of service, although there was little difference between each criterion at high levels.

Lead time flexibility is shown to be the leading criterion for hospital pharmacists, with lead time duration a fairly close second, both for distribution from wholesalers and manufacturers. Again these results are generally in agreement with the previously derived interval scales for hospital pharmacists' service preferences.

Lead time duration is shown to be the almost unanimous primary criterion for retail chemists when receiving supplies from wholesalers. This result is fairly well in accordance with the previously derived interval scale. For direct distribution from manufacturers lead time duration is shown as being the foremost criterion with lead time flexibility second. This is essentially the reverse of the situation on the previously derived interval scale, although it was found that there was little to choose between these two criteria at the top end of the scale.

The results of the survey amongst non-respondents indicate that there seems to be no obvious bias between these and the paired comparison preferences provided by the respondents.

The difficulties experienced in managing to obtain a straight ranking response from these non-respondents adds further support to the use of a method of paired comparisons in evaluating the relative importance of the three lead time criteria.

Comparisons with Research Suppositions:

The interval scales derived for each major type of distribution channel depict the relative positions of each of three lead time characteristics in order of importance as perceived by the customer concerned.

The research suppositions, proposed earlier, relate each characteristic to each type of customer in terms of primary importance.

The interval scales provide a means for comparing the empirical response to the research suppositions both at high and low levels of service. These comparisons will be made in the next chapter.

It should be noted that lead time criteria are considered most important to the customer when their nominal scale values are both 0 and 100. A score of 100 indicates that a high level of one criterion is preferable to high levels of the other two; a score of 0 indicates that a low level of one criterion is least preferred to low levels of the other two.

3. Analysis of Doctor's Responses

Questionnaires were mailed to a sample drawn from a national population of doctors, in both general practice and hospitals. The questionnaire design and the generation of the sample were discussed in Chapter 7.

The doctors' responses are tabulated in Appendix C as Exhibit 3.

There is no detailed analysis required in order to interpret these responses, and any conclusions that may be drawn from them will be made in the next, and final, chapter.

Summary

The responses to each of the questionnaires were analysed in such a way as to draw a comparison between these empirical results and the research suppositions postulated earlier in Chapter 6.

The response data is of an ordinal nature. The analysis converted this into interval scales for each set of responses, presented either as ranked data (manufacturers) or paired comparison data (customers).

A comparison was made with the research suppositions concerning the manufacturer's materials flow path, by representing activities' positions relative to the changed activity within a set of rings; the closer to the centre an activity is, the closer it is to the changed activity on the materials flow path. A tabular comparison between % inclusion of activities and % inclusion of scale values (those relevant activities on the interval scale) was made for two cases: one, considering the closest segment to the centre, and two, considering the closest two segments to the centre.

The interval scales, derived from the customers' responses, included six conditions, related to high and low levels of the lead time criteria. The high and low level sets were compared separately. A high scale value for a high level alternative indicated that the high level criterion was preferable. Conversely a low scale value for a low level alternative suggested that the low level criterion was preferable.

A survey of non-respondents amongst customers was made to ensure that there was no bias between their answers and those of the initial respondents.

Chapter 9

Summary, Conclusions and Implications of the Research

1. Summary

This research study was initially stimulated by the author's awareness, whilst working in industry, that excessive costs were maybe being incurred and profit opportunities lost through a company not viewing its logistics operation in total. The parochial approach to decision making by logistics management recognised the objectives of some sections, ignored those of others and failed to ensure that they all worked towards logistics goals of benefit to the company as a whole.

An academic approach was sought that would provide greater insight into the problem and pave the way to a solution that was applicable to all manufacturing industry.

A review of previous logistics research studies was made, where it was noted that they either failed to include all the logistics departments in the analysis, or else they neglected the effect of logistics decisions upon sales revenue or customer goodwill. It was suggested that a systems approach would be suitable for the purposes of this study in that it would reveal the interrelationships between individual logistics components. Used with a cost-effectiveness framework for decision making, the systems approach would ensure that a total logistics cost could be derived, having considered the combined effects of these interrelationships. The output of the logistics system is regarded as the measure of its effectiveness; in this case references were cited where customer service could be regarded as an appropriate measure of the logistics contribution to sales revenue and customer goodwill.

Previous research had shown that attempts to derive total company costs and benefits soon became over-complicated and their outcomes defied practical implementation by logistics management. With formalist, or analytical, methods of solution ruled out, and simulation studies beyond the limits of the resources of this research work, it seemed that a heuristic form of solution would have to be found that would simplify both the cost and the effectiveness analyses of the logistics system in a decision making situation. The situation considered to be of particular interest to company logistics management was in the evaluation of an alternative proposal regarding the operation of part of the logistics system.

Attention was drawn to a number of heuristic approaches presented in the literature as sets of rules designed to reduce the complexity of certain decision making situations, e.g. the selection of sites for the location of warehouses. As this research study is aimed at helping logistics management in any operational decision making context, heuristic guidelines are required that can be applied whatever alternative proposal is under consideration.

It was proposed that effects upon total costs and customer service levels must be evaluated in any logistics decision making situation. It was further hypothesised that logistics costs are incurred whenever a material changes its form, place or time utility. More specifically the following research suppositions were proposed:

> If an activity appropriate to a conversion point(s) is operationally changed, then its cost effects on the type of utility represented by that point(s) will be reflected most by the other activities appropriate to the same conversion point(s).
>
> The changed activity's cost effects on the types of utility not represented by the appropriate conversion point(s) will be felt most by activities corresponding to the nearest conversion point(s) on the materials flow path.

In recognising that time is progressively spent, as well as costs incurred, by material as it flows through the company's logistics system, two further research suppositions were proposed:

> If an activity appropriate to a conversion point(s) is operationally changed, then the time effects on the type of utility represented by that point(s) will be reflected most by the other activities appropriate to the same conversion point(s).
>
> The changed activity's time effects react most on the type of utility not represented by the appropriate conversion point(s) by affecting the duration of activities corresponding to the nearest conversion point(s) on the materials flow path.

These suppositions relate an activity's relative closeness to that of another on the materials flow path with the contribution of their interactive effect to both the total logistics cost and a measure of the lead time criteria; lead time duration, lead time consistency and lead time flexibility. These are the customer service factors selected as being appropriate to measure the effectiveness of the manufacturer's logistics system.

The suppositions represent heuristic guidelines that can provide a basis for reducing the number of activity interactions to be included in a cost-effectiveness analysis of the manufacturer's logistics system.

In testing the above research suppositions, it was found necessary to use empirical data from manufacturing industry. Because of the author's previous industrial experience, and also due to its general suitability, the pharmaceutical industry, in Britain, was selected for this purpose.

A detailed analysis was made of the pharmaceutical manufacturer's logistics system and of the distribution channels used to supply the customers.

It was hypothesised that different types of customers might place different priorities on the customer service criteria. More specifically the following suppositions were made in the context of the three main customer groups in the pharmaceutical industry:

> Lead time consistency is a primary criterion of customer service for pharmaceutical wholesalers.
>
> Lead time duration is a primary criterion of customer service for retail chemists.
>
> Lead time flexibility is a primary criterion of customer service for hospital pharmacists.

There was found to be very little available information concerning the logistics operations of pharmaceutical manufacturers and the service requirements of their customers. It was therefore necessary to test each of the research suppositions against empirical data provided by people working in the pharmaceutical industry. An empirical research design was described to that effect.

After initial pilot surveys had been carried out, questionnaires were administered to samples of managers with pharmaceutical manufacturing companies and to pharmaceutical wholesalers, hospital pharmacists, retail chemists and doctors.

From manufacturers' and customers' responses, the ordinal data, in the form of rankings or paired comparison preferences, were converted into interval scales and these were compared by a number of means to the implications of the research suppositions.

The doctors survey was intended to gauge the nationwide frequency of stockout situations with ethical pharmaceuticals, and to assess the doctors' reactions to these with respect to their prescribing habits.

2. Conclusions

It has been a basic assumption of this thesis that an acceptance of the total logistics concept is necessary in order for manufacturers to take an overall view of their logistics operation. In doing so they may be able to reduce their total logistics costs, or increase them to gain proportionally greater benefits from increased sales revenue or, more indirectly, from increased customer goodwill.

An acceptance of the total logistics concept is an essential foundation of the systems approach to logistics decision making. If the component logistics operations are not viewed in total, then the logistics system will not have been completely portrayed and derived measures for the system as a whole, e.g., total logistics costs, may be unreliable.

However, the results of the Initial Survey amongst pharmaceutical manufacturers suggest that their organisational structures do not reflect an acceptance of the total logistics concept. Responses to Question 10 (Appendix A, Exhibit 4) show that only 10% of the companies interviewed gave operational responsibility to one man for each of the eight logistics functions considered in this study. Furthermore 55% of the companies' managers had responsibility for only four of the logistics functions.

On the other hand even taking a total systems view of the individual company may not be enough. Heskett and Ballou (83), for instance, point to the conflict between buyer, carrier and seller in many distribution channels. They argue that manufacturers' requests for a total logistics approach may not be compatible with the profit maximisation objectives of middlemen within the distribution channel. Heskett and Ballou, in fact, regard the distribution channel as a total system of which the manufacturer's contribution is only a part. This thinking is in line with many earlier authors (see Chapter 3). This approach is, however, considered to be too impractical for operational (day-to-day) decision making within a manufacturer's organisation where the other members of the distribution channel operate independently. Dearden (53) warns that:

> "....The total system concept has been leading management in the wrong direction since it implies that there is a single information system for a company and that this information system should be considered in total...."
> (Reference: Dearden (53))

Dearden distinguishes between the flows of financial, personnel and logistics information. The total logistics concept of previous chapters was based on a single material flow system through the company with information flows essentially represented as feedbacks between logistics activities, flowing in the opposite direction to the material. The idea of there being more than one information flow system acting within the logistics operation will be considered again later when evidence is presented in support of those research suppositions relating to the logistics system of the manufacturer.

The criteria of customer service selected in Chapter 5 as measures of logistics system effectiveness were lead time flexibility, lead time duration and lead time consistency. A considerable amount of evidence was cited in support of the selection of these three factors. For instance, Christopher and Wills (39), although recognising that delivery service comprises many elements, recommended that these three particular criteria be singled out for special attention.

Discussions with pharmaceutical manufacturers during the Initial Survey also indicated that they placed great emphasis on the satisfaction of these three customer service criteria. Evidence of this is provided by the responses to Questions 11 and 12 of the Initial Survey. 68% of manufacturers interviewed were found to be distributing, to some extent at least, with company-owned or company-leased vehicles, and 32% of manufacturers interviewed were delivering according to scheduled times. This last figure had increased over the past few years and it was thought that more of the larger manufacturers were likely to begin scheduled deliveries in 1976, as the general trend towards reducing the numbers of direct customer accounts continued.

The emphasis placed on scheduled deliveries is indicative of the importance of lead time consistency as a criterion of customer service. All pharmaceutical manufacturers were found to provide means for the despatch of products which may be urgently required at very short notice using air freight, passenger trains, taxis, etc. This response to urgent requests reflects the importance of lead time flexibility as another criterion of customer service.

Wholesalers make regular deliveries as frequently as three or four times a day to retail chemists. This is a frequent and fast service, almost second-to-none, and suggests the relevance of lead time duration as a further customer service criterion.

On examining the responses to each of the customer surveys it was apparent that several respondents, especially hospital pharmacists and retail chemists, thought that additional service criteria should have been included. For instance, in selecting which wholesaler to purchase from, a customer may consider factors such as, incidence of stock outs, accuracy of despatch contents with that of the requested order, condition of order on arrival with respect to spillage and breakage, in addition to the lead time criteria. Although the three lead time characteristics were selected here as the most appropriate performance measures of the typical logistics system, a company who felt that other criteria were more relevant to their own situation could include them in the effectiveness analysis.

Conclusions about the results from each of the Major Surveys carried out in this research can be made under the headings of Total Logistics Costs and Customer Service Criteria, in accordance with the cost and effectiveness analysis structure of the thesis.

Total Logistics Costs

The tabulated summaries of results from the responses to the Manufacturers Major Survey were shown in Tables 8.2 and 8.3 of the previous chapter. Table 8.2 drew a comparison between the empirical responses and the research suppositions by deriving a % difference value for each question/change case. This difference is the % inclusion of scale values (derived from the empirical data) less the % inclusion of logistics activities (resulting from application of the research supposition).

A positive difference value indicates a measure of support for the research supposition from the evidence of the empirical response data, since a reduction in the number of logistics activities has resulted in a smaller reduction in the proportion of the relevance of these activities to the analysis. Conversely, a negative difference value indicates a lack of support for the research supposition.

In Table 8.2 two lines of results were shown for each question/ change case. The first line complies directly with the appropriate research supposition as it was stated in Chapter 6. The second line extends the research suppositions to include the next closest segment, of the ring diagrams, to which one or more activities have been assigned. The divided sections in Table 8.2 correspond respectively to each of the four research suppositions.

Tables 8.2 and 8.3 show that the majority of cases exhibit positive difference values and provide empirical evidence for an acceptance of each of the four research suppositions. The pronounced exceptions to this are with Question 1 Change E, Question 2 Change E and Question 3 Change E. Change E is common to each of these three exceptions. Stated again, Change E is:

> "Decrease by 2 weeks supply the inventory levels of each product in packed form ready for despatch".

It became apparent during the course of the research that the material and information flow representation of the manufacturer's logistics system may be incomplete, at least for pharmaceutical manufacturers. Due to their department organisation the inventory control functions for each of the material states (raw materials, intermediates and finished products) are often carried out by one section, or sometimes by one person. The linking of particular activities in this way suggests that it may be beneficial to include a communications system within the material flow chart of the logistics system. Billings (15) directs attention towards this point, by observing the following:

> "....It would appear that efficient and effective coordination is the element most critically needed in the logistics of physical distribution ....."
> (Reference: Billings (15))

In considering the coordination between decision areas in a company, Hertz (82) views the flows of information which affect decisions as cutting across departmental lines. Maybe it can also be said that they might cut across the material flow path of the manufacturer's logistics system.

It is noted earlier in this chapter that Dearden (53) recognises a number of different information systems acting within a company. LaLonde and Grashof (107) refer directly to the inventory control function in suggesting that the link between material and information flows within the logistics system is:

> "....centred on the relationship between the speed of the flow of correct information through the system and the amount of inventory that must be held at various points in the system".
> (Reference: LaLonde and Grashof (107))

If a direct link between inventory control activities is established on the materials flow path, then conversion points 2, 6 and 10 will be connected together. By altering the positions of certain activities on the appropriate ring diagrams in Appendix A, Exhibit 10, the results in Table 8.2 are changed with respect to both Changes D and E (both directly affecting inventory control activities). The affected sections of Table 8.2 are summarised in Table 9.1.

It can be seen in Table 9.1 that the % difference values have increased positively in all cases from those in Table 8.2. Four of the eight values do, however, still remain negative, but, except for the first line results of Question 2 Change E whose difference value remains unchanged, the values have decreased negativities.

The results in Table 8.3 for Question 3, Changes D and E, remain unaffected by the inclusion of the communications link between inventory control functions.

There would appear to be an appreciable weight of evidence to support the contention that a link-up between inventory control functions as a communications flow might be a useful addition to the materials flow representation of the logistics systems of pharmaceutical manufacturers.

Referring back again to the results in Table 8.2, it will be recalled that two lines of results are shown for each case. The first is appropriate to the research supposition as originally stated where activities are only included in the closest possible ring to the centre in the ring diagram. The second applies to an extension of the research supposition where activities are considered both in the nearest and the next-to-nearest rings.

Question	Change	Number of possible activities	Reduced Number of activities	% inclusion of activities	% inclusion of scale values.	% difference	Number of activities included	Activities Excluded
1	D	12	8	66.7	62.4	-4.3	5	G3
			9	75.0	100.0	+25.0	6	-
1	E	12	11	91.7	62.8	-28.9	6	G3
			12	100	100	0	7	-
2	D	25	1	4.0	13.7	+ 9.7	1	D1,E4,E7 G2,H1,H2
			5	20.0	57.5	+37.5	4	E4,E7,G2
2	E	25	16	64.0	29.2	-34.8	3	C1,D1,E4,G2 H1,H2,H3
			23	92.0	76.0	-16.0	8	C1,G2

<u>Table 9.1</u> Retabulation of Sections of Table 8.2 to Show Effects of Including a Communications Link Between Inventory Control Functions

Table 8.2 showed that the % difference value altered between the first and second line of results for each case. Some changed towards a higher positive value, some towards a lower positive value and some towards a negative value. Table 9.2 presents a summary of these effects. As with Table 8.2, it is divided into four sections, each corresponding, in order, to the first four research suppositions.

Table 9.2 shows that extending the research suppositions results in higher aggregate correlations (higher positive difference values) with the empirical response data for sections one, three and four. In section two, however, the reverse effect is found with a lower aggregate % difference value.

In the main, though it would appear that extending the research supposition to include activities within the nearest two possible rings on the appropriate ring diagram might prove a useful amendment to the heuristic procedure for selecting only the most relevant logistics activities.

Question	Change	% Differences as % inclusion of scale values - % inclusion of activities: Results Line 1	Results Line 2
Section 1			
1	D	-10.5	+18.8
1	E	-38.2	- 9.3
2	A	+30.0	+21.8
2	C	+18.7	+13.9
2	F	+27.5	+83.3
3	B	+50.0	0
Totals		+78.9	+128.5
Average (÷ 6)		+13.1	+ 21.4
Section 2			
1	A	+46.1	+38.4
1	B	- 1.3	+11.9
1	C	+ 3.8	- 8.3
1	F	+46.1	+38.4
2	B	+10.5	+ 4.0
2	D	+ 9.7	+19.7
2	E	-34.8	-34.4
3	C	+40.0	0
Totals		+120.1	+68.9
Average (÷ 8)		+ 15.0	+ 8.6
Section 3			
5	G	+ 16.7	0
5	K	- 14.3	+42.8
7	J	+ 20.9	+ 7.2
7	L	- 6.7	+86.2
Totals		+ 16.6	+136.2
Average (÷4)		+ 4.2	+ 34.1
Section 4			
7	G	+ 1.0	+ 6.7
7	H	+ 65.3	+ 58.7
7	I	+ 21.7	+ 34.5
7	K	+ 39.9	+ 86.7
Totals		+ 127.9	+188.6
Averages (÷ 4)		+ 32.0	+ 47.1

Table 9.2. Summary of the Effects on Extending Research Suppositions to Include Logistics Activities Within the Nearest Two Segments on the Ring Diagrams.

Customer Service Criteria:

In Chapter 8 interval scales were constructed from responses to the questionnaires presented to customers. These interval scales showed the relative preferences to each of three customer service criteria for Pharmaceutical Wholesalers, Hospital Pharmacists and Retail Chemists.

Lead time duration, consistency and flexibility (the three customer service criteria) were earlier assigned to each of the three customer types with respect to priority. These correlations represented three research suppositions proposed in Chapter 6.

By directly comparing the interval scales with the statements of the research suppositions, conclusions can be made concerning the service preferences of customers. These are now presented for each customer service criterion, in turn:

Lead Time Duration -

The interval scales derived in Cahpter 8 show that lead time duration is placed first at the top end of the scale for retail chemists (distribution via wholesalers), and at the bottom end of the scale for wholesalers. The top ends of the interval scales are appropriate to higher levels of service; the bottom ends to lower levels of service.

The research supposition supposes that lead time duration is a primary criterion of customer service to retail chemists. The empirical evidence, as featured by the interval scale, would seem to uphold this supposition, but only for cases where the retail chemist is receiving medicines via wholesalers, and then only at higher levels of service. The supposition falls down for cases of direct distribution from manufacturers, and from wholesalers where their level of service is low.

Responses to other questions in the Retail Chemists Questionnaire (results tabulated in Appendix B Exhibit 8) indicate, however, that the great majority of retail chemists' ethical requirements are purchased indirectly via wholesalers, and that wholesalers generally offer retail chemists extremely high levels of service. The majority of chemists purchase less than 5% of medicines (both by value and number of orders) direct from manufacturers, and again the majority receive a daily, or better, delivery frequency from their two main wholesalers.

In this operating environment, it may be concluded that retail chemists are receiving the majority of ethical medicines via wholesalers, and are provided with relatively high service levels. The research supposition that lead time duration is a primary criterion of customer service to retail chemists would therefore seem to be supported by the empirical data.

Lead Time Consistency -

Amongst the interval scales of Chapter 8 lead time consistency has only emerged as first for the top end of the wholesalers scale.

The research supposition supposes that lead time consistency is a primary criterion of customer service to pharmaceutical wholesalers. The empirical evidence can therefore be expected to uphold this supposition when the levels of service received from manufacturers are considered to be fairly high. When the levels of service are low lead time duration can be expected to become the primary criterion.

Responses to questions in the Wholesalers Questionnaire (results tabulated in Appendix B Exhibit 6) indicate a fairly wide spread in the levels of service received by wholesalers from manufacturers. The majority of orders are received within lead times of one and three weeks, but the proportion of receipts by scheduled delivery from manufacturers varies from less than 10% to as much as 60% of total deliveries.

It must therefore be concluded that the placing of lead time consistency as a primary criterion of service to pharmaceutical wholesalers is only true in certain cases, where the measure of customer service to a wholesaler is considered to be relatively high. An individual examination of the wholesalers' responses indicates that those wholesalers receiving a higher proportion of scheduled deliveries have favoured lead time consistency as an important service criterion more than those wholesalers receiving a lesser proportion of scheduled deliveries.

Lead Time Flexibility -

Lead time flexibility is shown as a primary criterion of service on the interval scales for the following cases: by hospital pharmacists for distribution from manufacturers and wholesalers at both upper and lower levels of service; by retail chemists for distribution from manufacturers at both upper and lower levels, and for distribution via wholesalers at lower service levels.

The research supposition supposes that lead time flexibility is a primary criterion of customer service to hospital pharmacists. The empirical evidence can therefore be seen to entirely uphold this supposition for all manner of ethical medicines distribution to hospital pharmacists.

Responses to questions in the Hospital Pharmacists Questionnaire (results tabulated in Appendix B Exhibit 7) in fact indicate that only between 20% and 40% of ethical medicines are supplied via wholesalers to the majority of hospital pharmacists. The level of service received from the wholesalers would however seem to be high with at least a daily delivery frequency from one or more wholesalers for the majority. The level of service received from manufacturers is likely to vary depending upon the particular manufacturer and the hospital's location.

Service Expectations from Manufacturers -

In the particular context of supplies from manufacturers, lead time flexibility has been indicated as the primary service criterion for both hospital pharmacists and retail chemists. However, the reverse is apparent for wholesalers, where lead time consistency is selected at upper service levels and lead time duration at lower service levels.

These findings imply that the pharmaceutical manufacturer who accepts direct orders from chemists and pharmacists finds it necessary to be more flexible in his operations than the manufacturer who discourages direct accounts. This latter policy might enable the manufacturer to concentrate more on uplifting levels of service, as measured by lead time consistency and duration, to his wholesaler customers.

Stock-Outs -

Responses to questions in the Doctors Questionnaire (results tabulated in Appendix C Exhibit 3) indicate that stock-out frequencies, which have an adverse bearing directly on sales revenue, are, at the present time, very few.

They also indicate that, in the event of a stock-out situation, doctors show more inclination to switch brands of medicine the more urgently the treatment is required for the patient's welfare. More significant than this rather predictable conclusion is that a product categorisation based on the degree of substitutability of the product has little relevance to the doctor's tolerance in a stock-out situation.

Summary of Conclusions -

It is convenient to list the foregoing conclusions in summarised form:

i) Research suppositions, concerning the selection of logistics activities as relevant according to their relative positions on the materials flow chart, were made in Chapter 6. They were tested by aggregating managers' responses to 12 hypothetical changes, each presented in three separate groupings according to which type of utility they affected. It has been shown that these responses provide some evidence towards accepting the research suppositions as heuristic guidelines for decision making by logistics managers in the pharmaceutical industry.

ii) It has been demonstrated that if the research suppositions are extended to include logistics activities in the nearest two positions to that of the changed activity, then the empirical response supports these modified suppositions to an increased degree.

iii) It was suggested that an information sub-system of some kind may have to be included in the materials flow representation. A communications sub-system, linking up inventory control activities, has been tried and found to increase the correspondence between the empirical response and the research suppositions for those cases where any initial correlation was lacking.

iv) It has been shown that empirical response upholds the research supposition that lead time duration is a primary criterion of customer service for retail chemists, at least for deliveries from wholesalers.

v) Empirical response was shown to be emphatic in supporting the research supposition that lead time flexibility is a primary criterion of customer service for hospital pharmacists.

vi) The research supposition that lead time consistency is a primary criterion of customer service for pharmaceutical wholesalers was only indicated as being supported, by empirical response data, in cases where the existing levels of service can be considered to be relatively high. A measure of current levels of customer service for a particular wholesaler-manufacturer situation should enable some prediction to be made as to the accuracy of the research supposition in that case.

vii) The evidence from doctors' returns indicated that direct sales revenue is not being lost as a result of prolonged stock-outs to any appreciable extent.

3. Implications of the Findings for Manufacturers

At the commencement of this research it was stressed that any outcomes from the study should be directed at aiding decision-making by the logistics managers of manufacturing industry in general, and the pharmaceutical manufacturing industry in particular. Hopefully the heuristic guidelines that have emerged, expressed as a series of research suppositions, will help logistics management in more clearly analysing a complex situation, by identifying and selecting those interactions between logistics activities that most affect total logistics costs and levels of customer service when any alternative proposal is being considered.

The major implications for manufacturing industry can be summarised as follows:

i) The materials flow path through the company provides a logical connection for all the logistics activities of the manufacturer. It represents a progressive sequence in achieving departmental objectives, which should be coincident with the material's increasing utility value.

This research study has demonstrated the use of the materials flow path in providing a heuristic set of rules by which the interactive effects, between activities represented on the flow path, can be assessed relative to any one activity.

ii) The traditional organisation structure of many manufacturers is not conducive to the implementation of the total logistics concept. Logistics activities are often split beneath the control of marketing and production managers. This makes it difficult for them, or their subordinate managers, to take logistics decisions when considering the ramified effects they may have upon total costs and levels of customer service. Whether the status of the logistics manager is represented as a line or a staff function within the organisation is not the important point. What matters most is to ensure that one manager takes decisions on logistics operations knowing what their effect upon total logistics costs and customer service levels will be. To do this he must have been able first to select and then to quantify the relevant effects from a vast number of possible interactions existing within the logistics system complex.

iii) The different service priorities indicated by customer groups might suggest to manufacturers that grounds exist for re-organising their logistics operations on a basis of levels of customer service.

For instance, the findings of this research suggested that the avoidance of excessive lead time durations was a particularly important criterion of customer service to pharmaceutical wholesalers. On the other hand, lead time flexibility was considered by hospital pharmacists to be a more critical criterion of customer service than either lead time duration or consistency.

The customer surveys carried out in this research were directed on to a nationwide sample of the customers of pharmaceutical manufacturers. Many of the questions included in the questionnaires to each customer group sought general information such as location, proximity to suppliers, turnover etc. It could be supposed that customers' preferences amongst service criteria could vary according to one or all of these factors. For instance a wholesaler in Scotland who does not receive scheduled deliveries from pharmaceutical manufacturers may regard the relevance of lead time consistency differently from the wholesaler in London who is regularly supplied according to schedules.

It is the task of the manufacturer to identify the factors relevant to his own situation. He can then include these in his own customer survey and structure the questions accordingly.

The heuristic set of rules, as proposed here, can be used in carrying out cost and effectiveness analyses of the logistics system. Previously, many research investigations have merely identified logistics activities, and the interactive effects between them. The use of a heuristic set of rules to reduce the number of interactive effects to be included can be considered as a one-step advancement on the previous studies.

However, any company wishing to incorporate the principles of the proposed heuristic guidelines in its logistics decision-making procedures, must first of all be able to model its own logistics operations.

The merits of simulation models as representations of the logistics system in operation were presented in earlier chapters. It was noted that their most obvious advantage is being able to account for the time aspects of the operation, both future and present. This research study has upheld that it is essential for any logistics system analysis to be able to predict the effects of any alternative proposal upon the lead time characteristics, considered as being criteria of customer service. To do this, the logistics system analysis would have to derive a lead time for every forecasted order, or group of orders, received from a customer, using a model of the company's logistics operations. In this way time phasing of the cost-effectiveness analysis could be achieved (1).

As an aid to any company wishing to model the operations of its logistics system, the development of a simulation model is now discussed.

A Proposal for a Simulation Study

Chapter 3 discussed the advantages of simulation over other methods in providing a means of analysing the logistics system. It provides a tool for experimentation in testing hypotheses and decision rules. It enables the dynamics of a logistics system to be investigated. It can realistically represent customer requirements, in terms of the customer service criteria (lead time reliability, duration and flexibility). It can deal with the multi-product situation. It is flexible and can take account of changed conditions without a major re-programming effort.

In criticising the limitations of Kuehn and Hamburger's (104) heuristic rules employed in locating warehouses, Shycon and Maffei (151) recommend taking a simulation approach to the problem . They state that:

> "...At present it (Kuehn and Hamburger's model) appears to have significant limitations, but it is likely that further work can make it more useful. Ultimately some combination of these methods as a first approximation, and then the use of simulation techniques may provide the answer...."
> (Reference: Shycon and Maffei (151)).

On the debit side, though, simulations were found to require great outlays of resources, in terms of man hours, computer time and the large amount of information required as input data (158).

It was suggested, earlier in Chapter 3 and above, that a hybrid form of analysis could be used. DeHayes and House (54) were foremost with this idea as a follow-up to the work of Nolan and Sovereign (135). They considered the use of a recursive approach where the analysis is first carried out at an aggregate level with an optimising technique (a linear programme in their case). Simulation is then used to fill in the details which can be passed back for a repeated optimisation. Although their objective was to optimise the parameters of the logistics system the optimising step which they used can be viewed as a heuristic, or rule-of-thumb, for simplifying the scope of the simulation. The optimisation pre-sets the ranges of variables to be included as alternative conditions in the simulation.

The simulation is required to provide the essential information for an overall cost-effectiveness comparison of alternatives, e.g. Schorr (149). This information includes total logistics costs, lead time characteristics (reliability, average duration and flexibility) and stock-out frequency, the last two factors relating to the effectiveness of each alternative in terms of resulting sales revenue. How the logistics system reacts to a pattern of demand (the demand forecast) will determine the respective measures of these factors.

It is both impossible and undesirable to experiment on a firm's actual logistics system; implementation of an alternative operation within the system could prove costly, both in the short and long term. Partial implementation of an alternative may avoid incurring excessive costs, but the results will generally not be fully representative if the change due to the non-linearity of the logistics activities.

It is necessary to formulate a model of the logistics system that will be the basis of simulated experiments with alternative conditions. The type of model used depends upon the objectives of the simulation.

A model format must be chosen that represents the logistics system so that cost and service criteria information can be produced for a range of possible alternative conditions. The accuracy with which this information represents the logistics system depends basically on to what extent, and in how much detail, the interactions between cost and time factors within the system are represented.

The Model of the Logistics System

The simulation is carried out using a mathematical, or quantified, representation of the logistics system. This is known as the model of the system. It normally consists of a series of equations showing relationships between the variables of the logistics system.

An example of a simple model of a single channel, multi-process system is provided by Figure 9.1 which represents a simplified flow chart.

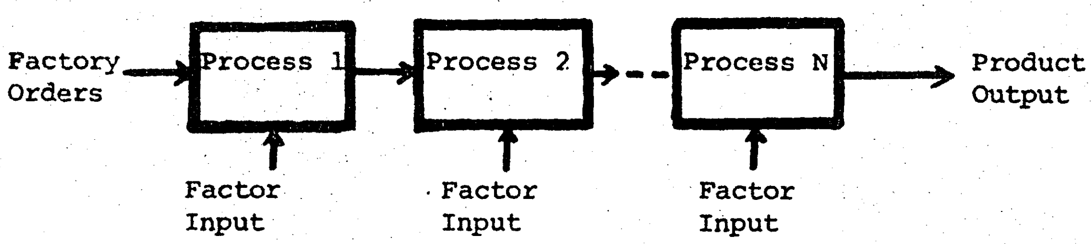


Figure 9.1: The Flow Chart for a Dynamic Model of a Production - Inventory System

Figure 9.1 is an example of a model based on the flow of material through the firm. Not all models are similarly based; for instance, Stasch's framework for a model of the physical distribution subsystem was based on 3 theoretical considerations (159): the total physical distribution costs associated with a particular market i) will increase with the volume shipped to that market, ii) will increase with distance, and iii) will decrease as delivery time increases. Algebraic expressions can be developed for each.

Models based on the flows of material, and information, through the system have recurred in the literature since Cox and Goodman (48) first traced back all the materials involved in building a house. This model, and others (e.g. Bowersox et al (18)), has depicted the movement of materials through the institutions of the distribution channel. More specifically, a model can represent the physical flow of materials through a single department or firm. Brooks (22) represents a sugar refinery's refining processes as a simulation model which can predict the outcome on the products' characteristics as a result of a technical change in conditions. Yurow (181) also analyses and simulates the production and distribution systems for a tufted carpet mill, where qualitative measures of performance are needed in simulating such discrete activities as weekly production scheduling.

It is possible to distinguish between two lines of thought in modelling logistics systems: the first represents the logistics system as a flow chart for materials and information (as the previous examples), the second represents the logistics system as a hierarchical decision-making sequence.

In criticising Connors et al's "Distribution System Simulator" (44), Hax (78) suggests that different models are needed to deal with individual decisions at each decision-making level. He recognises 3 such levels in his hierarchy: 1) strategic planning - facilities design; 2) tactical planning - aggregate capacity evaluation - effective allocation of resources; 3) operational control - detailed scheduling.

In developing SIMPAC (a management control systems simulation model) Kagdis and Lackner (98) design their model around the decision rules for management control. They represent the total business system (including all functional areas) as a flow chart of resources (e.g. money, materials and manpower) and information. Their simulation is concerned with the control of budgets within an organisation.

The choice of the model, as a suitable means of representing the logistics system, should reflect the objectives of the study. The simulation should be designed to produce the information required of it by the easiest possible means.

A model of the logistics system suitable for developing the findings of this study would have to use the material flow chart of Figure 6.1, as shown in Chapter 6, if it is to simulate the lead time characteristics, based on a forecasted demand pattern. It is also suggested that the same material flow chart is the most suitable framework for analysing those interactions that affect contributions to the total logistics cost. It is the activities themselves, acting on the materials to increase their utility values, that incur logistics costs. Decisions, whether strategic, tactical or operational, affect the activities and the costs they incur through the information flow amongst functions or departments.

It is therefore necessary to include an information flow in the simulation model, so that the pattern of decision-making can be built up.

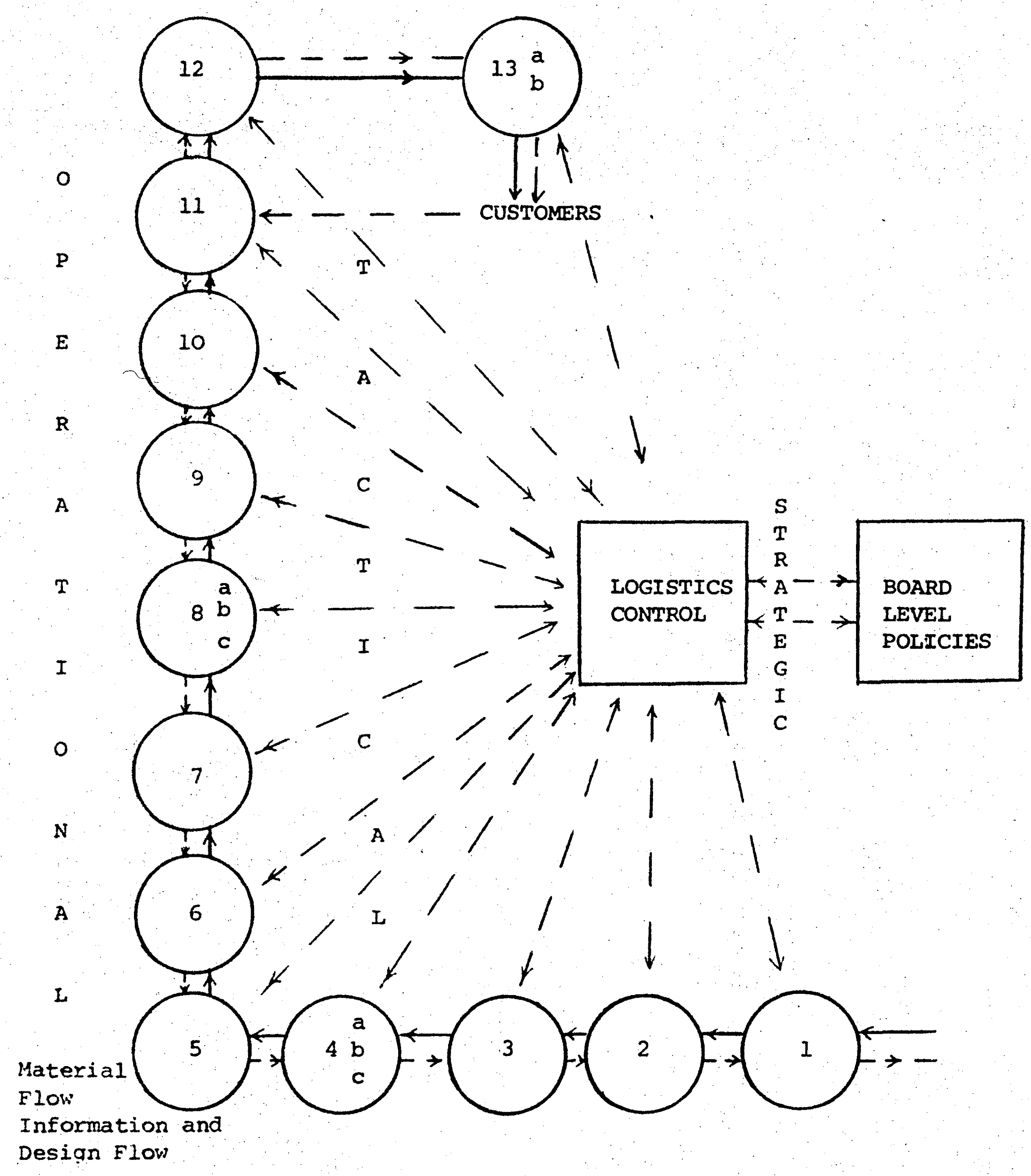


Figure 9.2. The Material - Information Flow Chart Showing the 3 levels of Decision in the Decision-Making Hierarchy (Strategic, Tactical, Operational). (Nodes numbered as for Figure 6.1. Chapter 6)

Noting Hax's (78) recommendation for a framework of a hierarchical system of decision-making, Figure 9.2 shows the position of the 3 types of decision in the logistics system. Strategic decisions guide the control policies of a centralised logistics control function, e.g., the logistics manager. He instructs each of the conversion nodes in the material flow sequence through a series of tactical decisions. The operational decisions may be considered as relating to those flows of information between conversion nodes along the material flow chart.

One advantage inherent in the framework of Figure 9.2 is that it shows how the various decision levels can interact.

Table 9.3 shows how the activities of the logistics system can be associated with each of the 3 decision levels: strategic, tactical and operational. In drawing up the list of activities in the first place (see previous chapter 6) those directly concerned with strategic decisions were omitted, e.g., location of facilities. This study is less concerned with the design of a new distribution system than with the evaluation of alternative operations within an existing system.

If an algebraic expression can be developed for each of the link-ups in Figure 9.2 then a model for a simulation analysis will have been established. More decision links than those shown will be required, due to the breakdown into more detailed decisions, necessary to meet the needs of an accurate simulation of the operation of the logistics system.

The algebraic expressions would be needed to interrelate the times of carrying out activities, and also to interrelate the costs amongst activities and decisions.

If the analysis of the pharmaceutical logistics system is to consider all the relevant activities, then the number of interactive effects between each would be considerable, and pose major problems of analysis.

It would appear that a heuristic framework needs to be constructed in order to reduce the complexity of the analysis to a level acceptable to logistics operations management. It is suggested that the research suppositions proposed and tested in this thesis can serve as the necessary heuristic framework.

Activity No.	Conversion Point Nos.	Type of Decision	Activity No.	Conversion Point Nos.	Type of Decision
A1	13a	t	C4	12	t
A2	13b	o	C5	12	o
A3	13a	o	D1	1,3,5,7,9	t,o
A4	13a	o	D2	2,6,10,11	t,o
A5	13a	o	E1	13a,13b	o
A6	13a	t,o	E2	13a,13b	o
A7	13a	o	E3	11	o
A8	13a	o	E4	11	o
A9	13a	t,o	E5	2,4b,6,8b, 10,13b	t,o
A10	13a	t	E6	13a	o
A11	13a	t,o	E7	11,13a	o
A12	13a	o	E8	11	t
B1	2,6,10	s,t	F1	2	t
B2	10	s,t	F2	6	t
B3	2,6,10	s,t	F3	10,13b	t
B4	13b	t,o	G1	4a,8a	t
B5	2,6,10, 13b	t	G2	4c,8c	t
B6	2,6,10,13b	o	G3	4b,8b	t,o
C1	11	o	H1	1	t,o
C2	12	t	H2	1	t,o
C3	8a	t	H3	1	o

(s = strategic; t = tactical; o = operational)

Table 9.3 Type of Decision Associated with each Logistics System Activity

A Heuristic Framework to Reduce the Simulation's Complexity

The complexity of simulating a total logistics system is so great that, really, only subsets of the system can be selected for simulation at any one stage. The choice of these subsets, or, more fundamentally, the method of their selection, has differed widely amongst investigators.

Some have considered only component problems of the logistics system, anyway, e.g. Shycon and Maffei (150) who only dealt with the location of facilities. These approaches, aimed at simple component problems, are prevalent in the earlier literature, and can be accused of sub-optimising in that they disregard interactive cost and time effects with other elements in the total logistics system. This research study has attempted to take the component solutions one step further by considering the total logistics system with a view to arriving at solutions best for the overall distribution organisation.

Where the single component solution attempts can be strongly criticised is in their elimination of other parts of the logistics system with no justification for thus simplifying the analysis.

Those researchers taking a more total approach, have presented a basis for selecting certain logistics areas, and for eliminating others. For instance both Stasch (159) and Jacoby and Harrison (93) use a topological tree to show the connections between facilities and markets. A particular market, or area for analysis, can be selected and the most adjacent links to that market can be investigated. Jacoby and Harrison (93) recognise that clusters of variables often seem to converge to a single node in a way described by a simple function; by progressively absorbing such variables, the size of the experiment can be reduced. Stasch (159) uses a physical distribution criterion of volume-distance-delivery time to identify relatively high distribution costs to certain markets.

Other methods of simplifying the analysis have been used. Wayman (178) constructs his model to focus on those areas that have the most <u>direct</u> financial impact on total logistics costs. For his study of a State liquor distribution system he identifies inventory investment as being the chief cost contributor. He thus relates all alternative system designs to their 'return-on-inventory-investment' when comparing them.

To carry out a simulation of the logistics system in total requires a considerable amount of abstraction and aggregation, the level of which will decide whether such a simulation is acceptable or not. How the abstractions and aggregations are done represents the framework for analysing the system, which in turn shows the point of view and the objectives of the model builder. House (88) states that simulation studies rely upon the model builder to specify the structural relationships.

The research suppositions upon which this study is based could form a possible basis for incorporation into the simulation analysis. Their function would be to identify those areas most pertinent to the analysis, and simplify the simulation. However, as Aggarwal (2) warns, the heuristic rules, in whatever form, must be incorporated into the simulation analysis to fit in easily and not to complicate the model-building effort.

Referring back to Figure 9.2, each of the conversion points (numbered 1 to 13) warrants inclusion in the simulation analysis as a separate routine. The computation of the routines will be similar for those representing changes in place, time and form utility. Each will have to be worked through separately, though, in order to evaluate total logistics costs, overall lead time for each order and the inventory levels at any time, i.e., the performances of the customer order cycle and the internal reorder cycle with respect to the costs involved in achieving them.

The research suppositions serve to eliminate from consideration many of the possible interactions involved that complicate the analysis. They select only those interactions adjacent to the source of the change as it occurs on the material/information flow chart of Figure 9.2. In this way only a selected number of routines need be worked through in full, i.e., worked through considering the interactions with other activities. The remaining routines can be included in the analysis in much simpler form, as interactive effects can be ignored, and the costs and throughput times calculated as if no change had occurred.

This is best illustrated by considering the two types of suppositions aimed at reducing the complexity of the simulation analysis i) in terms of logistics costs and ii) in terms of customer service, as shown in Figure 9.3.

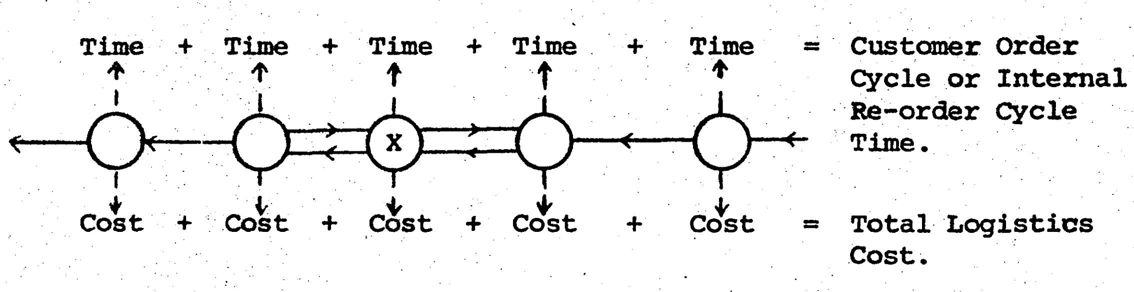


Figure 9.3. The Extent of the Computation Required in a Simulation of the Material Flow Chart of the Logistics System when the Heuristic Rule is Applied.

A change is made on an activity appropriate to a conversion point, denoted X in Figure 9.3. If, for simplicity, the two conversion points adjacent to it are identified as incorporating significant interactive effects with the changed activity by the heuristic rule, then there will be two-way flows to be considered between these points. The costs and times appropriate to the three nodes, depicted in Figure 9.3, are calculated by a consideration of all the interactions between the activities appropriate to these three nodes.

Hence, the costs and times of activities appropriate to the three nodes, 'X' and those adjacent to it, are calculated considering the effects of the change on each of the activities. The costs and duration of activities appropriate to the other nodes are only adjusted if the quantity throughput has altered. The cost-quantity and time-quantity relationships for each activity will have to be known.

Calculation of total logistics cost: following the above procedure each activity cost is calculated, depending on whether its cost is altered through any change brought about by the changed logistics activity, or more straightforwardly by a resultant change in the material or information throughput at each appropriate node.

The relationships between costs of activities and the effects of the changes activity could be much more complex, since the change can be of any form, not just in throughput.

Calculation of cycle times: here it is essential to know the critical paths of the activities involved at each node. A changed activity can affect the durations of each activity, with the result that a node's critical time can be changed, and even the critical path itself. The duration at each node is the sum of the durations of those activities making up the critical path.

For the node X and those adjacent to it in Figure 9.3., the times of activities can vary by interactive effects resulting from the changed activity. For the remaining nodes in the system, activity durations are considered to only vary as the throughput is affected.

Using the Results of the Simulation in a Cost-Effectiveness Analysis of the Logistics System:

Having made a hypothetical change to an activity within the logistics system complex, the simulation analysis should result in a pattern of customer order cycle and internal supply cycle times. This latter can be interpreted to represent stock out frequencies. These results are obtained for a future period of time, based on a known demand forecast. The latter will ideally be available for each product line, or group of product lines, to be ordered by each customer, or group of customers.

This simulation will have been carried out at the operational level of decision making (see Figure 9.2). The strategic decisions will be constant throughout and represented as policies which provide the constraints to the simulated conditions, e.g., inventory levels, stock-out policies. Under these conditions values of the utilities of lead time consistency, average duration and flexibility can be calculated from the simulated set of customer order cycle lead times. It is particularly important that the values of utilities are separately calculated for each group of customers since it was found that such values have different significance to each customer group. For each calculated level of utility it is possible to read off its benefit value to the manufacturer for each group of customers.

These values of benefit, deriving from lead time characteristics calculated under simulated conditions, can be compared with the total logistics costs to assess the merits of any logistics system, or a change made therein.

The total logistics costs are obtained by summing the individual costs of each activity. Changes made on a single activity within the logistics system may well affect the total system costs. The effects on other activities are evaluated by the methods previously outlined, and a cost contribution for each logistics activity is obtained.

The merits of any change will rest on the ratio of the benefits obtained, quantified, as suggested here, in terms of service utility values, to the total logistics costs resulting from the change.

4. Implications of the Findings for Logistics Research.

This research thesis, and its findings, have a number of implications for the theory of logistics systems analysis and in its application to industrial situations. These may be summarised as follows:

i) Logistics theory emphasises the need in decision-making to include all the activities relevant to the logistics operation. The theory does not however indicate a method of analysis, which is computationally feasible for day-to-day decision making by logistics management, that is capable of handling all the inevitable interactions between activities. A lack of suitable hypotheses to relate these logistics activities, and their interactive effects upon total logistics costs and levels of customer service, is apparent.

This research has tentatively opened a way towards developing such a hypothesis by suggesting a number of research suppositions based on the relative positions of logistics activities on the materials flow path. Empirical data was obtained that was found to go some way towards supporting these suppositions in the context of the pharmaceutical manufacturer's logistics operation.

An implication of the research findings for logistics theory is therefore that a materials flow path, constructed on the basis of material's increasing utility value, can provide a means for developing a heuristic model that can be used to reduce the number of interactive effects.

ii) The fixed effectiveness approach to many logistics system analyses has resulted in an over-emphasis on cost-minimisation approaches to logistics planning. This approach obscures the many possible benefits open to a company in taking advantage of increased sales revenue and/or customer goodwill through improved service. This research has looked at three customer service characteristics: lead-time duration, consistency and flexibility, and has assessed customer reaction to them.

An implication for logistics systems theory is that logistics expenditure needs to be assessed not only in terms of budgetary limitations but also with respect to criteria of customer service. The three lead time characteristics of duration, consistency and flexibility were selected as being most appropriate to this study, but a manufacturer should be free to choose whichever criteria he considers to be most applicable.

iii) The empirical evidence obtained in this research was found to support the hypothesis that different groups of customers lay emphasis on different customer service criteria. Although the responses to the Customer Surveys did not wholly support the specific research suppositions, as stated, they did at least point to the situation whereby different customer groups, and distribution channels, have varying preferences.

An implication of these findings in the application of logistics systems theory is that a company's logistics effort may require to be organised on a customer service level basis. By doing so alternative logistics system proposals may be assessed in the light of their true effects on customer service levels, as well as on total logistics costs.

iv) It is essential that a model of the logistics operation be used in ascertaining the effects of each component activity upon costs and service levels. It is suggested here that a simulation model is the most suitable for the logistics system representation, especially in view of the lead time derivations involved. If this simulation is carried out in conjunction with heuristic guidelines of the type proposed in this study, then the inherent complexity of the simulation may be able to be reduced sufficiently to allow a practical application by logistics management.

* * *

The heuristic framework proposed by this research study represents a step towards the formulation of a hypothesis for selecting only those interactions, or trade-offs, of particular importance to any logistics analysis. It has enabled a progression to be made beyond the mere identification of logistics activities, so prevalent in earlier research studies.

It could be that an intensive study of one firm's logistics operations may lead to a more detailed definition of the heuristic framework which could be tested on other companies in other industries.

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APPENDICES

APPENDIX A

EXHIBIT 1

Introductory Letter to Pharmaceutical Manufacturers

15th November, 1973

To: The Information Officer

Dear Sir,

I am preparing a doctoral research thesis concerned with the marketing of products by the pharmaceutical industry, under the direction of Dr. Martin Christopher and Professor Gordon Wills of the Department of Marketing and Logistics, Cranfield Institute of Technology. My interest in the pharmaceutical industry stems from the fact that I was connected with it for four years prior to taking up my present studentship.

To ensure that my research is in line with current industrial concern I need to have a background knowledge of the products marketed by selected UK pharmaceutical companies.

I would be most grateful if you could send me any information on the products which you market, whether they be ethical pharmaceuticals (branded or unbranded), proprietary medicines, veterinary and animal health products, cosmetics, toiletries or any other product lines which you sell. The information I am particularly keen to acquire would include a straight listing of your products, product descriptions, bulletins and sales literature of your pharmaceutical, veterinary and animal health product lines, and any company reports that are available.

The main subject for my research thesis will be concerned with distribution in the pharmaceutical industry. Could you possibly give me the name of the manager responsible for distribution within your company, so that I may contact him with a view to discussing my research.

My research work is being sponsored by a two year grant from the Social Science Research Council. I would like to assure you that any information gathered is purely for the purpose of helping me develop my doctoral research. It will not be published in any way without your prior permission.

I do hope you are able to help me in this matter, and look forward to your reply.

Yours faithfully,

R.E. Gregson

APPENDIX A

EXHIBIT 2

Letter to Logistics Managers of Pharmaceutical Manufacturers

Dear

I am carrying out research work for a Ph.D at Cranfield School of Management. I wonder if you would be willing to help me.

I am studying distribution in the pharmaceutical industry, particularly those operations concerned with the overall flow of materials and customer service levels.

I would be most grateful if you could see me sometime. This would involve just a brief discussion, centred around a number of general questions which I would like to ask.

Prior to doing this research I worked for several years in the production department of Pfizer Ltd. The problems that I encountered in coordinating production interests with those of other related departments fired my interest in this area of investigation. I should now add that I have no connections whatsoever with Pfizer; my research work is entirely sponsored by a grant from a Government research council.

I have a clear idea of what information I require. I have previously carried out similar interviews with a number of other pharmaceutical companies. Any discussions would be treated with the strictest confidence and would not be named in either my thesis or any resulting reports.

I have discussed my project with the Office of Health Economics who have expressed interest, and recognised its potential as a practical aid to the industry, as distinct from being just academic.

In return for your cooperation, I would later send you a report giving a comparative look at problem areas in distribution. The results may be useful to you as an aid in either reducing costs or improving distribution performance.

I hope you will be able to grant me your cooperation by suggesting a time when I could visit you; without this cooperation my work would suffer in terms of its practical contribution to the industry.

Yours sincerely,

R.E. Gregson

APPENDIX A

Exhibit 3

Examples of Types of Information Required in the Initial Survey Amongst Pharmaceutical Manufacturers

1. Which companies have manufacturing facilities in Great Britain.
2. The relative size and degree of multinationality of each company.
3. The sizes of their ethical product range and their diversified product interests.
4. The number of distribution centres used in this country, by each company.
5. Their policies towards channels of distribution to their customers.
6. The size of their ethical product business in Great Britain measured by number of orders. This must be interpreted in conjunction with 5, since a company distributing directly to retailers might do the same volume of business as one who distributes only to wholesalers, but will receive a larger number of smaller orders.
7. The extent of the logistics manager's responsibility in the company organisation.
8. Details on the methods of delivery used to customers.
9. The average lead times offered to customers.
10. The average item availability percentages achieved at any one time, or conversely, the percentage of stock outs at any one time.
11. The average stock levels held as finished goods.
12. Whether or not, lead time variations to customers, not on scheduled routes, is due to their regional location or to a priority customer policy of some type.
13. The relative direct financial magnitude of each of eight logistics departments.
14. Examples of any changes that have recently been made, or are being contemplated, that will either affect logistics costs, or customer service levels, or both.

APPENDIX A

EXHIBIT 4

Results of the Initial Survey Amongst Pharmaceutical Manufacturers

1. Does your Company have manufacturing facilities in Britain?

		No. of Respondents	% of Total Response
1.	YES	20	80
2.	NO	5	20
	Totals	25	100
	% Response to Question		100

2. How large is the spread of your Company's basic production facilities throughout the World?

		No. of Respondents	% of Total Response
1.	Worldwide, including plant in Great Britain	13	52
2.	Worldwide, excluding plant in Great Britain.	1	4
3.	Basic production plant limited to one country	9	36
4.	No basic production plant anywhere	2	8
	Totals	25	100
	% Response to Question		100

3. How large is the spread of your Company's <u>pharmaceutical</u> production facilities throughout the World?

	No. of Respondents	% of Total Response
1. Worldwide, including production plant in Great Britain	15	60
2. Worldwide, excluding production plant in Great Britain	1	4
3. Production plant restricted to one country	9	36
Totals	25	100
% Response to Question		100

4. To how many World markets does the British operation of your Company export ethical products?

	No. of Respondents	% of Total Response
1. All World markets with none, or very few, exclusions	18	72
2. Limited World areas	3	12
3. Home markets only, with exports only as internal Company transfers	4	16
Totals	25	100
% Response to Question		100

5. How large is the range of your Company's ethical product lines?

	No. of Respondents	% of Total Response
1. Over 50 lines, including specialities	9	36
2. 20-50 lines, including specialities	10	40
3. Less than 20 lines, including specialities	3	12
4. No specialities in range	3	12
Totals	25	100
% Response to Question		100

6. To what extent has your Company diversified into other product interests besides ethicals?

	No. of Respondents	% of Total Response
1. Marketing/Production of other non-pharmaceutical products, e.g. foods, cosmetics, chemicals.	16	64
2. Marketing/Production of other pharmaceutical products, e.g., over-the-counter medicines	8	32
3. No diversification away from ethicals.	1	4
Totals	25	100
% Response to Question		100

7. How many finished goods warehouses or distribution depots does your Company maintain in Great Britain to serve the Home market?

		No. of Respondents	% of Total Response
1.	3 or more	5	20
2.	2	2	8
3.	1	18	72
	Totals	25	100
	% Response to Question		100

8. What channels of distribution does your Company use for its ethical products to the Home market?

		No. of Respondents	% of Total Response
1.	Through wholesalers only	1	4
2.	Through wholesalers and large hospitals	4	16
3.	Through wholesalers and all hospitals	4	16
4.	Through wholesalers, all hospitals and retailers (or retail buying groups)	3	12
5.	Through wholesalers, all hospitals and all retailers	13	52
	Totals	25	100
	% Response to Question		100

9. What is the average number of orders per day your Company receives for ethical products from Home customers?

		No. of Respondents	% of Total Response
1.	Less than 50	2	12
2.	50 - 100	4	23.33
3.	100 - 150	4	23.33
4.	150 - 200	3	18
5.	More than 200	4	23.33
	Totals	17	100.0
	% Response to Question		68

10. Over how many of the 8 logistics departments - Transport, Storage and Warehousing, Order Preparation and Packaging, Materials Handling, Documentation and Order Processing, Inventory Control, Production Scheduling, Purchasing - within your Company do you have responsibility for day-to-day running?

		No. of Respondents	% of Total Response
1.	4	11	55
2.	5	1	5
3.	6	5	25
4.	7	1	5
5.	8	2	10
	Totals	20	100
	% Response to Question		100

11. To what extent does your Company carry out its distribution to Home customers using its own, or leased, vehicles?

		No. of Respondents	% of Total Response
1.	For all distribution, except for certain odd consignments.	4	16
2.	Partly	9	36
3.	For local deliveries only	4	16
4.	None	8	32
	Totals	25	100
	% Response to Question		100

12. Does your Company regularly service its customers with scheduled deliveries?

		No. of Respondents	% of Total Response
1.	To all customers, maybe with a few exceptions.	5	20
2.	To certain sections of customers	3	12
3.	No	17	68
	Totals	25	100
	% Response to Question		100

13. For deliveries to customers, other than those that are scheduled, what mode of transport is predominantly used by your Company?

	No. of Respondents	% of Total Response
1. Road	8	40
2. Rail	2	10
3. Post	5	25
4. No predominant made	5	25
Totals	20	100
% Response to Question		100

14. What is the Home customer's average lead time from the time of placing the order with your Company to the time of receiving the goods?

	No. of Respondents	% of Total Response
1. 5 working days or less	8	34.8
2. 10 working days or less	13	56.5
3. 15 working days or less	2	8.7
Totals	23	100
% Response to Question		92

15. What average % item availability has your Company maintained during the last year on ethical products ready for immediate despatch?

	No. of Respondents	% of Total Response
1. 99 - 100%	7	30.5
2. 95 - 99%	9	39.2
3. 90 - 95%	3	12.9
4. Less than 90%	4	17.4
Totals	23	100
% Response to Question		92

16. What average stock levels for all ethical product lines does your Company hold as finished goods ready for despatch?

	No. of Respondents	% of Total Response
1. 1 month or less	2	13.33
2. 3 months or less	9	60.0
3. 6 months or less	2	13.33
4. Greater than 6 months	2	13.33
Totals	15	100.0
% Response to Question		60

17. Are the variations in lead time to your Company's customers within a group, e.g. wholesalers, retailers or hospitals, who are not on scheduled delivery routes, due to their geographical location or a priority customer policy of some sort?

	No. of Respondents	% of Total Response
1. Geographical location only	17	85
2. Priority customers	3	15
Totals	20	100
% Response to Question		100

18. Of the 8 logistics departments in your Company in what order would you place them with respect to their direct contribution to total logistics costs?

	*Points Scored	No.of Respon-ses	Average Points per Res-ponse	% Response to Question
1. Inventory Control(Inventory Investment)	160	20	8.0	100
2. Transportation	124	18	6.9	90
3. Order Preparation and Packaging	69	12	5.75	60
4. Order Processing and Documentation	39	8	4.9	40
5. Production Scheduling (Economic batch sizes, run lengths etc.)	28	6	4.66	30
6. Purchasing (Bulk discounts, selection of supplier etc.)	8	3	2.66	15
7. Storage and Warehousing	30	7	4.3	35
8. Materials Handling	15	6	2.5	30

*Points scoring system: 8 pts for 1st place; 7 pts for 2nd place; 6 pts for 3rd place; etc..... down to 1 pt. for 8th place.

19. In what logistics areas within your Company are you contemplating or have recently made, changes in the operations which have affected costs?

You can list more than one area, if applicable.

	No.of Responses	% of Total Response
1. Decreasing inventory levels of finished goods, product intermediaries and raw materials.	8	22.2
2. Increasing proportion of deliveries by road freight.	6	16.7
3. Increasing proportational use of air freight for exports.	5	13.8
4. Reducing the number of direct accounts.	5	13.8
5. Increasing the minimum order size.	3	8.3
6. Purchasing larger than normal quantities of raw materials to obtain bulk discounts.	2	5.6
7. Reducing the number of warehouses or distribution depots.	2	5.6
8. Installing shrink wrapping machine on packaging line.	1	2.8
9. Using only one carrier instead of several.	1	2.8
10. On-line packaging at end of pharmaceutical production process.	1	2.8
11. Consolidating loads for export by use of containers.	1	2.8
12. Ceasing scheduled deliveries to even out work load in warehouse.	1	2.8
Total No. of Responses	36	100.0
Total No. of Companies Responding		20
% Response to Question		80

20. In what logistics areas within your Company are you contemplating, or have recently made, changes in the operations which have affected customer lead times or service?

You can list more than one area, if applicable.

	No. of Responses	% of Total Response
1. Speeding up the order processing operation.	6	20.6
2. Making more accurate and frequent demand forecasts.	5	17.2
3. Using scheduled deliveries to customers.	4	13.8
4. Ensuring that production schedules were more flexible in event of demand changes.	3	10.3
5. Ensuring that purchasing was more flexible in reacting to demand changes.	3	10.3
6. Replacing present warehouse with an 'automated' one.	2	6.9
7. Appointing selected retail agencies	2	6.9
8. Increasing the storage capacity of the existing warehouse.	1	3.5
9. Using leased or public warehouses to provide extra storage capacity.	1	3.5
10. Building an additional warehouse.	1	3.5
11. Using an increased number of carriers for delivery to customers.	1	3.5
Total No. of Responses	29	100.0
Total No. of Companies Responding		18
% Response to Question		72

APPENDIX A

EXHIBIT 5

Questionnaire to Pharmaceutical Manufacturers

QUESTIONNAIRE

ALL OF THE FOLLOWING QUESTIONS RELATE TO HYPOTHETICAL CHANGES BEING MADE WITHIN YOUR COMPANY. THE CHANGES WOULD BE PROPOSED BY A DEPARTMENT WISHING TO EITHER DECREASE ITS COSTS, INCREASE ITS EFFECTIVENESS, OR BOTH.

I WOULD LIKE YOU TO CONSIDER THE EFFECTS ON THE OPERATIONS / DECISIONS LISTED DOWN THE SIDE FOR EACH CHANGE, IN TURN, WHERE THE EFFECTS COULD EITHER PUT UP OR BRING DOWN COMPANY COSTS.

1. PLEASE CONSIDER MAKING CHANGES A, B, C, D, E AND F (SEE OVER PAGE) ONE AT A TIME. THEN, OF THE OPERATIONS / DECISIONS LISTED DOWN THE LEFT-HAND COLUMN, SELECT FOUR THAT YOU THINK WOULD BE MOST AFFECTED BY THE CHANGE. SELECT FOUR OF THEM FOR <u>EACH</u> CHANGE AND RANK THEM IN ORDER OF RELATIVE MAGNITUDE OF EFFECT, 1, 2, 3 AND 4 (1 FOR MOST AFFECT, 2 FOR SECOND MOST AFFECT, ETC.) DOWN EACH COLUMN.

   PLEASE PUT NUMBERS 1, 2, 3 AND 4 IN APPROPRIATE BOXES FOR EACH CHANGE.

LIST OF OPERATIONS / DECISIONS (AFFECTING COST)	CHANGE A: <u>HOME</u> - USING ROAD FREIGHT INSTEAD OF RAIL FOR ALL SHIPMENTS OVER 10 LB WEIGHT TO CUSTOMERS IN NORTH ENGLAND AND SCOTLAND. <u>ABROAD</u> - INCREASING USE OF AIR FREIGHT TO SELECTED COUNTRIES.	CHANGE B: <u>INSTALLATION OF</u> A SHRINK WRAPPING MACHINE ON THE PACKAGING LINE FOR ALL GOODS TO HOME CUSTOMERS. PRIMARILY THIS WILL REDUCE PACKAGING LABOUR COSTS.	CHANGE C: <u>IMPOSING A</u> INCREASED MINIMUM OR SIZE OF £5 VALUE PER ORDER FROM CUSTOMER
SCHEDULING TIMES OF ARRIVAL AND DEPARTURE OF THE TRANSPORT FOR EACH DESPATCH OF CUSTOMER'S GOODS			
SELECTING INTERNAL WAREHOUSE DESIGN E.G. LAYOUT, SIZE, TYPE OF SHELVING AISLE WIDTH, ETC.			
DECIDING WHETHER TO USE, AND IF SO WHERE, PUBLIC AND/OR LEASED WAREHOUSES			
DESIGNING AND OPERATING SPECIAL STORAGE ARRANGEMENTS E.G. REFRIGERATION, HIGH SECURITY STORAGE			
MAINTAINING AND PROTECTING THE PHYSICAL CONDITION OF THE INVENTORY DURING STORAGE			
SELECTING AND OPERATING MATERIALS HANDLING EQUIPMENT FOR MOVEMENT OF MATERIALS WITHIN WAREHOUSE.			

CONTINUED OVER PAGE

PARING AND HANDLING OF SHIPP-
G DOCUMENTS, E.G. BILLS OF
DING, FREIGHT CONTRACTS, FREIGHT
LLS ETC.

EPARING AND HANDLING OF
VERNMENT DOCUMENTS E.G. EXPORT
CLARATIONS, CERTIFICATES OF
IGIN, INPORT LICENCES, ETC.

EPARING AND HANDLING OF INTERNAL
NTROL INFORMATION, E.G.
VENTORY CONTROLS, PRODUCTION
HEDULES, ETC.

TTING AND CONTROLLING INVEN-
RY LEVELS OF RAW MATERIALS AND
CKAGING COMPONENTS.

TTING AND CONTROLLING INVENTORY
VELS OF PRODUCTION INTERMED-
TES AND BULK PRODUCTS.

TTING AND CONTROLLING INVENTORY
VELS OF PACKED FINISHED GOODS.

HEDULING DATES FOR PRODUCTION
NS.

[illegible] OPERATIONS / DECISIONS ([illegible]ING COST)	CHANGE D: DECREASE BY 25% THE AGGREGATE INVENTORY LEVELS OF PRODUCT INTERMEDIATES AND BULK PRODUCTS HELD AT ALL STAGES OF PRODUCTION	CHANGE E: DECREASE BY 2 WEEKS SUPPLY THE INVENTORY LEVELS OF EACH PRODUCT IN PACKED FORM READY FOR DESPATCH	CHANGE F: PURCHASE LARGER THAN NORMAL QUANTITIES OF SOME RAW MATERIALS TO OBTAIN SUBSTANTIAL BULK BUYING DISCOUNT TERMS.
SCHEDULING TIMES OF ARRIVAL AND DEPARTURE OF THE TRANSPORT FOR EACH DESPATCH OF CUSTOMER'S GOODS	☐	☐	☐
SELECTING INTERNAL WAREHOUSE DESIGN E.G. LAYOUT, SIZE, TYPE OF SHELVING AISLE WIDTH, ETC.	☐	☐	☐
DECIDING WHETHER TO USE, AND IF SO WHERE, PUBLIC AND/OR LEASED WAREHOUSES	☐	☐	☐
DESIGNING AND OPERATING SPECIAL STORAGE ARRANGEMENTS E.G. REFRIGERATION, HIGH SECURITY STORAGE	☐	☐	☐
MAINTAINING AND PROTECTING THE PHYSICAL CONDITION OF THE INVENTORY DURING STORAGE	☐	☐	☐
SELECTING AND OPERATING MATERIALS HANDLING EQUIPMENT FOR MOVEMENT OF MATERIALS WITHIN WAREHOUSE.	☐	☐	☐
PREPARING AND HANDLING OF SHIPPING DOCUMENTS, E.G. BILLS OF LADING, FREIGHT CONTRACTS, FREIGHT BILLS, ETC.	☐	☐	☐
PREPARING AND HANDLING OF GOVERNMENT DOCUMENTS E.G. EXPORT DECLARATIONS, CERTIFICATES OF ORIGIN, INPORT LICENCES, ETC.	☐	☐	☐
PREPARING AND HANDLING OF INTERNAL CONTROL INFORMATION, E.G. INVENTORY CONTROLS, PRODUCTION SCHEDULES, ETC.	☐	☐	☐
SETTING AND CONTROLLING INVENTORY LEVELS OF RAW MATERIALS AND PACKAGING COMPONENTS	☐	☐	☐
SETTING AND CONTROLLING INVENTORY LEVELS OF PRODUCTION INTERMEDIATES AND BULK PRODUCTS	☐	☐	☐
SETTING AND CONTROLLING INVENTORY LEVELS OF PACKED FINISHED GOODS	☐	☐	☐
SCHEDULING DATES FOR PRODUCTION RUNS.	☐	☐	☐

PLEASE CONSIDER MAKING CHANGES A, B, C, D, E AND F (AS BEFORE) ONE AT A TIME, BUT WITH A NEW LIST OF OPERATIONS / DECISIONS. THIS TIME, SELECT SIX THAT YOU THINK WOULD BE MOST AFFECTED BY THE CHANGE. SELECT 6 OF THEM FOR EACH CHANGE AND RANK THEM IN ORDER OF MAGNITUDE OF EFFECT 1, 2, 3, 4, 5 AND 6 (1 FOR MOST AFFECT, 2 FOR SECOND MOST AFFECT, ETC.) DOWN EACH COLUMN.

PLEASE PUT NUMBERS 1, 2, 3, 4, 5 AND 6 IN APPROPRIATE VACANT BOXES FOR EACH CHANGE.

OF OPERATIONS / DECISIONS ECTING COST)	CHANGE A: HOME-USING ROAD FREIGHT INSTEAD OF RAIL FOR ALL SHIPMENTS OVER 10 LB. WEIGHT TO CUSTOMERS IN NORTH ENGLAND AND SCOTLAND. ABROAD - INCREASING USE OF AIR FREIGHT TO SELECTED COUNTRIES	CHANGE B: INSTALLATION OF A SHRINK WRAPPING MACHINE ON THE PACKAGING LINE FOR PACKAGING ALL GOODS TO HOME CUSTOMERS. PRIMARILY THIS WILL REDUCE PACKAGING LABOUR COSTS.	CHANGE C: IMPOSING AN INCREASED MINIMUM ORDER SIZE OF £50 VALUE PER ORDER FROM ANY CUSTOMER.
CTING THE METHOD OF TRANSPORT DELIVERY OF EACH SHIPMENT TO OMERS, WHETHER AT HOME OR AD			
CTING THE SPECIFIC CARRIER WILL PROVIDE THE REQUIRED OD OF TRANSPORT			
RTAINING THE PROPER CLASS-ATION DESCRIPTIONS, PACKING IREMENTS, RATES, ETC. FOR SHIPMENT			
RVISING THE ACTUAL DESPATCH HE PARCELS AND PACKAGES THE WAREHOUSE			
OLIDATING AND POOLING TO ADVANTAGE OF CARLOAD RATES, AINERISATION, ETC., CIALLY EXPORTS.			
RING THE SHIPMENTS DURING SIT			
KING ON PROGRESS OF THE DES-IED GOODS; MAKING SURE THEY ARRIVED ON TIME; ARRANGING SPECIAL SERVICES			
ATING, CONTROLLING AND TAINING A COMPANY-OWNED, OR D, FLEET OF VEHICLES			
DING WHETHER TO USE FREIGHT ARDERS AND TO WHAT EXTENT, IANDLING EXPORT AND IMPORT IENTS			

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MANAGING TRANSPORT RATE NEGOTIATIONS, ADJUSTMENTS, NEW CLASSIFICATIONS, LEGISLATION, ETC. FOR THE COMPANY	☐	☐	☐
ROUTING OF SHIPMENTS AT HOME AND ABROAD; SELECTING POINTS OF INTERNATIONAL ENTRY AND EXIT	☐	☐	☐
ORDER PICKING FROM WAREHOUSE SHELVES TO MAKE UP INDIVIDUAL CUSTOMERS' ORDERS	☐	☐	☐
SELECTING AND OPERATING MATERIALS HANDLING EQUIPMENT FOR MOVING MATERIALS BETWEEN WAREHOUSE AND PLANT	☐	☐	☐
SELECTING AND OPERATING MATERIALS HANDLING EQUIPMENT FOR MOVING MATERIALS WITHIN THE WAREHOUSE	☐	☐	☐
PREPARING AND HANDLING OF SHIPPING DOCUMENTS, E.G. BILLS OF LADING, FREIGHT CONTRACTS, FREIGHT BILLS, ETC.	☐	☐	☐
PREPARING AND HANDLING OF GOVERNMENT DOCUMENTS, E.G. EXPORT DECLARATIONS, CERTIFICATES OF ORIGIN, IMPORT LICENCES, ETC.	☐	☐	☐
HANDLING OF FINANCIAL DOCUMENTS, E.G. CREDIT CONTROL, LETTERS OF CREDIT, INVOICES, ETC.	☐	☐	☐
AUDITING AND ARRANGING FOR PAYMENTS OF FREIGHT BILLS, CUSTOMS DUTY, INSURANCE PREMIUMS ETC.	☐	☐	☐
RECEIVING AND PROCESSING OF CUSTOMERS' ORDERS, SENDING COPIES TO WAREHOUSE AND INVOICE SECTION	☐	☐	☐
RECEIVING AND FOLLOWING UP ON CUSTOMER COMPLAINTS, E.G. LOSS AND DAMAGE CLAIMS, OVERCHARGE CLAIMS, RETURN OF UNSOLD GOODS ETC.	☐	☐	☐
DECIDING MINIMUM ORDER SIZE AND MINIMUM ORDERING FREQUENCY BY CUSTOMERS	☐	☐	▨
DETERMINING THE BATCH SIZES OR LENGTHS OF PRODUCTION RUNS, AT EACH PRODUCTION STAGE	☐	☐	☐
DETERMINING HOW MUCH OF EACH RAW MATERIAL AND PACKAGING COMPONENTS TO BUY AT A TIME	☐	☐	☐
DECIDING WHEN THESE DELIVERIES OF RAW MATERIALS AND PACKAGING COMPONENTS SHOULD BE DELIVERED	☐	☐	☐
DECIDING WHICH SUPPLIERS TO	☐	☐	☐

I OF OPERATIONS / DECISIONS FECTING COSTS)	CHANGE D: DECREASE BY 25% THE AGGREGATE INVENTORY LEVELS OF PRODUCT INTERMEDIATES AND BULK PRODUCTS HELD AT ALL STAGES OF PRODUCTION	CHANGE E: DECREASE BY 2 WEEKS SUPPLY THE INVENTORY LEVELS OF EACH PRODUCT IN PACKED FORM READY FOR DESPATCH	CHANGE F: PURCHASE LARGER THAN NORMAL QUANTITIES OF SOME RAW MATERIALS TO OBTAIN SUBSTANTIAL BULK BUYING DISCOUNT TERMS
.ECTING THE METHOD OF TRANSPORT ₹ DELIVERY OF EACH SHIPMENT TO ;TOMERS, WHETHER AT HOME OR ₹OAD	☐	☐	☐
.ECTING THE SPECIFIC CARRIER) WILL PROVIDE THE REQUIRED THOD OF TRANSPORT	☐	☐	☐
:ERTAINING THE PROPER CLASSICATION DESCRIPTIONS, PACKING QUIREMENTS, RATES, ETC. FOR :H SHIPMENT	☐	☐	☐
'ERVISING THE ACTUAL DESPATCH THE PARCELS AND PACKAGES)M THE WAREHOUSE	☐	☐	☐
ISOLIDATING AND POOLING TO (E ADVANTAGE OF CARLOAD RATES, ITAINERISATION, ETC., 'ECIALLY EXPORTS	☐	☐	☐
;URING THE SHIPMENTS DURING ANSIT	☐	☐	☐
:CKING ON PROGRESS OF THE DESTCHED GOODS; MAKING SURE THEY /E ARRIVED ON TIME; ARRANGING ₹ SPECIAL SERVICES	☐	☐	☐
:RATING, CONTROLLING AND INTAINING A COMPANY-OWNED, OR ASED, FLEET OF VEHICLES	☐	☐	☐
:IDING WHETHER TO USE FREIGHT ₹WARDERS AND TO WHAT EXTENT, ₹ HANDLING EXPORT AND IMPORT IPMENTS	☐	☐	☐
IAGING TRANSPORT RATE NEGOTIA)NS, ADJUSTMENTS, NEW CLASSIFATIONS, LEGISLATION, ETC. FOR : COMPANY	☐	☐	☐
JTING OF SHIPMENTS AT HOME) ABROAD; SELECTING POINTS OF TERNATIONAL ENTRY AND EXIT	☐	☐	☐
)ER PICKING FROM WAREHOUSE :LVES TO MAKE UP INDIVIDUAL ;TOMERS' ORDERS	☐	☐	☐

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SELECTING AND OPERATING MATERIALS HANDLING EQUIPMENT FOR MOVING MATERIALS BETWEEN WAREHOUSE AND PLANT	☐	☐	☐
SELECTING AND OPERATING MATERIALS HANDLING EQUIPMENT FOR MOVING MATERIALS WITHIN THE WAREHOUSE	☐	☐	☐
PREPARING AND HANDLING OF SHIPPING DOCUMENTS, E.G. BILLS OF LADING, FREIGHT CONTRACTS, FREIGHT BILLS, ETC.	☐	☐	☐
PREPARING AND HANDLING OF GOVERNMENT DOCUMENTS, E.G. EXPORT DECLARATIONS, CERTIFICATES OF ORIGIN, IMPORT LICENCES, ETC.	☐	☐	☐
HANDLING OF FINANCIAL DOCUMENTS, E.G. CREDIT CONTROL, LETTERS OF CREDIT, INVOICES, ETC.	☐	☐	☐
AUDITING AND ARRANGING FOR PAYMENTS OF FREIGHT BILLS, CUSTOM DUTY, INSURANCE PREMIUMS ETC.	☐	☐	☐
RECEIVING AND PROCESSING OF CUSTOMERS' ORDERS, SENDING COPIES TO WAREHOUSE AND INVOICE SECTION	☐	☐	☐
RECEIVING AND FOLLOWING UP ON CUSTOMER COMPLAINTS, E.G. LOSS AND DAMAGE CLAIMS, OVERCHARGE CLAIMS, RETURN OF UNSOLD GOODS ETC.	☐	☐	☐
DECIDING MINIMUM ORDER SIZE AND MINIMUM ORDERING FREQUENCY BY CUSTOMERS	☐	☐	☐
DETERMINING THE BATCH SIZES OR LENGTHS OF PRODUCTION RUNS, AT EACH PRODUCTION STAGE	☐	☐	☐
DETERMINING HOW MUCH OF EACH RAW MATERIAL AND PACKAGING COMPONENTS TO BUY AT A TIME	☐	☐	▨
DECIDING WHEN THESE DELIVERIES OF RAW MATERIALS AND PACKAGING COMPONENTS SHOULD BE DELIVERED	☐	☐	☐
DECIDING WHICH SUPPLIERS TO PURCHASE FROM	☐	☐	☐

PLEASE CONSIDER MAKING CHANGES A. B. C. D. E AND F (AS BEFORE) ONE AT A TIME, BUT WITH ANOTHER LIST OF OPERATIONS / DECISIONS. THIS TIME SELECT TWO THAT YOU THINK WOULD BE MOST AFFECTED BY THE CHANGE. SELECT 2 OF THEM FOR EACH CHANGE AND RANK THEM IN ORDER OF MAGNITUDE OF EFFECT, 1 AND 2, DOWN EACH COLUMN.

PLEASE PUT NUMBERS 1 AND 2 IN APPROPRIATE VACANT BOXES FOR EACH CHANGE.

ST OF OPERATIONS / DECISIONS FFECTING COSTS)	CHANGE A: HOME - USING ROAD FREIGHT INSTEAD OF RAIL FOR ALL SHIPMENTS OVER 10 LB.WEIGHT TO CUSTOMERS IN NORTH ENGLAND AND SCOTLAND ABROAD - INCREASING USE OF AIR FREIGHT TO SELECTED COUNTRIES.	CHANGE B: INSTALLATION OF A SHRINK WRAPPING MACHINE ON THE PACKAGING LINE FOR PACKAGING ALL GOODS TO HOME CUSTOMERS. PRIMARILY THIS WILL REDUCE PACKAGING LABOUR COSTS.	CHANGE C: IMPOSING AN INCREASED MINIMUM ORDER SIZE OF £50 VALUE PER ORDER FROM ANY CUSTOMER
SIGN OF PACKAGING METHODS THIN THE WAREHOUSE, E.G. LLETS, MACHINES, NTAINERS, ETC.	☐	▨	☐
LECTING THE PRIMARY PACK: PE, SIZE, MATERIAL ETC.	☐	☐	☐
LECTING THE OUTER PACKAGE DESPATCH: TYPE, SIZE, TERIAL, DEGREE OF STANDARDATION, ETC.	☐	☐	☐
KAGING OPERATION: PARCELIG UP ORDERS FOR DESPATCH CUSTOMERS	☐	☐	☐
ERMINING WHICH PRODUCT IS BE PRODUCED IN A MULTI DUCT PLANT AT ANY ONE TIME.	☐	☐	☐

.IST OF OPERATIONS / DECISIONS (AFFECTING COSTS)	CHANGE D: DECREASE BY 25% THE AGGREGATE INVENTORY LEVELS OF PRODUCT INTERMEDIATES AND BULK PRODUCTS HELD AT ALL STAGES OF PRODUCTION	CHANGE E: DECREASE BY 2 WEEKS SUPPLY THE INVENTORY LEVELS OF EACH PRODUCT IN PACKED FORM READY FOR DESPATCH	CHANGE F: PURCHA LARGER THAN NORM QUANTITIES OF SO RAW MATERIALS TO OBTAIN SUBSTANTI BULK BUYING DISC TERMS.
)ESIGN OF PACKAGING METHODS ITHIN THE WAREHOUSE, E.G. 'ALLETS, MACHINES, :ONTAINERS, ETC.			
;ELECTING THE PRIMARY PACK: TYPE, SIZE, MATERIAL ETC.			
;ELECTING THE OUTER PACKAGE FOR DESPATCH: TYPE, SIZE, MATERIAL, DEGREE OF STANDARD-ISATION, ETC.			
'ACKAGING OPERATION: PARCEL-.ING UP ORDERS FOR DESPATCH TO CUSTOMERS			
)ETERMINING WHICH PRODUCT IS TO BE PRODUCED IN A MULTI 'RODUCT PLANT AT ANY ONE TIME			

THE QUESTIONS SO FAR HAVE BEEN CONCERNED WITH IDENTIFYING HOW A CHANGE WITHIN THE COMPANY :OULD ALTER THE TOTAL COMPANY COSTS BY ITS EFFECTS ON OTHER OPERATIONS / DECISIONS.

THE REMAINING QUESTIONS DEAL WITH HOW A CHANGE WITHIN THE COMPANY CAN EFFECT THE TIMING OR SPEED OF CARRYING OUT OTHER OPERATIONS, EITHER DIRECTLY, OR INDIRECTLY, THROUGH EFFECTS ON DECISIONS RELATED TO TIMING.

[ASE INDICATE BELOW WHICH OF THE DECISIONS LISTED DOWN THE LEFT-HAND COLUMN IS LIKELY
BE AFFECTED BY EACH OF THE PROPOSED CHANGES G, H, I, J, K AND L, CONSIDERED IN TURN.

CK VACANT BOXES APPROPRIATE TO AFFECTED DECISIONS, FOR EACH CHANGE.

OF DECISIONS ECTING TIMES)	CHANGE G: DECIDING TO SERVICE ALL WHOLESALER CUSTOMERS IN BRITAIN WITH A SCHEDULED VAN DELIVERY, CALLING ONCE EVERY FORT-NIGHT	CHANGE H: DECIDING TO REDUCE AISLE WIDTH WITHIN THE WAREHOUSE IN ORDER TO INCREASE THE STORING CAPACITY OF THE EXISTING WAREHOUSE WITHOUT NEED TO EXPAND OR BUILD/RENT ADDIT-IONAL WAREHOUSE	CHANGE I: DECIDING TO USE A PUBLIC WAREHOUSE IN THE MIDLANDS AS AN EXTRA TO PRESENT WAREHOUSE CAPACITY AT PLANT. WILL BE USED FOR STORING FINISHED GOODS READY FOR DISTRIBUTION TO HOME CUSTOMERS
CTION OF INTERNAL HOUSE DESIGN, E.G. UT, SIZE, TYPE OF VING, AISLE WIDTH,	☐	[shaded]	☐
DING WHETHER TO USE IF SO, WHERE PUBLIC OR LEASED WAREHOUSES	☐	☐	[shaded]
GNING SPECIAL STORAGE NGEMENT, E.G. IGERATION, HIGH RITY STORAGE	☐	☐	☐
CTING MATERIALS HANDLING PMENT FOR MOVEMENT OF RIALS WITHIN A WARE-E	☐	☐	☐
ING INVENTORY LEVELS OF MATERIALS AND PACKAGING ONENTS	☐	☐	☐
ING INVENTORY LEVELS OF JCTION INTERMEDIATES AND PRODUCTS	☐	☐	☐
ING INVENTORY LEVELS OF D FINISHED GOODS	☐	☐	☐
ULING DATES FOR COMMEN-IT AND COMPLETION OF JCTION RUNS FOR EACH JCTION STAGE	☐	☐	☐

LIST OF DECISIONS (AFFECTING TIMES)	CHANGE J: SPEEDING UP THE ORDER PROCESSING OPERATION SO THAT ALL ORDERS RECEIVED DURING A MORNING ARE TRANSMITTED TO THE WAREHOUSE BY 3 PM THAT DAY. PREVIOUSLY ORDERS WOULD TAKE A WHOLE DAY TO BE PROCESSED	CHANGE K: DECIDING TO BEGIN A LONG PRODUCTION RUN OF THE HIGHEST TURNOVER PRODUCT OF THE COMPANY 2 WEEKS EARLY DUE TO A SEASONAL UPSURGE IN DEMAND	CHANGE L: DECIDING TO BRING FORWARD DELIVERIES OF RAW MATERIALS AND COMPONENTS TO MEET EARLIER, THAN ORIGINALLY PLANNED PRODUCTION SCHEDUL
SELECTION OF INTERNAL WAREHOUSE DESIGN, E.G. LAYOUT, SIZE, TYPE OF SHELVING, AISLE WIDTH, ETC.	☐	☐	☐
DECIDING WHETHER TO USE AND, IF SO, WHERE PUBLIC AND/OR LEASED WAREHOUSES	☐	☐	☐
DESIGNING SPECIAL STORAGE ARRANGEMENT, E.G. REFRIGERATION, HIGH SECURITY STORAGE	☐	☐	☐
SELECTING MATERIALS HANDLING EQUIPMENT FOR MOVEMENT OF MATERIALS WITHIN A WAREHOUSE	☐	☐	☐
SETTING INVENTORY LEVELS OF RAW MATERIALS AND PACKAGING COMPONENTS	☐	☐	☐
SETTING INVENTORY LEVELS OF PRODUCTION INTERMEDIATES AND BULK PRODUCTS	☐	☐	☐
SETTING INVENTORY LEVELS OF PACKED FINISHED GOODS	☐	☐	☐
SCHEDULING DATES FOR COMMENCEMENT AND COMPLETION OF PRODUCTION RUNS FOR EACH PRODUCTION STAGE	☐	▨	☐

PLEASE CONSIDER, AGAIN, MAKING CHANGES G, H, I, J, K AND L AND ALSO CONSIDER THOSE DECISIONS WHICH YOU HAVE MARKED UNDER EACH OF THESE CHANGES IN THE PREVIOUS QUESTIONS.

OF THE OPERATIONS LISTED DOWN THE LEFT-HAND COLUMN, SELECT TWO THAT YOU THINK WOULD BE MOST AFFECTED BOTH BY THE CHANGE ITSELF AND THE APPROPRIATELY AFFECTED DECISIONS. SELECT TWO OF THEM FOR EACH CHANGE / DECISIONS AND RANK THEM 1 AND 2 DOWN EACH COLUMN.

PLEASE PUT NUMBERS 1 AND 2 IN APPROPRIATE VACANT BOXES FOR EACH CHANGE.

T OF OPERATIONS FECTING TIMES)	CHANGE G: DECIDING TO SERVICE ALL WHOLESALER CUSTOMERS IN BRITAIN WITH A SCHEDULED VAN DELIVERY CALLING ONCE A FORTNIGHT	CHANGE H: DECIDING TO REDUCE AISLE WIDTH WITHIN THE WAREHOUSE IN ORDER TO INCREASE THE STORAGE CAPACITY OF THE EXISTING WARE-HOUSE WITHOUT NEED TO EXPAND OR BUILD/ RENT ADDITIONAL WAREHOUSE	CHANGE I: DECIDING TO USE A PUBLIC WAREHOUSE IN THE MIDLANDS AS AN ADDITION TO PRESENT WAREHOUSE CAPACITY AT THE PLANT. WILL BE USED FOR STORING FINISHED GOODS FOR DISTRIBUTION TO HOME CUSTOMERS
E OF TRANSPORTATION FOR H DELIVERY OF GOODS TO TOMER			
E SPENT IN OPERATING CIAL STORAGE FACILITIES , REFRIGERATION, HIGH JRITY STORAGE			
E SPENT IN MAINTENANCE PROTECTION OF THE NTORY DURING STORAGE			
SPENT IN OPERATING RIALS HANDLING EQUIP- FOR MOVEMENT OF RIALS WITHIN WAREHOUSE			
SPENT IN HANDLING AND ING IN SHIPPING DOCUMENTS BILLS OF LADING, FREIGHT RACTS, FREIGHT BILLS.			
SPENT IN HANDLING AND ING IN GOVERNMENT DOCU- S E.G. EXPORT DECLARATION IFICATES OF ORIGIN, RT LICENCES ETC			
SPENT IN HANDLING RNAL CONTROL INFORMATION INVENTORY CONTROLS, UCTION SCHEDULES, ETC.			

List of operations (affecting times)	Change J: speeding up the order processing operation so that all orders received during a morning are transmitted to the warehouse by 3pm that day. Previously orders would take a whole day to be processed	Change K: deciding to begin a long production run of the highest turnover product of the company 2 weeks early due to a seasonal upsurge in demand	Change L: deciding to bring forward deliveries of raw materials and components to meet earlier, than originally planned, production schedules
Time of transportation for each delivery of goods to customer	☐	☐	☐
Time spent in operating special storage facilities e.g. refrigeration, high security storage	☐	☐	☐
Time spent in maintenance and protection of the inventory during storage	☐	☐	☐
Time spent in operating materials handling equipment for movement of materials within warehouse	☐	☐	☐
Time spent in handling and filling in shipping documents e.g. bills of lading, freight contracts, freight bills	☐	☐	☐
Time spent in handling and filling in government documents e.g. export declaration certificates or origin, import licences etc.	☐	☐	☐
Time spent in handling internal control information e.g. inventory controls, production schedules, etc.	☐	☐	☐

6. Please consider making changes G, H, I, J, K and L, as before, one at a time but with a new list of decisions. Indicate which are the most likely to be affected by each change by ticking the appropriate boxes.

List of decisions (affecting times)	Change G: deciding to service all wholesale customers in Britain with a scheduled van delivery, calling once every fortnight	Change H: deciding to reduce aisle width within the warehouse in order to increase the storage capacity of the existing warehouse without need to expand or build/rent an additional warehouse	Change I: deciding to use a public warehouse in the Midlands as as addition to present warehouse capacity at plant. It would be used for storing finished goods for distribution to home customers
;electing the method of transport for delivering each shipment from iarehouse to customer, at home ind abroad	☐	☐	☐
;electing the specific carriers iho will provide the required iethod of transport	☐	☐	☐
iscertaining the proper classification descriptions, packing iequirements, rates, etc. for ach shipment	☐	☐	☐
ieciding on the terms of insurance or each shipment	☐	☐	☐
ieciding whether to run a company wned or leased, fleet of vehicles	☐	☐	☐
ieciding whether to use freight orwarders and to what extent for xports/imports	☐	☐	☐
electing materials handling equipent for moving materials within he warehouse	☐	☐	☐
electing materials handling equipent for moving materials between arehouse and plant and vice versa	☐	☐	☐
eciding minimum order size and inimum ordering frequency by ustomers	☐	☐	☐
eciding on the batch sizes or umber of batches, for runs at each roduction stage	☐	☐	☐
etermining how much of each raw aterial and packaging component o be purchased at a time	☐	☐	☐
eciding when these deliveries of aw materials and packaging omponents are to be made	☐	☐	☐
eciding from which suppliers to ake the purchases	☐	☐	☐

LIST OF DECISIONS (AFFECTING TIMES)	CHANGE J: SPEEDING UP THE ORDER PROCESSING OPERATION SO THAT ALL ORDERS RECEIVED DURING A MORNING ARE TRANSMITTED TO THE WAREHOUSE BY 3 PM THAT DAY. PREVIOUSLY ORDERS WOULD TAKE A WHOLE DAY TO BE PROCESSED	CHANGE K: DECIDING TO BEGIN A LONG PRODUCTION RUN OF THE HIGHEST TURNOVER PRODUCT OF THE COMPANY 2 WEEKS EARLY DUE TO A SEASONAL UPSURGE IN DEMAND	CHANGE L: DECIDING TO BRING FORWARD DELIVERIES OF RAW MATERIALS AND COMPONENTS TO MEET EARLIER, THAN ORIGINALLY PLANNED PRODUCTION SCHEDULES
SELECTING THE METHOD OF TRANSPORT FOR DELIVERING EACH SHIPMENT FROM WAREHOUSE TO CUSTOMER, AT HOME AND ABROAD	☐	☐	☐
SELECTING THE SPECIFIC CARRIERS WHO WILL PROVIDE THE REQUIRED METHOD OF TRANSPORT	☐	☐	☐
ASCERTAINING THE PROPER CLASSIFICATION DESCRIPTIONS, PACKING REQUIREMENTS, RATES, ETC. FOR EACH SHIPMENT	☐	☐	☐
DECIDING ON THE TERMS OF INSURANCE FOR EACH SHIPMENT	☐	☐	☐
DECIDING WHETHER TO RUN A COMPANY OWNED OR LEASED, FLEET OF VEHICLES	☐	☐	☐
DECIDING WHETHER TO USE FREIGHT FORWARDERS AND TO WHAT EXTENT FOR EXPORTS/IMPORTS	☐	☐	☐
SELECTING MATERIALS HANDLING EQUIPMENT FOR MOVING MATERIALS WITHIN THE WAREHOUSE	☐	☐	☐
SELECTING MATERIALS HANDLING EQUIPMENT FOR MOVING MATERIALS BETWEEN WAREHOUSE AND PLANT AND VICE VERSA	☐	☐	☐
DECIDING MINIMUM ORDER SIZE AND MINIMUM ORDERING FREQUENCY BY CUSTOMERS	☐	☐	☐
DECIDING ON THE BATCH SIZES OR NUMBER OF BATCHES, FOR RUNS AT EACH PRODUCTION STAGE	☐	☐	☐
DETERMINING HOW MUCH OF EACH RAW MATERIAL AND PACKAGING COMPONENT TO BE PURCHASED AT A TIME	☐	☐	☐
DECIDING WHEN THESE DELIVERIES OF RAW MATERIALS AND PACKAGING COMPONENTS ARE TO BE MADE	☐	☐	☐
DECIDING FROM WHICH SUPPLIERS TO MAKE THE PURCHASES	☐	☐	☐

PLEASE CONSIDER AGAIN MAKING CHANGES G, H, I, J, K AND L AND ALSO CONSIDER THOSE DECISIONS WHICH YOU HAVE MARKED UNDER EACH OF THESE CHANGES IN THE PREVIOUS QUESTION.

OF THE OPERATIONS LISTED DOWN THE LEFT-HAND COLUMN, THIS TIME SELECT FOUR THAT YOU THINK WOULD BE MOST AFFECTED BOTH BY THE CHANGE ITSELF AND THE APPROPRIATELY AFFECTED DECISIONS. SELECT FOUR OF THEM FOR EACH CHANGE / DECISIONS AND RANK THEM IN RELATIVE ORDER OF MAGNITUDE OF EFFECT, 1, 2, 3 AND 4, DOWN EACH COLUMN (1 = MOST AFFECT, 2 = SECOND MOST AFFECT, ETC.).

PLEASE PUT NUMBERS 1, 2, 3 AND 4 IN APPROPRIATE BOXES FOR EACH CHANGE.

ST OF OPERATIONS FFECTING TIMES)	CHANGE G: DECIDING TO SERVICE ALL WHOLESALE CUSTOMERS IN BRITAIN WITH A SCHEDULED VAN DELIVERY CALLING ONCE EVERY FORTNIGHT	CHANGE H: DECIDING TO REDUCE AISLE WIDTH WITHIN THE WAREHOUSE IN ORDER TO INCREASE THE STORAGE CAPACITY OF THE EXISTING WAREHOUSE WITHOUT NEED TO EXPAND OR BUILD/ RENT AN ADDITIONAL WAREHOUSE	CHANGE I: DECIDING TO USE A PUBLIC WAREHOUSE IN THE MIDLANDS AS AN ADDITION TO PRESENT WAREHOUSE CAPACITY AT THE PLANT. IT WOULD BE USED FOR STORING FINISHED GOODS FOR DISTRIBUTION TO HOME CUSTOMERS
ME SPENT IN SUPERVISING THE TUAL DESPATCH OF THE PARCELS OM THE WAREHOUSE, INCLUDING IGHING AND CHECKING	☐	☐	☐
ME DELAY IN CONSOLIDATING D POOLING TO TAKE ADVANTAGE CARLOAD RATES, CONTAINER- ATION ETC. FOR EXPORTS	☐	☐	☐
ME SPENT IN CHECKING THE OGRESS OF DESPATCHED GOODS D ARRANGING FOR SPECIAL ANSPORT SERVICES IF NECESSARY	☐	☐	☐
ME SPENT IN TRANSPORT OF NISHED GOODS TO CUSTOMERS ING CUSTOMER-OWNED OR ASED, FLEET OF VEHICLES	☐	☐	☐
ME SPENT IN MANAGING TRANS- RT RATE NEGOTIATIONS, ADJUST- NTS, LEGISLATION, ETC. FOR E COMPANY	☐	☐	☐
ME SPENT IN ROUTING SHIPMENTS HOME AND ABROAD; SELECTING TERNATIONAL POINTS OF ENTRY D EXIT	☐	☐	☐
ME TAKEN TO PICK ORDERS FROM E WAREHOUSE SHELVES TO MAKE CUSTOMER ORDERS	☐	☐	☐
ME SPENT IN HANDLING MATER- LS BETWEEN WAREHOUSE AND	☐	☐	☐

TIME SPENT IN HANDLING AND FILLING IN GOVERNMENT DOCUMENTS E.G. EXPORT DECLARATIONS, CERTIFICATES OR ORIGIN, IMPORT LICENCES

TIME SPENT IN HANDLING AND FILLING IN FINANCIAL DOCUMENTS E.G. CREDIT CONTROL, LETTERS OF CREDIT, INVOICES

TIME SPENT IN AUDITING AND ARRANGING FOR PAYMENT OF FREIGHT BILLS, CUSTOMS DUTY, INSURANCE PREMIUMS

TIME TAKEN TO RECEIVE AND PROCESS ORDERS, SENDING COPIES TO WAREHOUSE AND INVOICE SECTION

TIME SPENT IN FOLLOWING UP ON CUSTOMER COMPLAINTS E.G. LOSS AND DAMAGE CLAIMS, OVERCHARGE CLAIMS, RETURN OF UNSOLD GOODS.

. P[illegible] CONSIDER MAKING CHANGES G, H, I, J, K AND L, AS BEFORE, ONE AT A TIME BUT WITH A NEW LIST OF DECISIONS

INDICATE WHICH ARE THE MOST LIKELY TO BE AFFECTED BY EACH CHANGE BY TICKING THE APPROPRIATE BOXES.

ST OF DECISIONS FFECTING TIMES)	CHANGE G: DECIDING TO SERVICE ALL WHOLESALE CUSTOMERS IN BRITAIN WITH A SCHEDULED VAN DELIVERY, CALLING ONCE EVERY FORTNIGHT	CHANGE H: DECIDING TO REDUCE AISLE WIDTH WITHIN THE WAREHOUSE IN ORDER TO INCREASE THE STORAGE CAPACITY OF THE EXISTING WAREHOUSE WITHOUT NEED TO EXPAND OR BUILD/RENT AN ADDITIONAL WAREHOUSE	CHANGE I: DECIDING TO USE A PUBLIC WAREHOUSE IN THE MIDLANDS AS AN ADDITION TO PRESENT WAREHOUSE CAPACITY AT THE PLANT. IT WOULD BE USED FOR STORING FINISHED GOODS FOR DISTRIBUTION TO HOME CUSTOMERS
:IDING ON THE DESIGN OF :KAGING METHODS WITHIN THE REHOUSE	☐	☐	☐
.ECTING THE PRIMARY PACK: PE, SIZE, MATERIAL, ETC.	☐	☐	☐
.ECTING THE OUTER PACKAGE: PE, SIZE, MATERIAL, DEGREE STANDARDISATION, STRENGTH :.	☐	☐	☐
:IDING WHICH PRODUCT IS TO PRODUCED IN A MULTI-)DUCT PLANT AT ANY ONE TIME	☐	☐	☐

ST OF DECISIONS FFECTING TIMES)	CHANGE J: SPEEDING UP THE ORDER PROCESSING OPERATION SO THAT ALL ORDERS RECEIVED DURING A MORNING ARE TRANSMITTED TO THE WAREHOUSE BY 3 PM THAT DAY. PREVIOUSLY ORDERS WOULD TAKE A WHOLE DAY TO BE PROCESSED	CHANGE K: DECIDING TO BEGIN A LONG PRODUCTION RUN OF THE HIGHEST TURNOVER PRODUCT OF THE COMPANY 2 WEEKS EARLY DUE TO A SEASONAL UPSURGE IN DEMAND	CHANGE L: DECIDING TO BRING FORWARD DELIVERIES OF RAW MATERIALS AND COMPONENTS TO MEET EARLIER, THAN ORIGINALLY PLANNED, PRODUCTION SCHEDULES
:CIDING ON THE DESIGN OF CKAGING METHODS WITHIN THE REHOUSE	☐	☐	☐
:LECTING THE PRIMARY PACK: 'PE, SIZE, MATERIAL, ETC.	☐	☐	☐
:LECTING THE OUTER PACKAGE: 'PE, SIZE, MATERIAL, DEGREE STANDARDISATION, STRENGTH C.	☐	☐	☐
CIDING WHICH PRODUCT IS TO PRODUCED IN A MULTI- ODUCT PLANT AT ANY ONE TIME	☐	☐	☐

9. AS A RESULT OF CHANGES G, H, I, J, K AND L, AND ALSO AS A RESULT OF EFFECTS ON THOSE DECISIONS WHICH YOU HAVE MARKED UNDER EACH OF THESE CHANGES IN THE PREVIOUS QUESTION, DO YOU THINK THE TIMING OR SPEED OF THE PACKAGING OPERATION (PARCELLING UP ORDERS FOR DESPATCH TO CUSTOMERS) WILL BE AFFECTED?

PLEASE ANSWER CONSIDERING EACH CHANGE, PLUS ITS AFFECTED DECISIONS, IN TURN.

CHANGE G	YES / NO	
CHANGE H	YES / NO	
CHANGE I	YES / NO	PLEASE DELETE AS APPROPRIATE
CHANGE J	YES / NO	
CHANGE K	YES / NO	
CHANGE L	YES / NO	

10. IF YOU FEEL THAT THE ANSWERS YOU HAVE BEEN ABLE TO GIVE REQUIRE FURTHER QUALIFICATION OR EXPLANATION, I WOULD APPRECIATE ANY FURTHER COMMENTS YOU MAY WISH TO MAKE. THANK YOU VERY MUCH FOR YOUR ASSISTANCE.

APPENDIX A

EXHIBIT 6

Interview Format for Verbal Administration of Questionnaire to Pharmaceutical Manufacturers

Change Cards

CHANGE A

CHANGE B

CHANGE C

CHANGE D

CHANGE E

CHANGE F

CHANGE G

CHANGE H

CHANGE I

CHANGE J

CHANGE K

CHANGE L

Department Cards

MATERIALS HANDLING

INVENTORY CONTROL

ORDER PICKING AND PACKAGING

ORDER PROCESSING & DOCUMENTATION

TRANSPORT

PURCHASING

PRODUCTION SCHEDULING

STORAGE AND WAREHOUSING

Interviewer's Format

Change.......... A

Question 1:

TRANSPORT
Scheduling ....

STORAGE AND WAREHOUSING

Internal warehouse design 4
Use of public/leased warehouses 2
Use of special storage arrangements ....
Looking after the physical condition of the inventory ....

MATERIALS HANDLING

Materials handling equipment within the warehouse 3

DOCUMENTATION AND ORDER PROCESSING

1

Shipping documentation ....
Government documentation ....
Internal control information ....

INVENTORY CONTROL

Inventory levels of raw materials .....

Inventory levels of production intermediates ......

Inventory levels of packed finished goods ....

PRODUCTION SCHEDULING

Scheduling dates ....

Question 2:

TRANSPORT

Scheduling the transport mode ....

Selecting the carrier ....

Obtaining the correct rate, packing requirements 5

Supervising the actual despatches ....

2

Consolidating/ pooling................

Insurance ....

Operating company vehicles ....

Managing rate negotiations ....

Routing shipments ....

ORDER PREPARATION AND PACKAGING

Order picking 1

MATERIALS HANDLING

Materials handling equipment within the warehouse 4

Materials handling equipment between warehouse and plant

DOCUMENTATION AND ORDER PROCESSING

Shipping documentation ....

Government documentation ....

Financial documentation ....

Paying freight bills ....

Order processing 3

Customer complaints ....

Setting minimum order size/frequency ....

PRODUCTION SCHEDULING

Determining batch sizes or length of production runs .....

PURCHASING

Deciding how much to buy ....

Deciding when to buy ....

Deciding from whom to buy ....

<u>Question 3</u>

ORDER PREPARATION AND PACKAGING

Packing methods 2

Primary pack ....

Outer pack 1

Packing operation 3

PRODUCTION SCHEDULING

Determining which product is to be produced ....

A hypothetical response, as rankings shown in the boxes, from a logistics manager.

Repeated format for changes B, C, D, E and F.

Change .... G

<u>Questions 4 and 5</u>

TRANSPORT

Delivery <u>time</u> ....

STORAGE AND WAREHOUSING

Internal warehouse design ....

Use of public/leased warehouses .... ✓

Design of special storage arrangements ....

<u>Time</u> spent in operating special storages .....

<u>Time</u> spent in looking after the physical condition of the inventory 1

MATERIALS HANDLING

Selecting equipment within the warehouse ....

Handling <u>time</u> within the warehouse ....

DOCUMENTATION AND ORDER PROCESSING

<u>Time</u> spent in completing shipping documents . 2

<u>Time</u> spent in completing government documents ....

<u>Time</u> spent in handling internal control information ...

INVENTORY CONTROL

Setting inventory levels of raw materials ...

Setting inventory levels of production intermediates ...

Setting inventory levels of packed finished goods ...

PRODUCTION SCHEDULING

Scheduling dates .....

Questions 6 and 7

TRANSPORT

Selecting the mode of transport ....

Selecting the specific carriers .... ✓

Getting the correct rates, packing requirements .... ✓

Insurance ....

Deciding whether or not to run a company-owned fleet .... ✓

Supervisory time in despatch ....

Time delay in consolidating/pooling 4

Time spent in checking progress of despatched goods ....

Delivery time using company-owned vehicles 3

Time spent in managing rate negotiations ....

Time spent in routing shipments ....

ORDER PREPARATION AND PACKAGING

Order picking time ....

MATERIALS HANDLING

Selecting equipment within the warehouse ....

Selecting equipment between warehouse and plant ....

Handling time within the warehouse ....

Handling time between warehouse and plant ....

ORDER PROCESSING AND DOCUMENTATION

Deciding on minimum order size and frequency .... ✓

Time spent in completing shipping documents 1

Time spent in completing government documents ...

Time spent in completing financial documents ....

Time spent in paying freight bills ....

Order processing time 2

Time spent in answering customer complaints .....

PRODUCTION SCHEDULING

Deciding batch size and run length ....

PURCHASING

Deciding how much to buy ....

Deciding when to buy ....

Deciding from whom to buy ....

Questions 8 and 9

ORDER PREPARATION AND PACKAGING

Design of packing methods ....

Primary pack ....

Outer pack ....

Packing time ....

PRODUCTION SCHEDULING

Deciding which product is to be produced ....

A hypothetical response from a logistics manager. Relevant decisions are indicated by ticks in the boxes. Ranked operations' times are also shown in the boxes.

Repeated format for changes H, I, J, K and L.

APPENDIX A

EXHIBIT 7

Tabulated Responses to Manufacturers Questionnaire (Major Survey)

Results from Manufacturers Questionnaire

Question No. 1

Change A

No. of Respondents 16

Activity Nos.		A2	B1	B3	B5	B6	D2	E1	E2	E5	F1	F2	F3	G3
Rank	1	12						1						
	2		1	2				2						
	3		1				2	1						
	4		1			1							1	
	5				1									
	6													
	7													

Question No. 1

Change B

No. of Respondents 16

Activity Nos.		A2	B1	B3	B5	B6	D2	E1	E2	E5	F1	F2	F3	G3
Rank	1		4	1	1	2	2				2		2	
	2	2	1			3	3				1			1
	3	1				1	3							1
	4			1			1							2
	5									1				
	6													
	7													

Question No. 1

Change C

No. of respondents 16

Activity Nos.		A2	B1	B3	B5	B6	D2	E1	E2	E5	F1	F2	F3	G3
Rank	1	4	1				2	5		1			2	
	2	4	1			1				1			2	
	3			1			1	1		1			3	
	4							1						2
	5	1												
	6													
	7													

Question No. 1

Change D

No. of respondents 16

Activity Nos.		A2	B1	B3	B5	B6	D2	E1	E2	E5	F1	F3	G3
Rank	1			3		1				1	1	2	7
	2			2		3					2	3	4
	3			2		1	2			1	3	2	4
	4		1	3		2	2	2		2			1
	5	2		1		2	3			1			1
	6					1				1	1	2	
	7						1						

Question No. 1

Change E

No. of respondents 16

Activity Nos.		A2	B1	B3	B5	B6	D2	E1	E2	E5	F1	F2	G3
Rank	1			2						3		3	8
	2	3		2		3	2				3	2	1
	3			5			1				3	1	5
	4	1		2		1	3	1		2	1	1	1
	5	1	1	2		2	1	1			1	1	
	6	1			1		1			1	1		
	7						1						

Question No. 1

Change F

No.of respondents 16

Activity Nos.		A2	B1	B3	B5	B6	D2	E1	E2	E5	F1	F2	F3	G3
Rank	1			4							12			
	2		1	9		1	2				1			1
	3		2			8	3				2			
	4			1		1	8				1			
	5		1				1			1				
	6								1					
	7													

Question No. 2

Change A

No. of respondents 16

Activity Nos.		A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7	E8	G2	H1	H2	H3
Rank	1	8	1		1			1		3		1													
	2	2	6		1			2		2											2				
	3	3	2		2			1		1					2			2		1					
	4				1						3			1	1			2							
	5		1					1										1	2				1		
	6																			1					
	7																								
	8																								
	9																								

Question No. 2

Change B

No. of respondents 16

Activity Nos.		A1	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7	E8	G2	H1	H2	H3
Rank	1	1		1	1	1			1				1		4							1		3		2
	2			1		2					1		2	1										2		2
	3			1					1		1		1		1							2		1		
	4	1			1	2							1											2		
	5					1																	2	1		1
	6		1												1											1
	7														1						1					
	8					1																				
	9																									

Question No. 2

Change C

No. of respondents 16

Activity Nos.		A1	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7	G2	H1	H2	H3
Rank	1	1				1					3		4			1			6						
	2	1	2			1			2			2	2			1		3	1		1				
	3	3			1				1		1				1	2		1	3		1				
	4					1		1				1	5		1			1	1		1	1	1		
	5	1	1	2					2				1			2							2		
	6		2	2		2					1	1													
	7	1		2		3					1							1							
	8		1			1																	2		
	9																								

Question No. 2

Change D

Nos. of respondents 15

Activity Nos.		A1	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7	E8	G2	H1	H2	H3
Rank	1													1					1				12	2		
	2														2				1		4		1	6	1	
	3	1											1	2	2	1			2			1		1	2	1
	4		1											4	1						1		2		2	
	5			1										2	2				1							
	6												1		1						1				1	1
	7																							2		
	8																								1	
	9																									

Question No. 2

Change E

Nos. of respondents 15

Activity Nos.		A1	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7	E8	G2	H1	H2	H3
Rank	1												1						2				12			
	2	1											1		4				1		5			2	1	
	3	1									1		2	1					2		1	1		3	2	
	4		1									1			1				1		2		1	1	2	1
	5			1	1								1	1	1										1	2
	6			1										1	1						1				1	1
	7		1									1												2		
	8														1										2	
	9																							1		

Question No. 2

Change F

No. of respondents 15

Activity Nos.		A1	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7	E8	G2	H2	H3
Rank	1													2	5									4	4
	2													3	3								1	2	4
	3												1	3	4										
	4													2	2		1								
	5																								
	6																								
	7																								
	8																								
	9																								

Question No. 3

Change A

No.of respondents 15

Activity Nos.		C2	C3	C4	C5	G1
Rank	1			2	2	
	2	1			1	
	3				1	
	4					

Question No. 3

Change D

No.of respondents 15

Activity Nos.		C2	C3	C4	C5	G1
Rank	1					14
	2				2	
	3					
	4					

Question No. 3

Change B

No.of respondents 15

Activity Nos.		C2	C3	C4	C5	G1
Rank	1		1	3	7	
	2		1	4	3	1
	3		4	1	1	
	4					1

Question No. 3

Change E

No.of respondents 15

Activity Nos.		C2	C3	C4	C5	G1
Rank	1				1	12
	2				3	
	3					
	4					

Question No. 3

Change C

No.of respondents 15

Activity Nos.		C2	C3	C4	C5	G1
Rank	1			7	7	
	2			5	6	
	3	3				
	4					

Question No. 3

Change F

No.of respondents 15

Activity Nos.		C2	C3	C4	C5	G1
Rank	1	1				2
	2					
	3					
	4					

Question No. 5

Change G

No. of respondents 15

Activity Nos.		B5	B6	D2	E1	E2	E5
Rank	1		4	2	4		1
	2			1	2		1
	3		1		1		
	4						1
	5						
	6						
	7						

Question No. 5

Change H

No. of respondents 15

Activity Nos.		A2	B5	B6	E1	E2	E5
Rank	1			3	11		
	2	2		5	2		
	3					1	
	4						
	5						
	6						
	7						

Question No. 5

Change I

No. of respondents 15

Activity Nos.		A2	B5	B6	D2	E1	E2	E5
Rank	1	9		2		1		2
	2		1	1	3	4		3
	3	2		2	2	2		
	4			1	2			3
	5				1		1	1
	6		1					1
	7					1		

Question No. 5

Change J

No. of respondents 15

Activity Nos.		A2	B5	B6	D2	E1	E2	E5
Rank	1	8				4		
	2	2			2		2	
	3			1	1			1
	4	1				1		
	5			1				1
	6				1		1	
	7		1					

Question No. 5

Change K

No. of respondents 15

Activity Nos.		A2	B5	B6	D2	E1	E2	E5
Rank	1			8	5			1
	2		1	3	2			3
	3		1	1	2			1
	4		1					
	5							
	6							
	7							

Question No. 5

Change L

No. of respondents 15

Activity Nos.		A2	B5	B6	D2	E1	E2	E5
Rank	1	1		6	5			1
	2			4	3			2
	3		2	1				1
	4						1	
	5							
	6							
	7							

Question No. 7

Change G

No. of respondents 15

Activity Nos.		A5	A6	A8	A9	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7
Rank	1	1	2		4		2	3			1			1		
	2		5	1			1	2		1				3		
	3	3			1		2	4			1			2		
	4	1	1	2		1		2		1				3		1
	5			1			1	1			4					3
	6	1				1				1			1			
	7						1								1	
	8			1												

Question No. 7

Change H

NO. of respondents 15

Activity Nos.		A5	A6	A8	A9	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7
Rank	1							4		9						
	2							3	5	3						
	3				1			2	3							
	4										1			1		1
	5										1					
	6															
	7															
	8															

Question No. 7

Change I

No. of respondents 15

Activity Nos.		A5	A6	A8	A9	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7
Rank	1	1			5		1	2						5		
	2			1	1		1			2	3			4		
	3	1	1		1			2		3			1	1	1	
	4		1	1		1			1	1	2					
	5	1				1				1	1					1
	6						1							1		
	7					1										
	8						1									
	9															1

Question No. 7

Change J

No. of Respondents 15

Activity Nos.		A5	A6	A8	A9	A11	A12	C1	D1	D2	E1	E2	E3	E6	E7
Rank	1		1					6			4		1		
	2	2			1			1		1		2	1		
	3		2					1					2		1
	4				2			1		1				1	
	5									1	1				1
	6				1	1									
	7		1				1								
	8					1									
	9							1							

Question No. 7

Change K

No. of respondents 15

Activity Nos.		A5	A6	A8	A9	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7
Rank	1							2	3	4						1
	2								3	4				1	1	
	3								2					1		
	4							1		1						1
	5							1								
	6															
	7															
	8															

Question No. 7

Change L

No. of respondents 15

Activity Nos.		A5	A6	A8	A9	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7
Rank	1				1				3	5						
	2								3	3						
	3												2			
	4											1				
	5							1								
	6															
	7															
	8															

Question No.	9
No. of respondents	15
Activity Nos.	C5
Change G	11
" H	7
" I	4
" J	11
" K	4
" L	3

APPENDIX A

EXHIBIT 8

Tabular Analyses to Convert Ordinal Rankings of Manufacturers' Responses into Interval Scales

Analysis of Manufacturers' Responses

Question 1 Change B

N = 16 n = 13

	Activity		A2	B1	B3	B5	B6	D2	E1	E2	E5	F1	F2	F3	G3
	Rank	R													
	1	5		4	1	1	2	2				2		2	
f matrix	2	4	2	1			3	3				1			1
	3	3	1				1	3							1
	4	2			1			1							2
	5	1									1				
				20	5	5	10	10				10		10	
fR matrix			8	4			12	12				4			4
			3				3	9							3
					2			2							4
											1				
ΣfR			11	24	7	5	25	33			1	14		10	11
ΣfR - 0.5N			3	16			17	25				6		2	3
p = ΣfR - 0.5N/nN			.014	.077			.082	.120				.029		.010	.014
z			-2.198	-1.426			-1.391	-1.175				-1.896		-2.327	-2.198
+ 2.327			.129	.901			.936	1.152				.431		0	.129

Question 1 Change C

N = 16 n = 13

	Activity Rank	R	A2	B1	B3	B5	B6	D2	E1	E2	E5	F1	F2	F3	G3
	1	5	4	1				2	5		1			2	
f matrix	2	4	4	1			1				1			2	
	3	3			1			1	1		1			3	
	4	2							1						2
	5	1	1												
			20	5				10	25		5			10	
			16	4			4				4			8	
fR matrix					3			3	3		3			9	
									2						8
			1												
Σ fR			37	9	3		4	13	30		12			27	8
Σ fR - 0.5N			29	1				5	22		4			19	
p =ΣfR - 0.5N/nN			.139	.005				.024	.106		.020			.091	
z			-1.085	-2.575				-1.978	-1.248		-2.054			-1.335	
+2.575			1.490	0				.597	1.327		.521			1.240	

<u>Question 1 Change D</u>

N = 16 n = 12

	Activity		A2	B1	B3	B5	B6	D2	E1	E2	E5	F1	F3	G3
	Rank	R												
	1	7			3		1				1	1	2	7
	2	6			2		3			1		2	3	4
f matrix	3	5			2		1	2			1	3	2	4
	4	4		1	3		2	2	2		2			1
	5	3	2		1		2	3			1			1
	6	2					1				1	1	2	
	7	1						1						
					21		7				7	7	14	49
					12		18			6		12	18	24
fR matrix					10		5	10			5	15	10	20
				4	12		8	8	8		8			4
			6		3		6	9			3			3
							2				2	2	4	
								1						
ΣfR			6	4	58		50	28	8	6	25	36	46	100
ΣfR - 0.5N					50		42	20			17	28	38	92
p =ΣfR - 0.5N/nN					.260		.219	.104			.089	.146	.198	.479
z					-.643		-.776	-1.259			- 1.346	-1.053	-.849	-.053
+ 1.346					.703		.570	.087			0	.293	.497	1.293

Question 1 Change E

N = 16 n = 12

	ACTIVITY Rank	R	A2	B1	B3	B5	B6	D2	E1	E2	E5	F1	F2	G3
	1	7			2						3		3	8
	2	6	3		2		3	2				3	2	1
f matrix	3	5			5			1				3	1	5
	4	4	1		2		1	3	1		2	1	1	1
	5	3	1	1	2		2	1	1			1	1	
	6	2	1			1		1			1	1		
	7	1						1						
					14						21		21	56
			18		12		18	12				18	12	6
					25			5				15	5	25
fR matrix			4		8		4	12	4		8	4	4	4
			3	3	6		6	3	3			3	3	
			2			2		2			2	2		
								1						
Σ fR			27	3	65	2	28	35	7		31	42	45	91
Σ fR - 0.5N			19		57		20	27			23	34	37	83
p = Σ fR - 0.5N/nN			.099		.297		.104	.141			.120	.177	.193	.432
z			-1.287		-.533		-1.259	-1.076			-1.175	-.927	-.867	-.171
+ 1.287			0		.754		.028	.211			.112	.360	.420	1.116

Question 1 Change F:

N = 16 n = 13

	Activity Rank	R	A1	B1	B3	B5	B6	D2	E1	E2	E5	F1	F2	F3	G3
	1	6			4							12			
f matrix	2	5		1	9		1	2				1			1
	3	4		2			8	3				2			
	4	3			1		1	8				1			
	5	2		1				1			1				
	6	1								1					
					24							72			
				5	45		5	10				5			5
fR matrix				8			32	12				8			
					3		3	24				3			
				2				2			2				
										1					
Σ fR				15	72		40	48		1	2	88			5
Σ fR - 0.5N				7	64		32	40				80			
p = Σ fR - 0.5N/nN				.034	.308		.154	.193				.385			
z				-1.825	-.502		-1.020	-.867				-.293			
+ 1.825				0	1.323		.805	.958				1.532			

Question 2 Change A

N = 16 n = 24

Activity	Rank	R	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7	E8	G2	H1	H2	H3
	1	6	8	1		1			1		3		1													
f matrix	2	5	2	6		1			2		2											2				
	3	4	3	2		2			1		1					2			2		1					
	4	3				1						3			1	1			2							
	5	2		1					1										1	2				1		
	6	1																			1					
			48	6		6			6		18		6													
			10	30		5			10		10											10				
			12	8		8			4		4					8			8		4					
						3						9			3	3			6							
				2					2										2	4				2		
																					1					
ΣfR			70	46		22			22		32	9	6		3	11			16	4	5	10		2		
ΣfR - 0.5N			62	38		14			14		24	1				3			8			2				
p = ΣfR - 0.5N/nN			.161	.099		.037			.037		.063	.003				.008			.021			.005				
z			-.990	-1.297		-1.787			-1.787		-1.530	-2.750				-2.410			- 2.033			-2.575				
+ 2.750			1.760	1.463		.963			.963		1.22	0				.340			.717			.175				

Question 2 Change B

N = 16 n = 25

	Activity Rank	R	A1	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7	E8	G2	H1	H2	H3
	1	8	2		1	1	2			1				2		6							1				
f matrix	2	7			1		2					1		2	1	1							1		1		1
	3	6			2					1		1		1		1							2				
	4	5	1			1	2							1											2		
	5	4					1																	2	1		1
	6	3		1												1											1
	7	2														1						1					
	8	1					1																				
			16		8	8	16			8				16		48							8				
					7		14					7		14	7	7							7		7		7
					12					6		6		6		6							12				
fRmatrix			5			5	10							5											10		
							4																	8	4		4
				3												3											3
																2						2					
							1																				
ΣfR			21	3	27	13	45			14		13		41	7	66						2	27	8	21		14
ΣfR - 0.5N			13		19	5	37			6		5		33		58							19		13		6
p = ΣfR - 0.5N/nN			.032		.048	.012	.093			.015		.012		.083		.145							.048		.032		.015
z			-1.85		-1.665	-2.257	-1.322			-2.170		-2.257		-1.358		-1.058							-1.665		-1.852		-2.170
+ 2.257			.405		.592	0	.935			.087		0		.872		1.199							.592		.405		.087

Question 2 Change C

N = 16 n = 24

	Activity / Rank	R	A1	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7	G2	H1	H2	H3
	1	8	1				1					3		4			1			6						
f matrix	2	7	1	2			1			2			2	2			1		3	1		1				
	3	6	3			1				1		1				1	2		1	3		1				
	4	5					1		1				1	5		1			1	1		1	1	1		
	5	4	1	1	2					2				1			2							2		
	6	3		2	2		2					1	1													
	7	2	1		2		3					1							1							
	8	1		1			1																	2		
			8				8					24		32			8			48						
			7	14			7			14			14	14			7		21	7		7				
fR matrix			18			6				6		6				6	12		6	18		6				
							5		5				5	25		5			5	5		5	5	5		
			4	4	8					8				4			8							8		
				6	6		6					3	3													
			2		4		6					2							2							
				1			1																	2		
ΣfR			39	25	18	6	33		5	28		35	22	75		11	35		34	78		18	5	15		
ΣfR - 0.5N			31	17	10		25			20		27	14	67		3	27		26	70		10		7		
p = ΣfR - 0.5N/nN			.081	.044	.026		.065			.052		.070	.037	.175		.008	.070		.068	.182		.026		.018		
z			-1.399	-1.706	-1943		-1.514			-1.626		-1.476	-1.787	-.934		-2.410	-1.476		-1.490	-.908		-1.943		-2.098		
+2.410			1.011	.704	.467		.896			.784		.934	.623	1.476		0	.934		.920	1.502		.467		.312		

Question 2 Change D

N = 15 n = 25

	Activity		A1	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7	E8	G2	H1	H2	H3
	Rank	R																									
	1	8													1					1				12	2		
	2	7														2				1		4		1	6	1	
f matrix	3	6	1											1	2	2	1			2			1		1	2	1
	4	5		1											4	1						1		2		2	
	5	4			1										2	2				1							
	6	3												1		1						1				1	1
	7	2																							2		
	8	1																								1	
															8					8				96	16		
																14				7		28		7	42	7	
fR matrix			6											6	12	12	6			12			6		6	12	6
				5											20	5						5		10		10	
					4										8	8				4							
														3		3						3				3	3
																									4		
																										1	
ΣfR			6	5	4									9	48	42	6			31		36	6	113	68	33	9
ΣfR - .5N														1.5	40.5	34.5				23.5		28.5		105.5	60.5	25.5	1.5
p = ΣfR-.5N/nN														.004	.108	.092				.063		.042		:281	.161	.068	.004
z														-2.650	-1.238	-1.329				-1.530		-1.728		-.580	-.990	-1.49	-2.650
+ 2.650														0	1.412	1.321				1.120		.922		2.07	1.66	1.16	0

Question 2 Change E

N = 15 n = 25

	Activity Rank	R	A1	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7	E8	G2	H1	H2	H3
f matrix	1	9												1						2				12			
	2	8	1											1		4				1		5			2	1	
	3	7	1									1		2	1					2		1	1		3	2	1
	4	6		1									1			1				1		2		1	1	2	2
	5	5			1	1								1	1	1										1	1
	6	4			1										1	1						1				1	
	7	3		1									1												2		
	8	2														1										2	
	9	1																							1		
fR matrix														9						18				108			
			8											8		32				8		40			16	8	
			7									7		14	7					14		7	7		21	14	7
				6									6			6				6		12		6	6	12	12
					5	5								5	5	5										5	5
					4										4	4						4				4	
				3									3												6		
																2										4	
																									1		
Σ fR			15	9	9	5						7	9	36	16	49				46		63	7	114	50	47	24
ΣfR - 0.5N			7.5	1.5	1.5								1.5	28.5	8.5	41.5				38.5		55.5		106.5	42.5	39.5	16.5
p = ΣfR-0.5N/nN			.020	.004	.004								.004	.042	.023	.111				.103		.148		.284	.113	.105	.044
z			-2.054	-2.65	-2.65								-2.65	-1.728	-1.996	-1.221				-1.264		-1.045		- .571	-1.21	-1.253	-1.706
+ 2.650			.596	0	0								0	.922	.654	1.429				1.386		1.605		2.079	1.44	1.397	.944

Question 2 Change F

N = 15 n = 24

	Activity Rank	R	A1	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7	E8	G2	H2	H3
f matrix	1	4													2	5									4	4
	2	3													3	3								1	2	4
	3	2												1	3	4										
	4	1													2	2		1								
fR matrix															8	20									16	16
															9	9								3	6	12
														2	6	8										
															2	2		1								
ΣfR														2	25	39		1						3	22	28
ΣfR - 0.5N															17.5	31.5									14.5	20.5
p = ΣfR - 0.5N/nN															.049	.088									.040	.057
z															-1.655	-1.353									-1.751	-1.581
+ 1.751															.096	.398									0	.170

Question 3 Change A

N = 15 n = 5

	ACTIVITY Rank	R	C2	C3	C4	C5	G1
f matrix	1	3			2	2	
	2	2	1			1	
	3	1				1	
fR matrix					6	6	
			2			2	
						1	
ΣfR			2		6	9	
$\Sigma fR - 0.5N$						1.5	
$p = \Sigma fR - 0.5N/nN$						.020	
z						-2.054	
+ 2.054						0	

Question 3 Change B

N = 15 n = 4

	ACTIVITY Rank	R	C3	C4	C5	G1
	1	4	1	3	7	
f matrix	2	3	1	4	3	1
	3	2	4	1	1	
	4	1				1
			4	12	28	
fR matrix			3	12	9	3
			8	2	2	
						1
Σ fR			15	26	39	4
ΣfR - 0.5N			7.5	18.5	31.5	
p = ΣfR - 0.5N/nN			.125	.308	.525	
z			-1.150	-.502	.063	
+ 1.150			0	.648	1.213	

Question 3 Change C

N = 15 n = 5

	ACTIVITY Rank	R	C2	C3	C4	C5	G1
f matrix	1	3			7	7	
	2	2			5	6	
	3	1	3				
fR matrix					21	21	
					10	12	
			3				
ΣfR			3		31	33	
$\Sigma fR - 0.5N$					23.5	25.5	
$p = \Sigma fR - 0.5N/nN$					.314	.340	
z					-.484	-.413	
+ .484					0	.071	

Question 3 Change D

N = 15 n = 5

	ACTIVITY Rank	R	C2	C3	C4	C5	G1
f matrix	1	2					14
	2	1				2	
fR matrix							28
						2	
ΣfR						2	28
$\Sigma fR - 0.5N$							20.5
$p = \Sigma fR - 0.5N/nN$							.273
z							-.603
+ .603							0

<u>Question 3 Change E</u>

N = 15 n = 5

	Rank	R	C2	C3	C4	C5	Gl
	ACTIVITY						
f matrix	1	2				1	12
	2	1				3	
fR matrix						2	24
						3	
Σ fR						5	24
ΣfR - 0.5N							16.5
p = ΣfR - 0.5N/nN							0.220
z							-.772
+ .772							0

<u>Question 3 Change F:</u>

N = 15 n = 5

	Rank	R	C2	C3	C4	C5	Gl
	ACTIVITY						
f matrix	1	1	1				2
fR matrix			1				2
Σ fR			1				2
Σ fR - 0.5N			0				0

Question 5 Change G

N = 15 n = 6

	ACTIVITY Rank	R	B5	B6	D2	E1	E2	E5
f matrix	1	4		4	1	5		1
	2	3			1	2		1
	3	2		1		1		
	4	1						1
fR matrix				16	4	20		4
					3	6		3
				2		2		
								1
ΣfR				18	7	28		8
ΣfR - 0.5N				10.5		20.5		0.5
p = ΣfR - 0.5N/nN				.117		.228		.006
z				-1.190		-.745		-2.510
+ 2.510				1.320		1.765		0

Question 5 Change H

N = 15 n = 7

	ACTIVITY Rank	R	A2	B5	B6	D2	E1	E2	E5
f matrix	1	3			3	11			
	2	2	2		5	2			
	3	1					1		
fR matrix					9	33			
			4		10	4			
							1		
ΣfR			4		19	37	1		
ΣfR - 0.5N					11.5	29.5			
p = ΣfR - 0.5N/nN					.110	.281			
z					-1.226	-.580			
+ 1.226					0	.646			

Question 5 Change I

N = 15 n = 7

	Rank	R	A2	B5	B6	D2	E1	E2	E5
f matrix	1	7	2	1	7	1			3
	2	6		2	2	3	1		4
	3	5	1		2	3	2		
	4	4			1	2			3
	5	3				1		1	1
	6	2		1					1
	7	1					1		
fR matrix			14	7	49	7			21
				12	12	18	6		24
			5		10	15	10		
					4	8			12
						3		3	3
									2
							1		
ΣfR			19	19	75	51	17	3	62
$\Sigma fR - 0.5N$			11.5	11.5	67.5	43.5	9.5		54.5
$p = \Sigma fR - 0.5N/nN$			.110	.110	.643	.414	.091		.519
z			-1.226	-1.226	.367	-.218	-2.360		.048
+ 2.360			1.134	1.134	2.727	2.142	0		2.408

<u>Question 5 Change J</u>

N = 15 n = 7

	ACTIVITY Rank	R	A2	B5	B6	D2	E1	E2	E5
f matrix	1	7	8				4		
	2	6	2			2		2	
	3	5			1	1			1
	4	4					1		
	5	3	1		1				1
	6	2				1		1	
	7	1		1					
fR matrix			56				28		
			12			12		12	
					5	5			5
							4		
			3		3				3
						2		2	
				1					
ΣfR			71	1	8	19	32	14	8
ΣfR - 0.5N			63.5		0.5	11.5	24.5	6.5	0.5
p = ΣfR - 0.5N/nN			.605		.005	.110	.233	.062	.005
z			.266		-2.575	-1.226	-.729	-1.538	-2.575
+ 2.575			2.841		0	1.349	1.846	1.037	0

Question 5 Change K:

N = 15 n = 7

	ACTIVITY Rank	R	A2	B5	B6	D2	E1	E2	E5
	1	4			8	5			1
f matrix	2	3		1	3	2			3
	3	2		1	1	2			1
	4	1		1					
					32	20			4
fR matrix				3	9	6			9
				2	2	4			2
				1					
ΣfR				6	43	30			15
ΣfR - 0.5N					35.5	22.5			7.5
p = ΣfR - 0.5N/nN					.338	.214			.071
z					-.418	-.793			-1.469
+ 1.469					1,051	.676			0

Question 5 Change L

N = 15 n = 7

	ACTIVITY Rank	R	A2	B5	B6	D2	E1	E2	E5
f matrix	1	4	1		6	5			1
	2	3			4	3			2
	3	2		2	1				1
	4	1						1	
fR matrix			4		24	20			4
					12	9			6
				4	2				2
								1	
Σ fR			4	4	38	29		1	12
Σ fR - 0.5N					30.5	21.5			4.5
p = ΣfR - 0.5N/nN					.291	.205			.043
z					-.550	-.823			-1.717
+ 1.717					1.167	.894			0

Question 7   Change G

N = 15   n = 15

	ACTIVITY Rank	R	A5	A6	A8	A9	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7
	1	8	1	2		4		2	3			1			1		
f matrix	2	7		5	1			1	2		1				3		
	3	6	3			1		2	4			1			2		
	4	5	1	1	2		1		2		1				3		1
	5	4			1			1	1			4					3
	6	3	1				1				1			1			
	7	2						1								1	
	8	1			1												
			8	16		32		16	24			8			8		
fR matrix				35	7			7	14		7				21		
			18			6		12	24			6			12		
			5	5	10		5		10		5				15		5
					4			4	4			16					12
			3				3				3			3			
								2								2	
					1												
ΣfR			34	56	22	38	8	41	76		15	30		3	56	2	17
ΣfR - 0.5N			26.5	48.5	14.5	30.5	0.5	33.5	68.5		7.5	22.5			48.5		9.5
p =ΣfR - 0.5N/nN			.118	.216	.065	.136	.002	.149	.305		.033	.100			.216		.042
z			-1.185	-.786	-1.514	-1.099	-2.880	-1.040	- .510		-1.839	-1.281			-.786		-1.728
+ 2.880			1.695	2.094	1.366	1.781	0	1.840	2.370		1.041	1.599			2.094		1.152

Question 7 Change H

N = 15 n = 15

	ACTIVITY Rank	R	A5	A6	A8	A9	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7
	1	5							4		9						
f matrix	2	4							3	5	3						
	3	3				1			2	3							
	4	2										1			1		1
	5	1										1					
									20		45						
fR matrix									12	20	12						
						3			6	9							
												2			2		2
												1					
ΣfR						3			38	29	57	3			2		2
$\Sigma fR - 0.5N$									30.5	21.5	49.5						
$p = \Sigma fR - 0.5N/nN$									.136	.096	.220						
z									-1.098	-1.305	-.772						
+ 1.305									.207	0	.533						

Question 7 Change I

N = 15 n = 15

	ACTIVITY Rank	R	A5	A6	A8	A9	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7
	1	9	1			1					12						
	2	8	1	1		2				6	2						
f matrix	3	7	2	2	2				2					1	1	1	
	4	6		1	1		1			2		2					
	5	5					1			1		1					2
	6	4						1							1		
	7	3					1										
	8	2						1									
	9	1															1
			9			9					108						
			8	8		16				48	16						
fR matrix			14	14	14				14					7	7	7	
				6	6		6			12		12					
							5			5		5					10
								4							4		
							3										
								2									
																	1
ΣfR			31	28	20	25	14	6	14	65	124	17		7	11	7	11
$\Sigma fR - 0.5N$			23.5	20.5	12.5	17.5	6.5		6.5	57.5	116.5	9.5			3.5		3.5
$p = \Sigma fR - 0.5N/nN$			.104	.091	.057	.078	.029		.029	.256	.518	.042			.015		.015
z			-1.259	-1.335	-1.581	-1.419	-1.896		-1.896	-.656	.045	-1.728			-2.170		-2.170
+ 2.170			.911	.835	.589	.751	.274		.274	1.514	2.215	.442			0		0

Question 7 Change J

N = 15 n = 14

	ACTIVITY Rank	R	A5	A6	A8	A9	A11	A12	C1	D1	D2	E1	E2	E3	E6	E7
f matrix	1	9		1					6			4		1		
	2	8	2			1			1		1		2	1		
	3	7		2					1					2		1
	4	6				2			1		1				1	
	5	5									1	1				1
	6	4				1	1									
	7	3		1												
	8	2					1									
	9	1							1							
fR matrix				9					54			36		9		
			16			8			8		8		16	8		
				14					7					14		7
						12			6		6				6	
											5	5				5
						4	4									
				3												
							2									
									1							
ΣfR			16	26		24	6		76		19	41	16	31	6	12
ΣfR - 0.5N			8.5	18.5		16.5			68.5		11.5	33.5	8.5	23.5		4.5
p = ΣfR - 0.5N/nN			.040	.088		.079			.326		.055	.160	.040	.112		.021
z			-1.751	-1.353		-1.412			-.451		-1.598	-.995	-1.751	-1.215		-2.034
+2.034			.283	.681		.622			1.583		.436	1.039	.283	.819		0

Question 7 Change K

N = 15 n = 15

	ACTIVITY Rank	R	A5	A6	A8	A9	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7
f matrix	1	5							2	3	4						1
	2	4								3	4				1	1	
	3	3								2					1		
	4	2							1		1						1
	4	1							1								
fR matrix									10	15	20						5
										12	16				4	4	
										6					3		
									2		2						2
									1								
ΣfR									13	33	38				7	4	7
$\Sigma fR - 0.5N$									5.5	25.5	30.5						
$p = \Sigma fR - 0.5N/nN$									.024	.113	.136						
z									-1.978	-1.210	-1.099						
+ 1.978									0	.768	.879						

Question 7 Change L

N = 15 n = 15

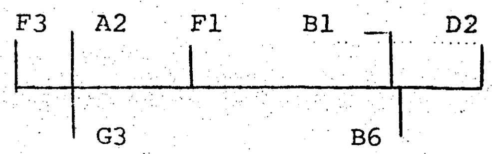
	ACTIVITY Rank	R	A5	A6	A8	A9	A11	A12	C1	D1	D2	E1	E2	E3	E4	E6	E7
	1	5				1				3	5						
f matrix	2	4								3	3						
	3	3												2			
	4	2											1				
	5	1							1								
						5				15	25						
fR matrix										12	12						
														6			
													2				
									1								
Σ fR						5			1	27	37		2	6			
Σ fR - 0.5N										19.5	29.5						
p = Σ fR - 0.5N/nN										.087	.131						
z										-1.360	-1.128						
+ 1.360										0	.232						

APPENDIX A

Exhibit 9

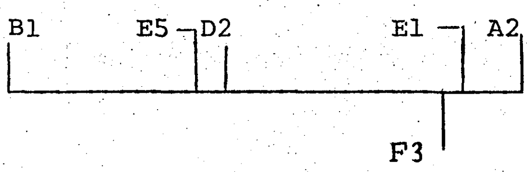
Derived Interval Scales from Manufacturers' Responses

Question 1 Change B



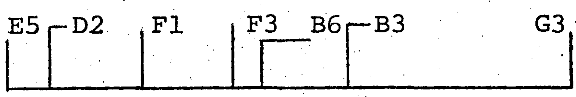
D2	31.4%
B6	25.4%
B1	24.5%
F1	11.7%
A2	3.5%
G3	3.5%
F3	O

Question 1 Change C



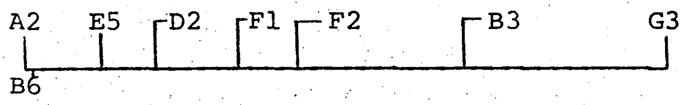
A2	28.8%
E1	25.6%
F3	24.0%
D2	11.5%
E5	10.1%
B1	O

Question 1 Change D



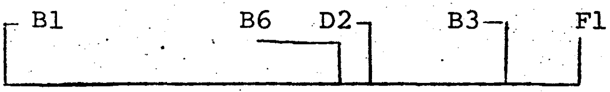
G3	37.6%
B3	20.4%
B6	16.6%
F3	14.4%
F1	8.5%
D2	2.5%
E5	O

Question 1 Change E



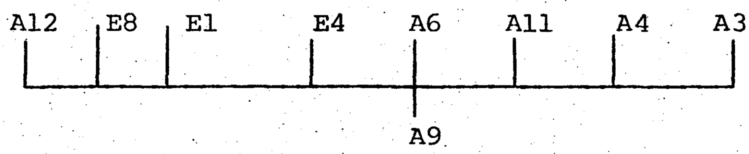
G3	37.2%
B3	25.2%
F2	14.0%
F1	12.0%
D2	7.0%
E5	3.7%
B6	0.9%
A2	O

Question 1 Change F



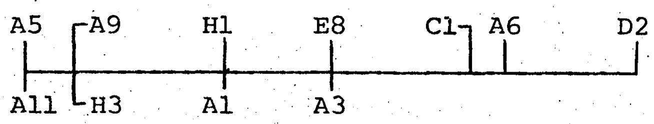
F1	33.2%
B3	28.7%
D2	20.7%
B6	17.4%
B1	O

Question 2 Change A



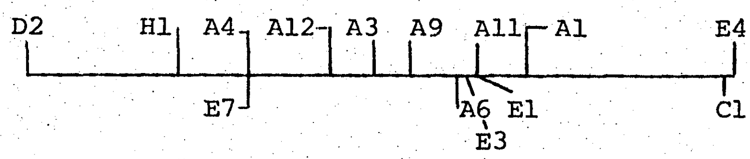
A3	23.1%
A4	19.2%
A11	16.1%
A6	12.7%
A9	12.7%
E4	9.4%
E1	4.5%
E8	2.3%
A12	O

Question 2   Change B



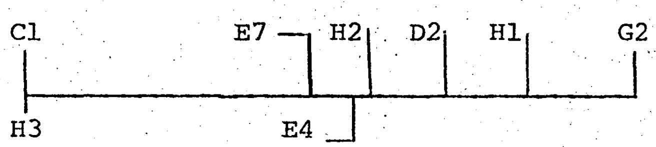
D2	23.2%	H1	7.8%
A6	18.1%	A9	1.7%
C1	16.9%	H3	1.7%
E8	11.4%	A11	O
A3	11.4%	A5	O
A1	7.8%		

Question 2   Change C



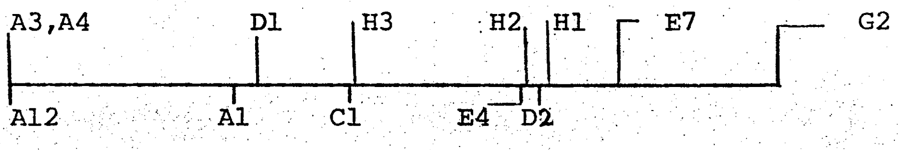
E4	13.6%	A9	7.1%
C1	13.4%	A3	6.4%
A1	9.2%	A12	5.7%
A11	8.5%	A4	4.2%
E1	8.5%	E7	4.2%
E3	8.3%	H1	2.8%
A6	8.1%	D2	O

Question 2   Change D



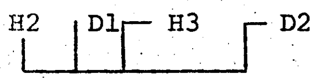
G2	21.4%	H2	12.0%
H1	17.2%	E4	11.6%
D1	14.6%	E7	9.5%
D2	13.7%	C1	O
		H3	O

Question 2 Change E



G2	16.6%	E4	11.1%
E7	12.9%	H3	7.6%
H1	11.6%	C1	7.4%
D2	11.5%	D1	5.3%
H2	11.2%	A1	4.8%
		A3	O
		A4	O
		A12	O

Question 2 Change F

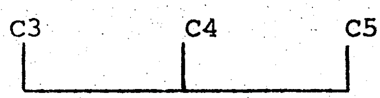


D2	60.0%	D1	14.4%
H3	25.6%	H2	O

Question 3 Change A

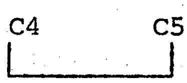
Insufficient response for comparison Activity C5 predominant.

Question 3 Change B



C5	65.2%
C4	34.8%
C3	O

Question 3 Change C



C5	100%	C4	O

Question 3 Change D

Insufficient response for comparison. Activity Gl predominant.

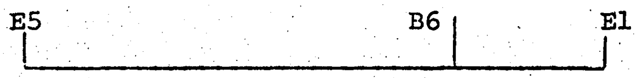
Question 3 Change E

Insufficient response for comparison. Activity Gl predominant.

Question 3 Change F

Insufficient response.

Question 5 Change G

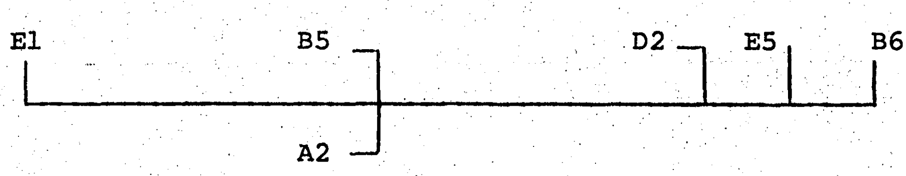


El	57.2%
B6	42.8%
E5	O

Question 5 Change H

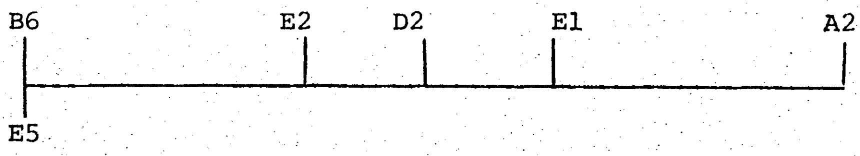
D2	100%
B6	O

Question 5 Change I



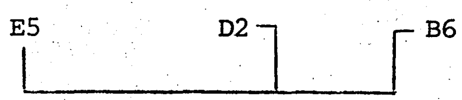
B6	28.6%	B5	11.9%
E5	25.2%	A2	11.9%
D2	22.4%	El	O

<u>Question 5 Change J</u>



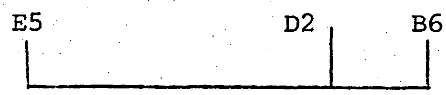
A2	40.2%	E2	14.6%
E1	26.1%	B6	O
D2	19.1%	E5	O

<u>Question 5 Change K</u>



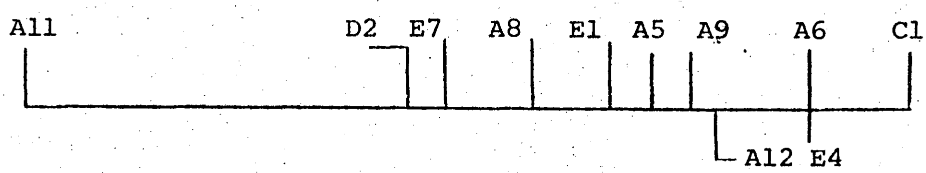
B6	60.8%
D2	39.2%
E5	O

<u>Question 5 Change L</u>



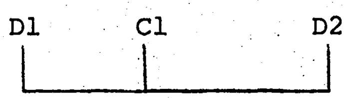
B6	56.7%
D2	43.3%
E5	O

<u>Question 7 Change G</u>



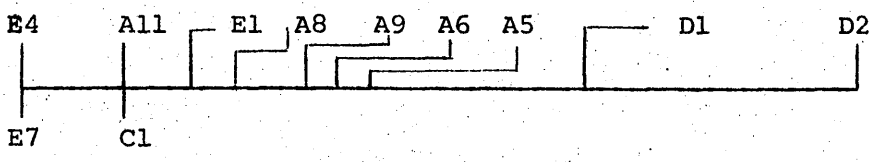
C1	13.9%	E1	9.4%
A6	12.3%	A8	8.0%
E4	12.3%	E7	6.8%
A12	10.8%	D2	6.1%
A9	10.5%	A11	O
A5	9.9%		

<u>Question 7   Change H</u>



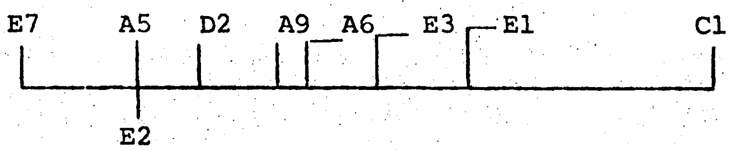
D2	72.0%
C1	28.0%
D1	0

<u>Question 7 Change I</u>



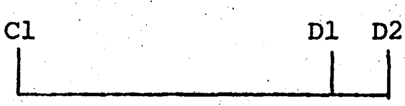
D2	28.4%	E1	5.7%
D1	19.4%	A11	3.5%
A5	11.7%	C1	3.5%
A6	10.7%	E4	0
A9	9.6%	E7	0
A8	7.5%		

<u>Question 7 Change J</u>



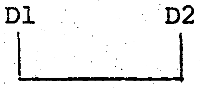
C1	27.6%	D2	7.6%
E1	18.1%	A5	4.9%
E3	14.3%	E2	4.9%
A6	11.8%	E7	0
A9	10.8%		

<u>Question 7 Change K</u>



D2	53.4%	C1	0
D1	46.6%		

Question 7 Change L



D2	100%
D1	0

Question 9 Changes G - L

($\Sigma fR - 0.5N$) is $>$ 0 only for changes G and J, where activity C5 can be said to be dominant.

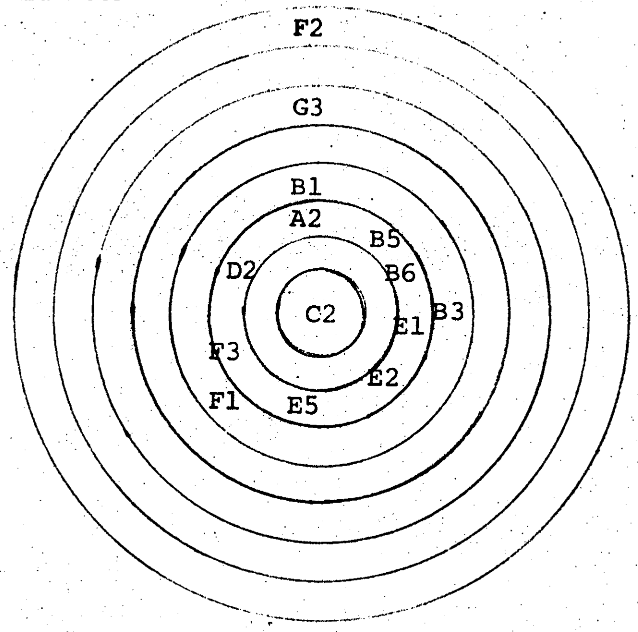
N.B. R = 1 for each choice

APPENDIX A

EXHIBIT 10

Construction of the Ring Diagrams as Representations of Logistics Activities' Relative Distances from the Changed Activity on the Materials Flow Path, and Comparisons with Research Suppositions.

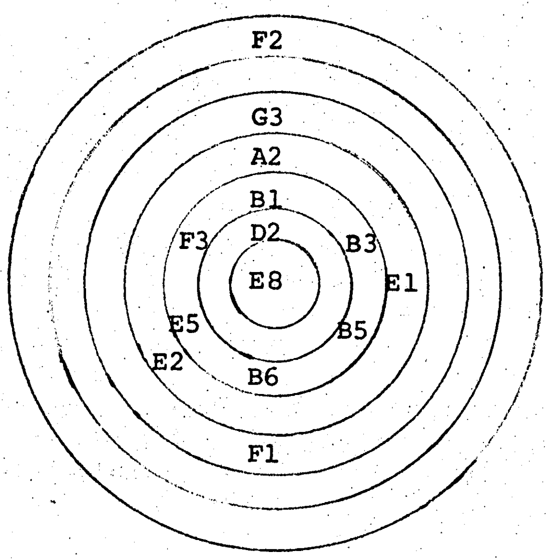
Question 1 Change B:



Consideration of only once-removed activities results in only 8 of the 13 possible activities being included; the derived interval scale shows that this will account for 60.3% of the scale values of relevant activities (D2 = 31.4%, B6 = 25.4%, A2 = 3.5%).

Extending the research supposition to include both once and twice-removed activities brings the number of activities down to 11 but with 96.5% of the scale values on the interval scale accounted for in this number (D2 = 31.4%, B6 = 25.4%, F1 = 11.7%, A2 = 3.5%).

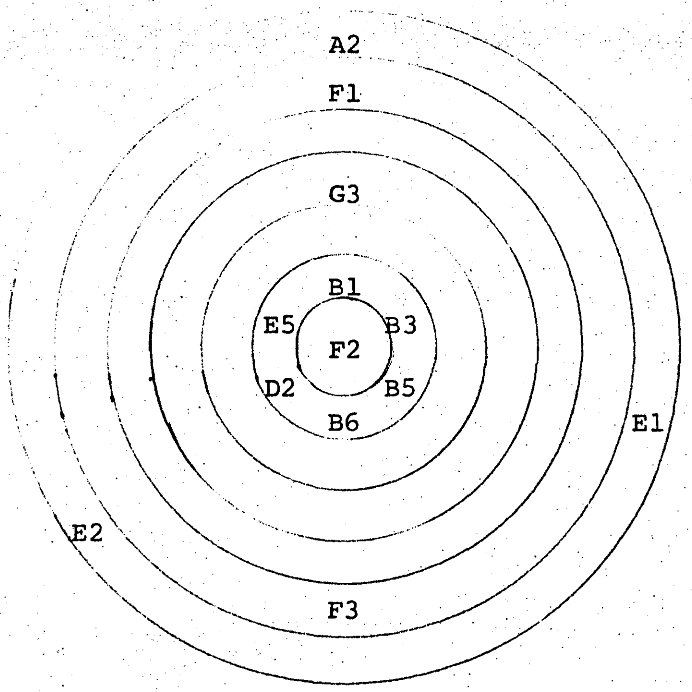
Question 1 Change C:



Once-removed activities only: number of activities 13 down to 1
% inclusion of scale values = 11.5% (D2 only)

Once and twice-removed activities: number of activities 13 down to 10
% inclusion of scale values = 100% (A2 = 28.8%, E1 = 25.6%, F3 = 24.0%, D2 = 11.5%, E5 = 10.1%)

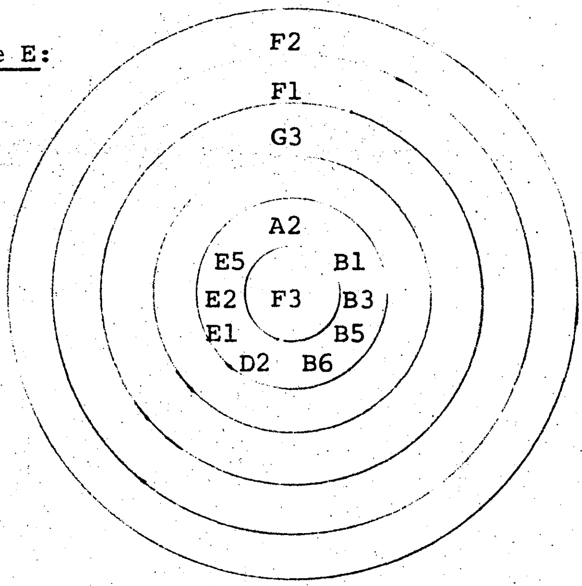
Question 1 Change D:



Coincident activities only: number of activities 12 down to 6
% inclusion of scale values = 39.5%
(B3 = 20.4%, B6 = 16.6%, D2 = 2.5%)

Coincident and twice-removed activities: number of activities 12 down to 7
% inclusion of scale values = 77.1%
(G3 = 37.6%, B3 = 20.4%, B6 = 16.6%, D2 = 2.5%)

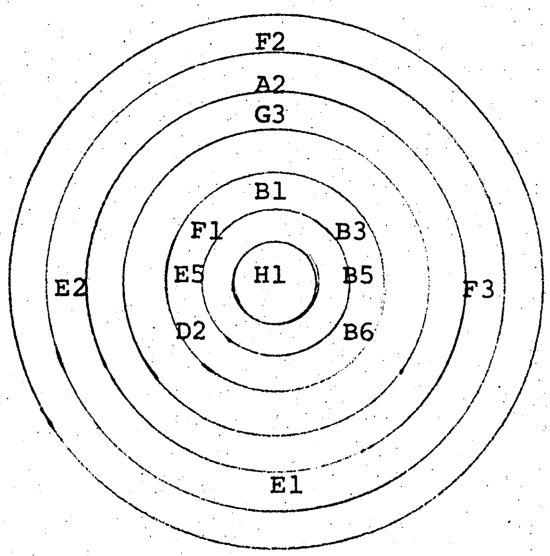
Question 1 Change E:



Coincident activities only: number of activities 12 down to 9
% inclusion of scale values = 36.8%
(B3 = 25.2%, D2 = 7.0%, E5 = 3.7%,
B6 = 0.9%)

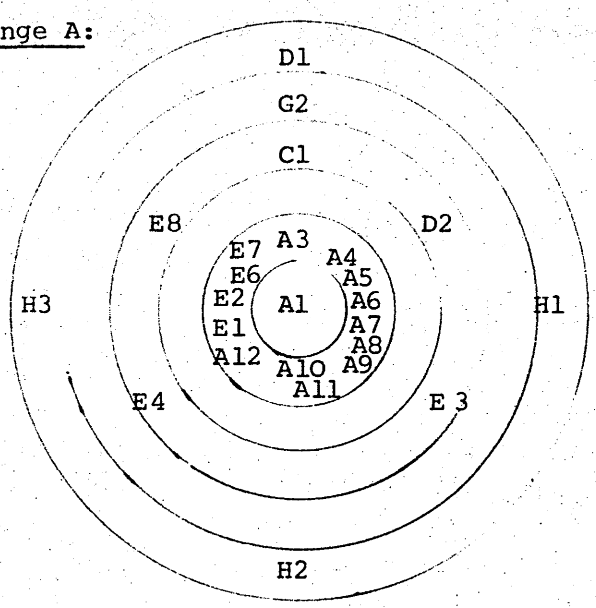
Coincident and twice-removed activities: number of activities 12 down to 10
% inclusion of scale values = 74.0%
(G3 = 37.2%, B3 = 25.2%, D2 = 7.0%,
E5 = 3.7%, B6 = 0.9%)

Question 1 Change F:



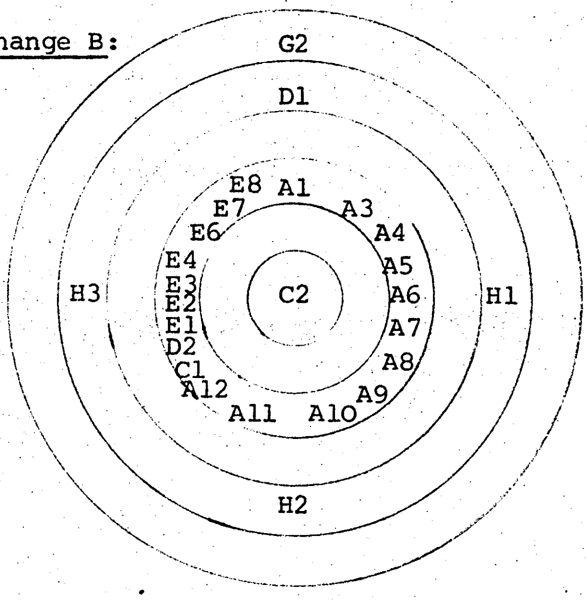
Once-removed activities only:	number of activities 13 down to 7 % inclusion of scale values = 100% (F1 = 33.2%, B3 = 28.7%, D2 = 20.7%, B6 = 17.4%)
Once and three times removed activities:	number of activities 13 down to 8 % inclusion of scale values = 100% (activity %'s as above)

<u>Question 2 Change A:</u>



Coincident activities only:	number of activities 24 down to 14 % inclusion of scale values = 88.3% (A3 = 23.1%, A4 = 19.2%, A11 = 16.1%, A6 = 12.7%, A9 = 12.7%, E1 = 4.5%)
Coincident and twice-removed activities:	number of activities 24 down to 19 % inclusion of scale values = 100%

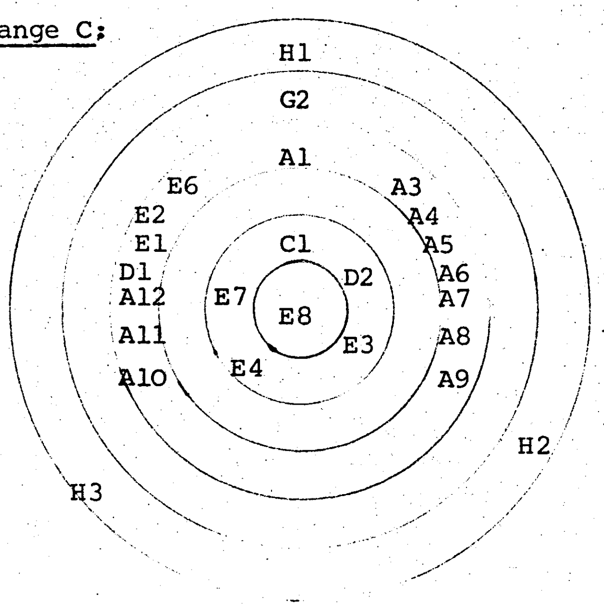
Question 2 Change B:



Once-removed activities only: number of activities 25 down to 20
% inclusion of scale values 90.5%
(D2 = 23.2%, A6 = 18.1%, C1 = 16.9%,
E8 = 11.4%, A1 = 7.8%, A9 = 1.7%)

Once and three times-removed activities: number of activities 25 down to 24
% inclusion of scale values 100%

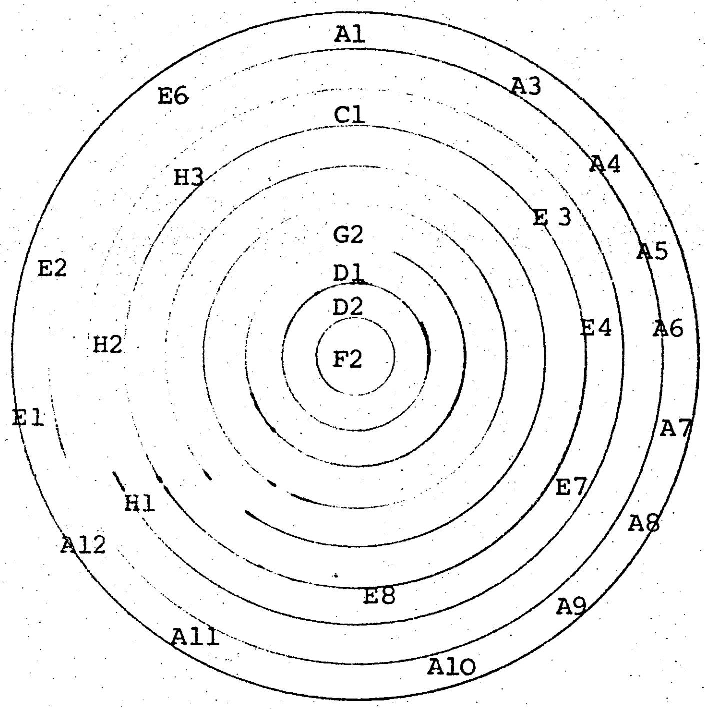
Question 2 Change C:



Coincident activities only: number of activities 24 down to 5
% inclusion of scale values 39.5%
(E4 = 13.6%, C1 = 13.4%, E3 = 8.3%,
E7 = 4.2%)

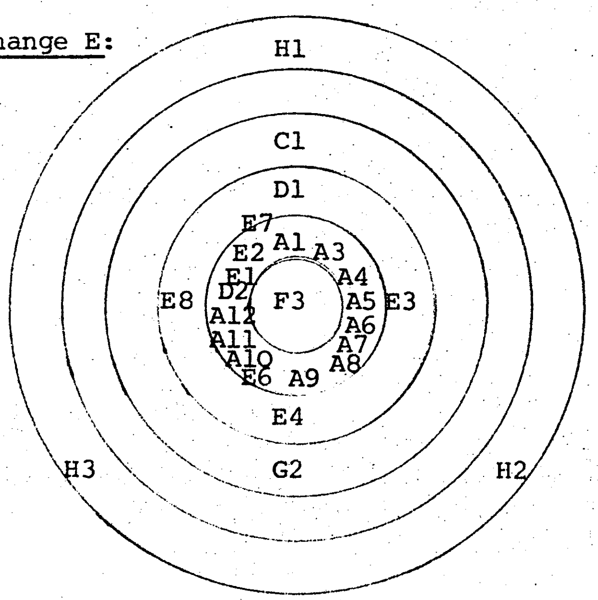
Coincident and twice-removed activities: number of activities 24 down to 20
% inclusion of scale values 97.2%
(E4 = 13.6%, C1 = 13.4%, A1 = 9.2%, A11 = 8.5%
E1 = 8.5%, E3 = 8.3%, A6 = 8.1%, A9 = 7.1%,
A3 = 6.4%, A12 = 5.7%, E7 = 4.2%, A4 = 4.2%)

Question 2 Change D:



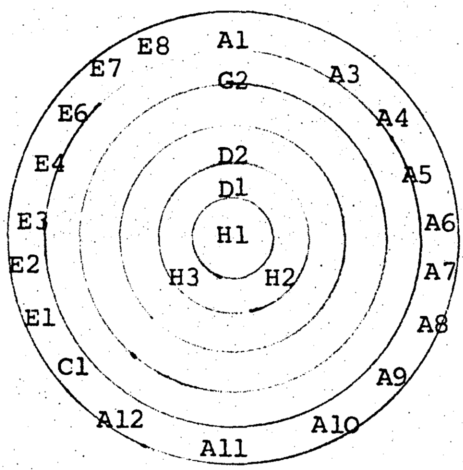
Coincident activities only:	number of activities 25 down to 1 % inclusion of scale values 13.6% (D2)
Coincident and once-removed activities:	number of activities 25 down to 2 % inclusion of scale values 28.3% (D1 = 14.6%, D2 = 13.6%)

Question 2 Change E:



Coincident activities only:	number of activities 25 down to 16 % inclusion of scale values 29.2% (E7 = 12.9%, D2 = 11.5%, A1 = 4.8%)
Coincident and once-removed activities:	number of activities 25 down to 20 % inclusion of scale values 45.6% (E7 = 12.9%, D2 = 11.5%, E4 = 11.1%, D1 = 5.3%, A1 = 4.8%)

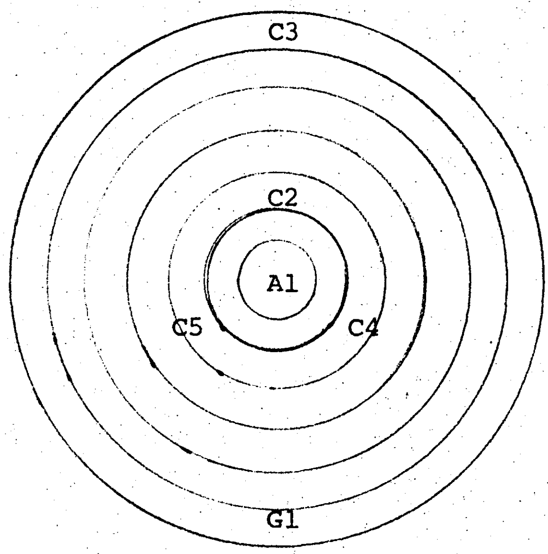
Question 2 Change F:



Coincident activities only: number of activities 24 down to 3
% inclusion of scale values 40% (H3 = 25.6%, D1 = 14.4%)

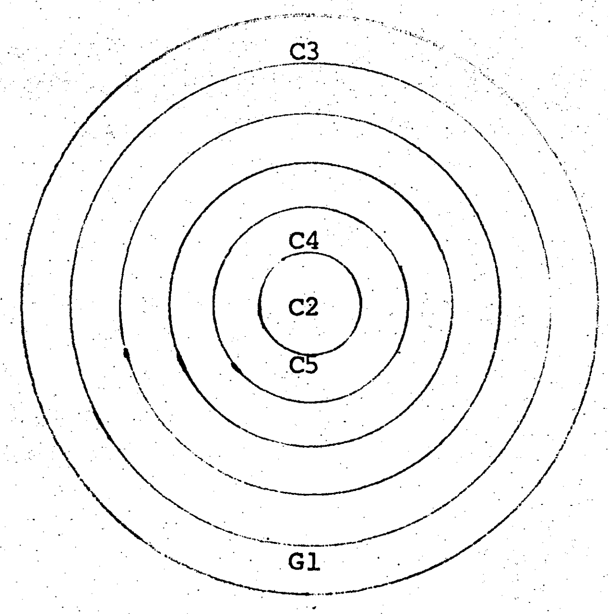
Coincident and once-removed activities: number of activities 24 down to 4
% inclusion of scale values 100% (D2 = 60.0%, H3 = 25.6%, D1 = 14.4%)

Question 3 Change A:



Consideration of only once-removed activities brings the number of activities from 5 down to 3; although it was not previously possible to draw an interval scale due to activity C5 being predominant, C5 is included as one of the three activities.

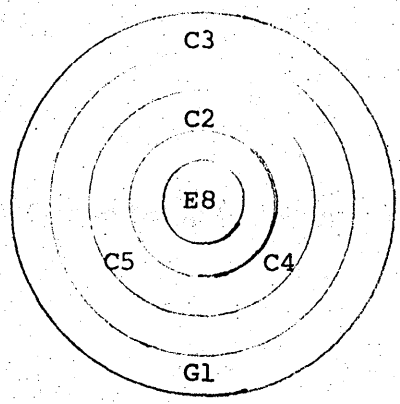
Question 3 Change B:



Coincident activities only: number of activities 4 down to 2
% inclusion of scale values 100%
(C5 = 65.2%, C4 = 34.8%)

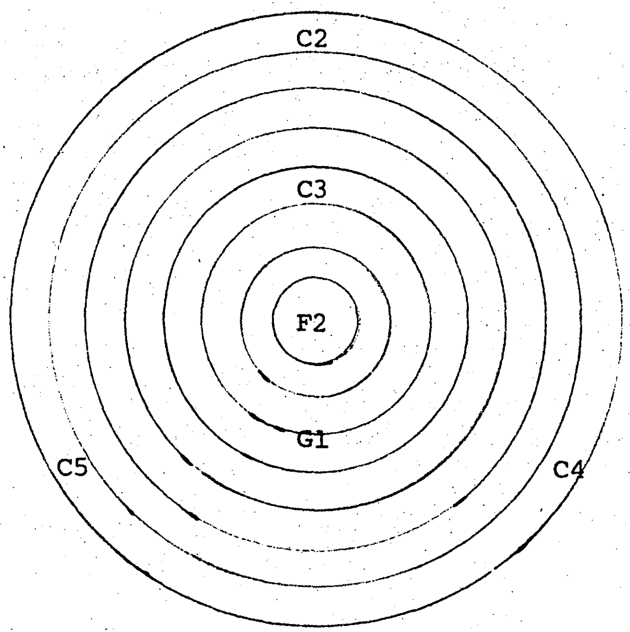
Coincident and four times-removed activities: no reduction in number of activities
% inclusion of scale values 100%
(as above).

Question 3 Change C:



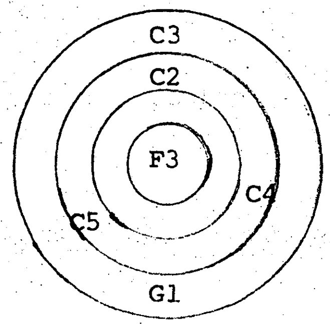
Once-removed activities only:	number of activities 5 down to 3 % inclusion of scale values 100% (C5 = 100%
Once and three times-removed activities:	no reduction in number of activities % inclusion of scale values 100% (C5)

Question 3 Change D:



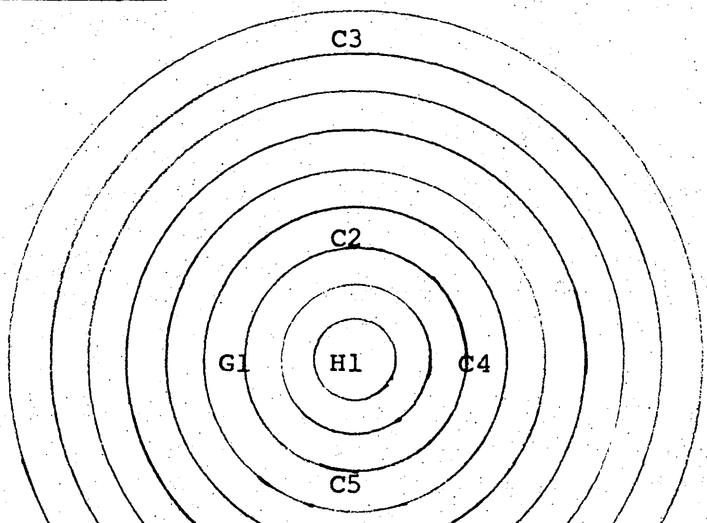
Consideration of only twice-removed activities brings the number of activities from 5 down to 2; although it was not previously possible to draw an interval scale due to activity G1 being predominant, G1 is indluded as one of the two activities.

Question 3 Change E:



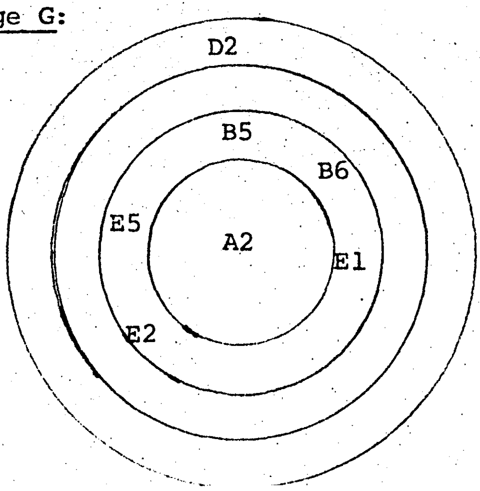
Consideration of only twice-removed activities brings the number of activities from 5 down to 3; it was not previously possible to draw an interval scale due to activity G1 being predominant. However G1 is not one of the three activities.

Question 3 Change F:



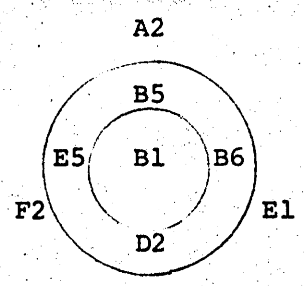
As previously noted, there was an insufficient response to this question to attempt any analysis.

Question 5 Change G:



Coincident activities only:	number of activities 6 down to 5 % inclusion of scale values 100% (E1 = 57.2%, B6 = 42.8%)
Coincident and twice-removed activities:	no reduction in number of activities % inclusion of scale values 100% (as above)

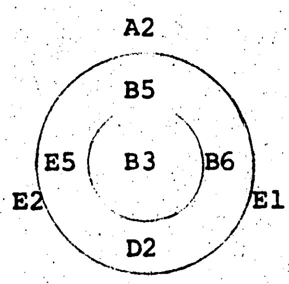
Question 5 Change H:



Coincident activities only: number of activities 7 down to 4
% inclusion of scale values = 100% (D2)

The remaining 3 activities are outside the area of consideration.

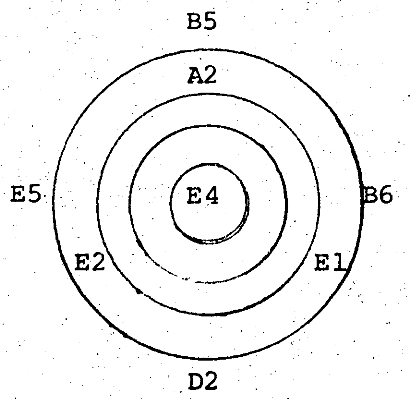
Question 5 Change I:



Coincident activities only: number of activities 7 down to 4
% inclusion of scale values = 88.1%
(B6 = 28.6%, E5 = 25.2%, D2 = 22.4%, B5 = 11.9%)

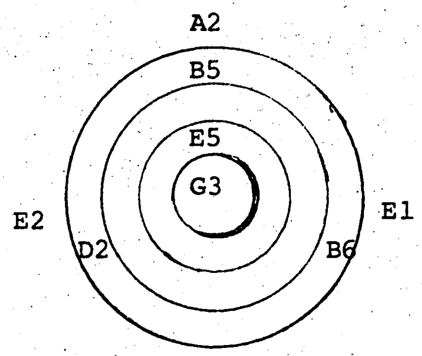
The remaining 3 activities are outside the area of consideration.

Question 5 Change J:



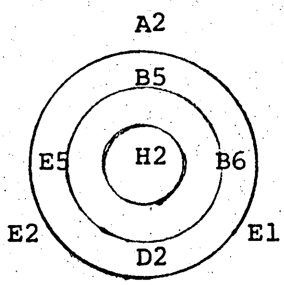
Twice-removed activities only: number of activities 7 down to 3
% inclusion of scale values = 80.9%
(A2 = 40.2%, E1 = 26.1%, E2 = 14.6%)
The remaining 4 activities are outside the area of consideration.

Question 5 Change K:



Coincident activities only: number of activities 7 down to 1
% inclusion of scale values = 0
Coincident and twice-removed activities: number of activities 7 down to 4
% inclusion of scale values = 100%
(B6 = 60.8%, D2 = 39.2%)

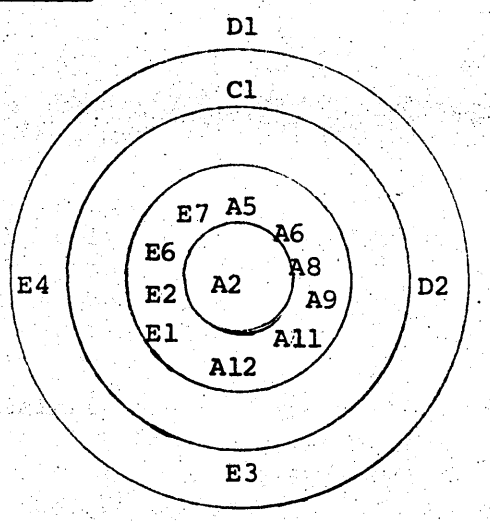
Question 5 Change L:



Once-removed activities only: number of activities 7 down to 4
% inclusion of scale values = 100%
(B6 = 56.7%, D2 = 43.3%)

The remaining three activities are outside the area of consideration.

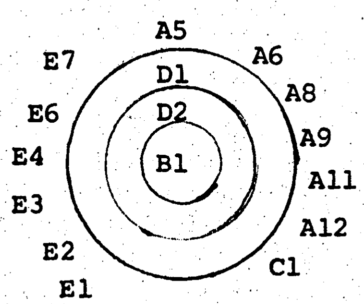
Question 7 Change G:



Coincident activities only: number of activities 15 down to 10
% inclusion of scale values = 67.7%
(A6 = 12.3%, A12 = 10.8%, A9 = 10.5%,
A5 = 9.9%, E1 = 9.4%, A8 = 8.0%, E7 = 6.8%)

Coincident and twice-removed activities: number of activities 15 down to 14
% inclusion of scale values = 100% (C1 = 13.9%, E4 = 12.3%, A6 = 12.3%, A12 = 10.8%, A9 = 10.5%, A5 = 9.9%, E1 = 9.4%, A8 = 8.0%, E7 = 6.8%, D2 = 6.1%)

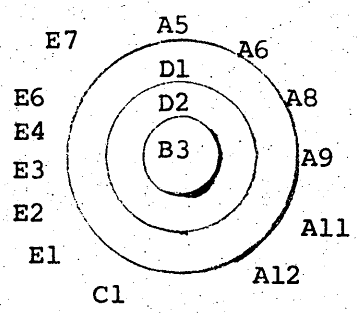
Question 7 Change H:



Coincident activities only: number of activities 15 down to 1
% inclusion of scale values = 72.0% (D2)

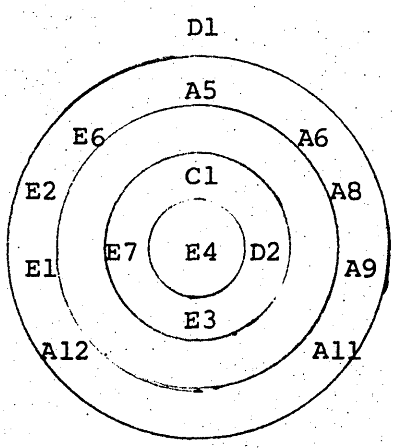
Coincident and once-removed activities: number of activities 15 down to 2
% inclusion of scale values = 72.0% (D2)

Question 7 Change I:



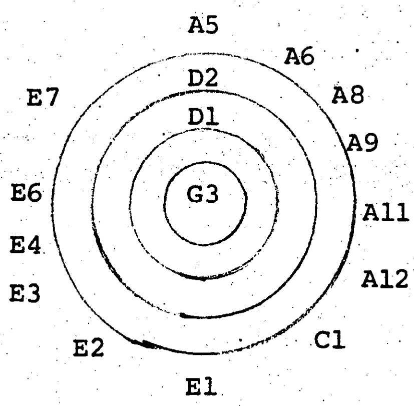
Coincident activities only:	number of activities 15 down to 1 % inclusion of scale values = 28.4% (D2)
Coincident and once-removed activities:	number of activities 15 down to 2 % inclusion of scale values = 47.8% (D2 = 28.4%, D1 = 19.4%)

Question 7 Change J:



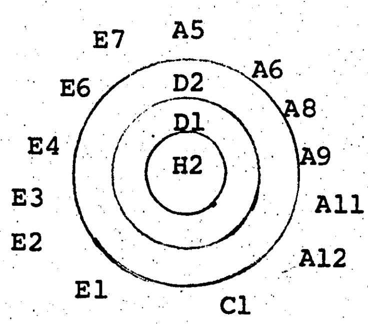
Coincident activities only:	number of activities 14 down to 4 % inclusion of scale values = 49.5% (C1 = 27.6%, E3 = 14.3%, D2 = 7.6%)
Coincident and twice-removed activities:	number of activities 14 down to 13 % inclusion of scale values = 100% (C1 = 27.6%, E1 = 18.1%, E3 = 14.3%, A6 = 11.8%, A9 = 10.8%, D2 = 7.6%, A5 = 4.9%, E2 = 4.9%)

Question 7 Change K:



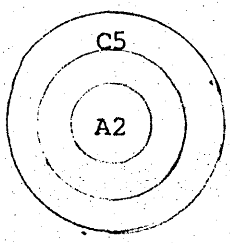
Once-removed activities only:	number of activities 15 down to 1 % inclusion of scale values = 46.6% (D1)
Once and twice-removed activities:	number of activities 15 down to 2 % inclusion of scale values = 100% (D2 = 53.4%, D1 = 46.6%)

Question 7 Change L:

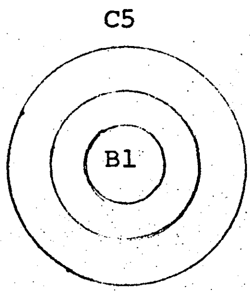


Coincident activities only:	number of activities 15 down to 1 % inclusion of scale values = 0
Coincident and once-removed activities:	number of activities 15 down to 2 % inclusion of scale values = 100% (D2 = 100%)

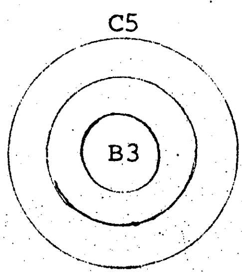
Question 9:



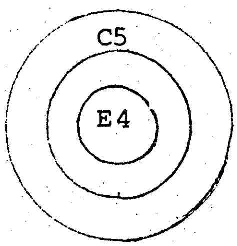
Change G



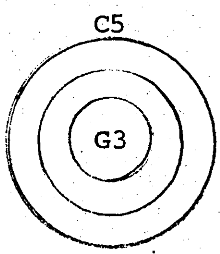
Change H



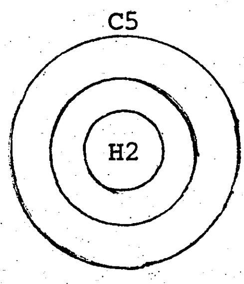
Change I



Change J



Change K



Change L

The proportion of respondents indicating activity C5 were as follows for each change:

Change G	11/15	=	73.3%
Change H	7/15	=	46.7%
Change I	4/15	=	26.7%
Change J	11/15	=	73.3%
Change K	4/15	=	26.7%
Change L	3/15	=	20.0%

APPENDIX B

EXHIBIT 1

Letter to Pharmaceutical Wholesalers,
Hospital Pharmacists and Retail
Chemists.

Cranfield

Cranfield School of Management

Cranfield Bedford MK43 0AL England
Telephone 0234-750111 (Bedford 750111) Telex 825072

[illegible] Wills BA ([illegible]) DMS FInstM MBIM
Professor of Marketing and Logistics Studies
and Director of Doctoral Studies

Dear Sir

I am carrying out a research study (for my Ph.D. degree) of the distribution methods of pharmaceutical manufacturers. I have been in contact with the National Association of Pharmaceutical Distributors, who suggested that I write to you direct.

Little information is available concerning the service expectations of wholesalers. The objective of this study is to ascertain wholesalers' attitudes toward the delivery service they get from manufacturers. I would, therefore, request your participation by answering the enclosed brief questionnaire.

I can assure you of the total anonymity of your response.

I sincerely hope that you will help me in this study by completing the questionnaire and returning it to me in the enclosed envelope (no stamp required).

Working in a cost-conscious business as you do, you will most likely find the questions interesting and thought-provoking. If you wish to see a summary of the results of this survey, please indicate in the space provided at the end, and I will then later forward a copy to you. If you have any queries would you please write to me at 2, Deal Castle Road, Deal, Kent CT14 7BB.

Yours faithfully

R E Gregson
Research Student
Cranfield School of Management

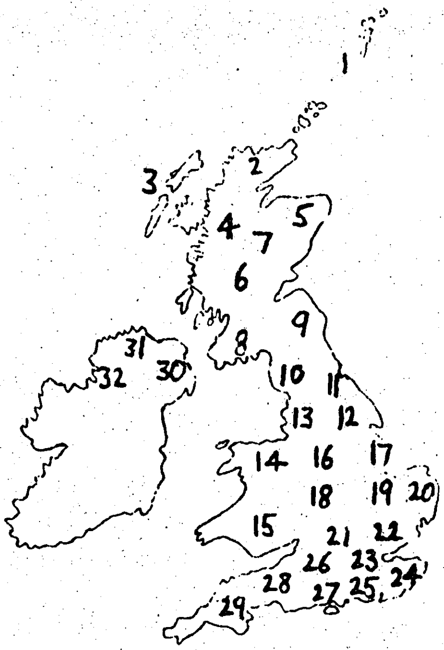
APPENDIX B

EXHIBIT 2

Questionnaire to Pharmaceutical Wholesalers

QUESTIONNAIRE

1. On the map of the British Isles, below, please circle the number corresponding closest to your district.



Do you supply hospitals only, retailers only, or both?...................

2. To give me some idea of the size of your ethical turnover would you indicate in which category your average annual turnover for ethical medicines falls?

Please tick in the appropriate box.

Less than £1 million p.a...................... ☐

£1 million - £2 million p.a.................... ☐

£2 million - £3 million p.a.................... ☐

£3 million - £4 million p.a.................... ☐

£4 million - £5 million p.a.................... ☐

Greater than £5 million p.a.................... ☐

3. In how large an area do you regularly deliver to pharmacies?

Please tick in the appropriate box

Within a 5 mile radius................ ☐

Within a 10 mile radius.............. ☐

Within a 20 mile radius.............. ☐

Within a 40 mile radius.............. ☐

Within a 60 mile radius.............. ☐

Other (please specify)..

4. Do you receive goods from some manufacturers according to their scheduled deliveries?

YES/NO (Please delete as appropriate)

5. If YES, what percentage of total ethical medicines, by value, that you order from all manufacturers, do you receive on a set day, i.e. as a scheduled delivery?

Is it:

Less than 10%.................... ☐

10 - 20%......................... ☐

20 - 30%......................... ☐

30 - 40%......................... ☐

40 - 50%......................... ☐

50 - 60%......................... ☐

Other (Please specify)..

6. Below are listed a number of waiting times between placing an order and receiving delivery for goods that are normally in stock with the manufacturer. On average what % of orders, in number, are appropriate to each waiting time.

Please enter % figure in each box

Less than 3 days.................. ☐

3 - 6 days........................ ☐

1 week - 13 days.................. ☐

2 weeks - 20 days................. ☐

3 weeks - 27 days................. ☐

Greater than 4 weeks.............. ☐

7. On <u>average</u> how frequently do you place orders with a manufacturer?

Please indicate %'s of number of orders below in the appropriate boxes

Every day......................... ☐

Every other day................... ☐

Once a week....................... ☐

Once every 10 days................ ☐

Every other week.................. ☐

Once a month...................... ☐

Other (please specify)..

A poor, or less than satisfactory, delivery service from manufacturers can reduce your efficiency or increase your costs.
Indicate below those categories that would be likely to concern you most.
Please indicate by ticking the appropriate boxes.

Higher stock holding costs.................................. ☐

Losing customers.. ☐

Your time spent in answering queries from pharmacists...... ☐

Your time involved in placing orders and chasing up late deliveries........ ☐

Others (Please specify)...

I would like you to consider the situation of there being six manufacturers (A,B,C,D,E and F) from whom you buy ethical medicines.

Manufacturer A. You receive deliveries from him between 5 - 9 days after placing your order. The average time is 7 days. If an order is very urgent he can ensure delivery to you in 5 - 7 days.

Manufacturer B. You receive a scheduled delivery service from him once every two weeks. These deliveries consistently arrive at the same time at specified 2-weekly intervals. For very urgent orders he will send them to you, usually by an external carrier or by post, arriving in 3 - 5 days.

Manufacturer C. You receive deliveries from him between 12 - 16 days after placing your order. The average time is 14 days. He will despatch very urgent orders to you, by first class post or passenger train, to arrive with you in 1 - 2 days.

Manufacturer D. You receive deliveries from him between 19 - 23 days after placing your order. The average time is 21 days. For very urgent orders he will send them to you, usually by external carrier or post, arriving in 2 - 4 days.

Manufacturer E. You receive deliveries from him between 10 - 18 days after placing your order. The average time is 14 days. For very urgent orders he will send them to you, usually by external carrier or post, arriving in 3 - 5 days.

Manufacturer F. You receive deliveries from him between 12 - 16 days after placing your order. The average time is 14 days. He will not accept any orders for earlier delivery, unless a delivery surcharge is paid by you.

I would like you to express your preferences between these six hypothetical manufacturers by considering each pair in turn. For the pairs listed below please mark the letter of the preferred manufacturer in the adjacent box. For instance, in (i) if you prefer manufacturer A to manufacturer B, mark the letter A in the adjacent box.

Which do you prefer?

(i)	Manufacturer A or Manufacturer B..........	☐
(ii)	Manufacturer A or Manufacturer C..........	☐
(iii)	Manufacturer D or Manufacturer E..........	☐
(iv)	Manufacturer A or Manufacturer E..........	☐
(v)	Manufacturer A or Manufacturer F..........	☐
(vi)	Manufacturer D or Manufacturer F..........	☐
(vii)	Manufacturer B or Manufacturer D..........	☐
(viii)	Manufacturer B or Manufacturer F..........	☐
(ix)	Manufacturer E or Manufacturer F..........	☐
(x)	Manufacturer C or Manufacturer D..........	☐
(xi)	Manufacturer C or Manufacturer E..........	☐
(xii)	Manufacturer B or Manufacturer C..........	☐

If you feel that the answers you have been able to give require further qualification, I would appreciate any further comments you may wish to make.

From your answers and those of other respondents, I hope to understand better the delivery service expectations of wholesalers.

Thank you very much for your assistance.

Please tick if you would like me to later forward you a summary of the results ( )

APPENDIX B

EXHIBIT 3

Questionnaire to Hospital Pharmacists

1. What approximate proportion of your ethical turnover, in terms of numbers of individual packs, is accounted for by items on contract? Please tick in appropriate box.

   0 - 10% . . . . ☐

   10 - 20% . . . . ☐

   20 - 30% . . . . ☐

   30 - 40% . . . . ☐

   More, (please specify) . . . .

2. For all ethical medicines (contract and non-contract) what approximate proportion, in terms of numbers of individual packs, do you obtain from wholesalers rather than buying direct from manufacturers? Please tick in appropriate box.

   0 - 10% . . . . ☐

   10 - 20% . . . . ☐

   20 - 30% . . . . ☐

   30 - 40% . . . . ☐

   More (please specify) . . . .

3. How close to your pharmacy is (i) the wholesaler with whom you place most of your orders, and (ii) the wholesaler with whom you place the next highest number of orders? Please tick in appropriate boxes.

	(i)	(ii)
Within 5 miles	☐	☐
5 - 10 miles	☐	☐
10 - 15 miles	☐	☐
15 - 25 miles	☐	☐
25 - 50 miles	☐	☐
More than 50 miles	☐	☐

4. How frequently do these wholesalers deliver to you? Do they call:

	(i)	(ii)
3 times a day	☐	☐
Twice a day	☐	☐
Once a day	☐	☐
Every other day	☐	☐
Once a week	☐	☐

Other (please specify) . . . .

5. On average, how frequently do you place orders with these wholesalers? Do you place them:

	(i)	(ii)
Twice a day	☐	☐
Once a day	☐	☐
Every other day	☐	☐
Once a week	☐	☐

Other (please specify) . . . .

6. I would like you to consider the situation of there being six wholesalers (A, B, C, D, E and F) from whom you could purchase most of your ethical medicines. Assume that they each offer the same discount terms.

Wholesaler A delivers twice a day. You have to place your orders before 10 a.m. for morning deliveries, and before 2.30 p.m. for afternoon deliveries. The times of the day when his deliveries are made are fairly consistent - they all arrive within one hour either side of set times in the morning and the afternoon.

Wholesaler B delivers once a day. You normally have to place orders by 10 a.m. for delivery that day, but very urgent orders will be accepted later if the van has not already left. The times of the day when his deliveries are made are very consistent - they all arrive within half an hour either side of a set time in the day.

Wholesaler C delivers once a day. You normally have to place orders by 10 a.m. for delivery that day, but very urgent orders will be accepted any time and specially delivered to you that day if necessary. The times of the day when his normal deliveries are made are fairly consistent - they all arrive within one hour either side of a set time in the day.

Wholesaler D delivers every other day. You have to place orders by 10 a.m. on delivery days for delivery that day. For very urgent orders placed on non-delivery days, the van can be diverted to call on you. The times of the day when his normal deliveries are made are fairly consistent - they all arrive within one hour either side of a set time in the day.

Wholesaler E delivers once a day. You normally have to place orders by 10 a.m. for delivery that day, but very urgent orders will be accepted later if the van has not already left. The times of the day when his deliveries are made are not very consistent, but they do all arrive within two hours either side of a set time in the day.

Wholesaler F delivers once a day. You have to place orders by 10 a.m. for delivery that day. No orders placed later will be delivered that day, even if urgent. The times of the day when his deliveries are made are fairly consistent - they all arrive within one hour either side of a set time in the day.

I would like you to express your preferences between these six hypothetical wholesalers by considering each pair of wholesalers in turn. For the pairs listed below please mark the letter of the preferred wholesaler in the adjacent box. For instance, in (i) if you prefer Wholesaler A to Wholesaler B, mark the letter A in the adjacent box.

Which do you prefer?

(i)	Wholesaler A or Wholesaler B	☐
(ii)	Wholesaler A or Wholesaler C	☐
(iii)	Wholesaler D or Wholesaler E	☐
(iv)	Wholesaler A or Wholesaler E	☐
(v)	Wholesaler A or Wholesaler F	☐
(vi)	Wholesaler D or Wholesaler F	☐
(vii)	Wholesaler B or Wholesaler D	☐
(viii)	Wholesaler B or Wholesaler F	☐
(ix)	Wholesaler E or Wholesaler F	☐
(x)	Wholesaler C or Wholesaler D	☐
(xi)	Wholesaler C or Wholesaler E	☐
(xii)	Wholesaler B or Wholesaler C	☐

7. I would next like you to consider the situation of there being six manufacturers (1, 2, 3, 4, 5 and 6) from whom you could purchase ethical medicines direct. Assume that they each offer the same discount terms.

Manufacturer 1. You receive deliveries from him between 5 - 9 days after placing your order. The average time is 7 days. If an order is very urgent he can ensure delivery to you in 5 - 7 days.

Manufacturer 2. You receive a scheduled delivery service from him once every two weeks. These deliveries consistently arrive at the same time at specified 2-weekly intervals. You must order at least 2 weeks in advance of delivery. For very urgent orders he will send them to you, usually by post, arriving in 3 - 5 days.

Manufacturer 3. You receive deliveries from him between 12 - 16 days after placing your order. The average time is 14 days. He will despatch very urgent orders to you by express, at no extra charge, to arrive with you in 1 - 2 days.

Manufacturer 4. You receive deliveries from him between 19 - 23 days after placing your order. The average time is 21 days. For very urgent orders he will send them to you, usually by post, arriving in 2 - 4 days.

Manufacturer 5. You receive deliveries from him between 10 - 18 days after placing your order. The average time is 14 days. For very urgent orders he will send them to you, usually by post, arriving in 3 - 5 days.

Manufacturer 6. You receive deliveries from him between 12 - 16 days after placing your order. The average time is 14 days. He will not accept any orders for earlier delivery, unless a delivery surcharge is paid by you.

I would like you to express your preferences between these six hypothetical manufacturers by considering each pair in turn. For the pairs listed below please mark the number of the preferred manufacturer in the adjacent box. For instance, in (i) if you prefer manufacturer 1 to manufacturer 2, mark the number 1 in the adjacent box.

Which do you prefer?

(i) Manufacturer 1 or Manufacturer 2 . . . . ☐

(ii) Manufacturer 4 or Manufacturer 6 . . . . ☐

(iii) Manufacturer 1 or Manufacturer 3 . . . . ☐

(iv) Manufacturer 1 or Manufacturer 5 . . . . ☐

(v) Manufacturer 4 or Manufacturer 5 . . . . ☐

(vi) Manufacturer 1 or Manufacturer 6 . . . . ☐

(vii) Manufacturer 2 or Manufacturer 4 . . . . ☐

(viii) Manufacturer 2 or Manufacturer 3 . . . . ☐

(ix) Manufacturer 2 or Manufacturer 6 . . . . ☐

(x) Manufacturer 3 or Manufacturer 4 . . . . ☐

(xi) Manufacturer 5 or Manufacturer 6 . . . . ☐

(xii) Manufacturer 3 or Manufacturer 5 . . . . ☐

If you feel that the answers you have been able to give require further qualification, I would appreciate any further comments you may wish to make.

From your answers and those of other respondents, I hope to understand better the delivery service expectations of pharmacists.

Thank you very much for your assistance.

Please tick if you would like me to later forward you a summary of the results (   ).

APPENDIX B

EXHIBIT 4

Questionnaire to Retail Chemists

1. How close to your pharmacy is (i) the wholesaler with whom you place most of your orders, and (ii) the wholesaler with whom you place the next highest number of orders?

Please tick in appropriate boxes

	(i)	(ii)
Within 5 Miles..................	☐	☐
5 -10 Miles.....................	☐	☐
10 - 15 Miles...................	☐	☐
15 - 25 Miles..................	☐	☐
25 - 50 Miles..................	☐	☐
More than 50 Miles............	☐	☐

2. How frequently do these wholesalers deliver to you? Do they call:

	(i)	(ii)
3 Times a Day..................	☐	☐
Twice a Day....................	☐	☐
Once a Day.....................	☐	☐
Every Other Day................	☐	☐
Once a Week....................	☐	☐

Other (Please Specify)...

3. On average, how frequently do you place orders with these wholesalers? Do you place them:

	(i)	(ii)
Twice a Day....................	☐	☐
Once a Day.....................	☐	☐
Every Other Day................	☐	☐
Once a Week....................	☐	☐

Other (Please Specify)...

4. I would like you to consider the situation of there being six wholesalers (A,B,C,D,E and F) from whom you could purchase most of your ethical medicines. Assume that they each offer the same discount terms.

Wholesaler A delivers twice a day. You have to place your orders before 10 a.m. for morning deliveries, and before 2.30 p.m. for afternoon deliveries. The times of the day when his deliveries are made are fairly consistent - they all arrive within one hour either side of set times in the morning and the afternoon.

Wholesaler B delivers once a day. You normally have to place orders by 10 a.m. for delivery that day, but very urgent orders will be accepted later if the van has not already left. The times of the day when his deliveries are made are very consistent - they all arrive within half an hour either side of a set time in the day.

Wholesaler C delivers once a day. You normally have to place orders by 10 a.m. for delivery that day, but very urgent orders will be accepted any time and specially delivered to you that day if necessary. The times of the day when his normal deliveries are made are fairly consistent - they all arrive within one hour either side of a set time in the day.

Wholesaler D delivers every other day. You have to place orders by 10 a.m.on delivery days for delivery that day. For very urgent orders placed on non-delivery days, the van can be diverted to call on you. The times of the day when his normal deliveries are made are fairly consistent - they all arrive within one hour either side of a set time in the day.

5. WHAT PROPORTION, BY VALUE, OF YOUR PRESCRIPTION MEDICINES DO YOU BUY DIRECT FROM MANUFACTURERS RATHER THAN FROM WHOLESALERS?

PLEASE TICK IN APPROPRIATE BOX

LESS THAN 5% BY VALUE . . . . ☐

5 - 10% BY VALUE . . . . ☐

10 - 20% BY VALUE . . . . ☐

20 - 30% BY VALUE . . . . ☐

OTHER (PLEASE SPECIFY) . . . .

6. WHAT PROPORTION OF YOUR PRESCRIPTION MEDICINES DO YOU BUY DIRECT FROM MANUFACTURERS, IN TERMS OF NUMBER OF ORDERS?

LESS THAN 5% OF ORDERS . . . . ☐

5 - 10% OF ORDERS . . . . ☐

10 - 20% OF ORDERS . . . . ☐

20 - 30% OF ORDERS . . . . ☐

OTHER (PLEASE SPECIFY) . . . .

7. WHEN YOU PURCHASE DIRECT FROM MANUFACTURERS ARE THE MEDICINES WHICH YOU ORDER YOUR HIGH TURNOVER LINES OR YOUR LOW TURNOVER LINES?

THE SCALE BELOW SHOWS NUMBER 5 TO REPRESENT YOUR LINES OF HIGHEST TURNOVER DOWN TO NUMBER 1 REPRESENTING YOUR LINES OF LOWEST TURNOVER. NUMBERS 2, 3 AND 4 REPRESENT TURNOVERS IN-BETWEEN HIGHEST AND LOWEST.

IN GENERAL, WHAT NUMBER APPLIES TO THE TYPE OF MEDICINES WHICH YOU MOSTLY ORDER DIRECT FROM MANUFACTURERS?

PLEASE CIRCLE APPROPRIATE NUMBER

HIGHEST		AVERAGE		LOWEST
5	4	3	2	1

8. WHEN YOU PURCHASE DIRECT FROM MANUFACTURERS ARE THE MEDICINES WHICH YOU ORDER THOSE WITH A HIGH RETAIL PRICE OR A LOW RETAIL PRICE?

THE SCALE BELOW SHOWS NUMBER 5 TO REPRESENT LINES OF HIGHEST RETAIL PRICE DOWN TO NUMBER 1 REPRESENTING LINES OF LOWEST RETAIL PRICE. NUMBERS 2, 3 AND 4 REPRESENT RETAIL PRICES IN-BETWEEN HIGHEST AND LOWEST.

IN GENERAL WHAT NUMBER APPLIES TO THE TYPES OF MEDICINES WHICH YOU MOSTLY ORDER DIRECT FROM MANUFACTURERS?

PLEASE CIRCLE APPROPRIATE NUMBER

HIGHEST		AVERAGE		LOWEST
5	4	3	2	1

Wholesaler E delivers once a day. You normally have to place orders by 10 a.m. for delivery that day, but very urgent orders will be accepted later if the van has not already left. The times of the day when his deliveries are made are not very consistent, but they do all arrive within two hours either side of a set time in the day.

Wholesaler F delivers once a day. You have to place orders by 10 a.m. for delivery that day. No orders placed later will be delivered that day, even if urgent. The times of the day when his deliveries are made are fairly consistent - they all arrive within one hour either side of a set time in the day.

I would like you to express your preferences between these six hypothetical wholesalers by considering each pair of wholesalers in turn. For the pairs listed below please mark the letter of the preferred wholesaler in the adjacent box. For instance, in (i) if you prefer Wholesaler A to Wholesaler B, mark the letter A in the adjacent box.

Which do you prefer?

(i) Wholesaler A or Wholesaler B................

(ii) Wholesaler A or Wholesaler C................

(iii) Wholesaler D or Wholesaler E................

(iv) Wholesaler A or Wholesaler E................

(v) Wholesaler A or Wholesaler F................

(vi) Wholesaler D or Wholesaler F................

(vii) Wholesaler B or Wholesaler D................

(viii) Wholesaler B or Wholesaler F................

(ix) Wholesaler E or Wholesaler F................

(x) Wholesaler C or Wholesaler D................

(xi) Wholesaler C or Wholesaler E................

9. I would next like you to consider the situation of there being six manufacturers (1,2,3,4,5 and 6) from whom you could purchase ethical medicines direct. Assume that they each offer the same discount terms.

Manufacturer 1. You receive deliveries from him between 5 - 9 days afte placing your order. The average time is 7 days. If an order is very urgent he can ensure delivery to you in 5 - 7 days.

Manufacturer 2. You receive a scheduled delivery service from him once every two weeks. These deliveries consistently arrive at the same time at specified 2-weekly intervals. You must order at least 2 weeks in advance of delivery. For very urgent orders he will send them to you, usually by post, arriving in 3 - 5 days.

Manufacturer 3. You receive deliveries from him between 12 - 16 days after placing your order. The average time is 14 days. He will despatch very urgent orders to you by express, at no extra charge, to arrive with you in 1 - 2 days.

Manufacturer 4. You receive deliveries from him between 19 - 23 days after placing your order. The average time is 21 days. For very urgent orders he will send them to you, usually by post, arriving in 2 - 4 days.

Manufacturer 5. You receive deliveries from him between 10 - 18 days after placing your order. The average time is 14 days. For very urgent orders he will send them to you, usually by post, arriving in 3 - 5 days.

Manufacturer 6. You receive deliveries from him between 12 - 16 days after placing your order. The average time is 14 days. He will not accept any orders for earlier delivery, unless a delivery surcharge is paid by you.

I would like you to express your preferences between these six hypothetical manufacturers by considering each pair in turn. For the pairs listed below please mark the number of the preferred manufacturer in the adjacent box. For instance , in (i) if you prefer manufacturer 1 to manufacturer 2, mark the number 1 in the adjacent box.

Which do you prefer?

(i)	Manufacturer 1 or Manufacturer 2...........	☐
(ii)	Manufacturer 4 or Manufacturer 6...........	☐
(iii)	Manufacturer 1 or Manufacturer 3...........	☐
(iv)	Manufacturer 1 or Manufacturer 5...........	☐
(v)	Manufacturer 4 or Manufacturer 5...........	☐
(vi)	Manufacturer 1 or Manufacturer 6...........	☐
(vii)	Manufacturer 2 or Manufacturer 4...........	☐
(viii)	Manufacturer 2 or Manufacturer 3...........	☐
(ix)	Manufacturer 2 or Manufacturer 6...........	☐
(x)	Manufacturer 3 or Manufacturer 4...........	☐
(xi)	Manufacturer 5 or Manufacturer 6...........	☐
(xii)	Manufacturer 3 or Manufacturer 5...........	☐

10. To give me some idea of the size of your ethical business would you please indicate in which category your average daily dispensing trade falle?

Please tick in appropriate box

Less than 40 prescription items per day . . . .

40 - 80 prescription items per day . . . .

80 - 150 prescription items per day . . . .

150 - 250 prescription items per day . . . .

More than 250 prescription items per day . . . .

If you feel that the answers you have been able to give require further qualification, I would appreciate any further comments you may wish to make.

From your answers and those of other respondents, I hope to understand better the delivery service expectations of pharmacists.

Thank you very much for your assistance.

Please tick if you would like me to later forward you a summary of the results (   )

APPENDIX B

EXHIBIT 5

Reminder letter to Wholesalers,
Hospital Pharmacists and Retail
Chemists.

Cranfield

Cranfield School of Management

Cranfield Bedford England MK43 0AL
Telephone 0234-750111 (Bedford 750111) Telex 825072
Gordon Wills BA (Pol Econ) DMS FInstM MBIM
Professor of Marketing and Logistics Studies
and Director of Doctoral Studies

Dear Sir,

Some while ago I sent you a questionnaire in connection with my studies on pharmaceutical distribution.

I realise that there is a considerable quantity of paperwork that you are required to complete nowadays, but I must stress that I do consider my research to be of great importance, and that your reply would be an invaluable aid to me.

I hope that it will be possible for you to complete the questionnaire, which I enclose together with a pre-paid envelope for its return.

Thanking you,

Yours faithfully,

R.E. Gregson

APPENDIX B

EXHIBIT 6

Tabulated Responses to Pharmaceutical
Wholesalers Questionnaire.

Question 1   Total number of respondents = 19   (18) *

% response to question = 25.7%   (24.3%) *

Regional Location	No.of Respond-ents	Regional Location	No.of Respond -ents	Regional Location	No.of Respond -ents	Regional Location	No.of Respond -ents
1		9	1	17	1	25	
2		10		18		26	
3		11	2	19		27	3
4		12	1	20		28	
5	1	13	5	21		29	1
6	1	14		22	1	30	
7		15		23	1	31	
8	1	16		24		32	

Total number of respondents = 16   (15)
% response = 21.6%   (20.2%)

Type of Customer	No.of Respondents
Retailers only	5
Hospitals only	1
Retailers and Hospitals	10

* Figures in brackets refer to the response rate prior to sending out the reminder letters.

<u>Question 2.</u> Total number of respondents = 17 (17)
% response = 23.0% (23.0%)

Size of Ethical Turnover	No. of Respondents
< £1 million p.a.	6
£1 million - £2 million p.a.	10
£2 million - £3 million p.a.	1
£3 million - £4 million p.a.	-
£4 million - £5 million p.a.	-
> £5 million p.a.	-

<u>Question 3</u> Total number of respondents = 19 (18)
% response = 25.7% (24.3%)

Radius of Delivery Area	No. of Respondents
5 miles	-
10 miles	1
20 miles	3
40 miles	6
60 miles	7
70 miles	2

<u>Question 4</u> Total number of respondents = 19 (18)
% response = 25.7% (24.3%)

Scheduled Deliveries?	No. of Respondents
Yes	19
No	-

<u>Question 5</u> Total number of respondents = 19 (18)
% response = 25.7% (24.3%)

Proportion of Receipts by Scheduled Delivery	No. of Respondents
< 10%	2
10% - 20%	6
20% - 30%	5
30% - 40%	3
40% - 50%	2
50% - 60%	1

<u>Question 6</u> Total number of respondents = 18 (17)
% response = 24.3% (23.0%)

Waiting Times	Percentages of Orders Received - Individual responses																		To-tal %	Ave.% per res-pond-ent
< 3 days	5				14			2										2	23	1.3
3 - 6 days	10	9	5	5	13		5	10			20	3			10	3	5	15	113	6.3
1 week-13 days	80	70	75	90	58	50	75	58	70	30	50	88	70	95	40	85	70	45	1199	66.6
2 weeks-20 days	5	20	10	5	11	40	20	20	25	60	30	6	30	5	45	12	15	20	379	21.0
3 weeks-27days		1	10		3	10		10	5	10		2			5		5	18	79	4.4
> 4 weeks					1							1					5		7	0.4

Question 7 Total number of respondents = 15 (14)
% response = 20.3% (18.9%)

Ordering Frequency	%'s of Orders placed - Individual responses															Total %	Ave.% per respondent
Every Day																	
Every Other Day																	
Once a week			75	5		10		50		67		50		60		317	21.1
Once every 10 days								20								20	1.3
Every other week	90	90	25	45	100	85	30	20	100	33	95	50	95	40	80	978	65.3
Once a month	10	10		50		5	70	10			5		5		20	185	12.3

Question 9 Total number of respondents = 19 (18)
% response = 25.7% (24.3%)

Alternative Manufacturers	A	B	C	D	E	F
A	9½	12	4	0	1	0
B	7	9½	6	0	0	1
C	15	13	9½	0	0	0
D	19	19	19	9½	18	8
E	18	19	19	1	9½	1
F	19	18	19	11	18	9½

The cell entries in the above matrix are the numbers of wholesaler respondents who preferred the "column" to the "row" alternative. The diagonal cells are given a value $\frac{N}{2}$ $(\frac{19}{2} = 9\frac{1}{2})$.

APPENDIX B

EXHIBIT 7

Tabulated Responses from Hospital
Pharmacists Questionnaire

Question 1 Total number of respondents = 50 (41)*
% response = 36.2% (29.7%) *

Proportion of Medicines on Contract with Manufacturers	No. of Responses
0 - 10%	2
10 - 20%	5
20 - 30%	15
30 - 40%	16
40 - 50%	1
50 - 60%	6
60 - 70%	3
70 - 80%	2

Question 2 Total number of respondents = 55 (47)
% response = 39.9% (34.1%)

Proportion of Medicines Obtained through Whole-salers	No. of Responses
0 - 10%	3
10 - 20%	6
20 - 30%	15
30 - 40%	24
40 - 50%	2
50 - 60%	2
60 - 70%	-
70 - 80%	3

*Figures in brackets refer to the response rate prior to sending out the reminder letters.

Question 3 Part i)   Total number of respondents = 61   (51)
% response = 44.2%   (36.9%)

Proximity of Wholesaler with whom Pharmacist places most of his orders	No. of Responses
Within 5 miles	12
5 - 10 miles	17
10 - 15 miles	4
15 - 25 miles	13
25 - 50 miles	12
More than 50 miles	3

Question 3 Part ii)   Total number of respondents = 60   (50)
% response = 43.5%   (36.2%)

Proximity of Wholesaler with whom Pharmacist places his next highest number of orders	No. of Responses
Within 5 miles	11
5 - 10 miles	2
10 - 15 miles	9
15 - 25 miles	8
25 - 50 miles	17
More than 50 miles	12

<u>Question 4 Part i)</u>

Total number of respondents = 59 (50)
% response = 42.8% (36.2%)

Frequency of Deliveries by First Wholesaler	No. of Responses
3 times a day	1
Twice a day	18
Once a day	36
Every other day	2
Twice a week	2
Once a week	-

<u>Question 4 Part ii)</u>

Total number of respondents = 59 (50)
% response = 42.8% (36.2%)

Frequency of Deliveries by Second Wholesaler	No. of Responses
3 times a day	-
Twice a day	15
Once a day	31
Every other day	5
Twice a week	8
Once a week	-

Question 5 Part i) Total number of respondents = 60 (50)
% response = 43.5% (36.2%)

Ordering Frequency with First Wholesaler	No. of Responses
Twice a day	6
Once a day	35
Every other day	7
Twice a week	2
Once a week	-

Question 5 Part ii) Total number of respondents = 59 (49)
% response = 42.8% (35.5%)

Ordering Frequency with Second Wholesaler	No. of Responses
Twice a day	5
Once a day	28
Every other day	11
Twice a week	9
Once a week	6

<u>Question 6</u> Total number of respondents = 56 (46)
% response = 40.6% (33.3%)

Alternative Wholesalers	A	B	C	D	E	F
A	28	13	27	0	7	2
B	43	28	42	7	0	2
C	29	14	28	0	0	0
D	56	49	56	28	36	22
E	49	56	56	20	28	9
F	54	54	56	34	47	28

<u>Question 7</u> Total number of respondents = 53 (44)
% response = 38.4% (31.9%)

Alternative Manufacturers	1	2	3	4	5	6
1	26½	11	35	0	21	4
2	42	26½	46	16	0	15
3	18	7	26½	0	1	0
4	53	37	53	26½	39	13
5	32	53	52	14	26½	1
6	49	38	53	40	52	26½

The cell entries in both of the above matrices are the numbers of hospital pharmacist respondents who preferred the "column" to the "row" alternative. The diagonal cells are given a value $\frac{N}{2}$. (question 6, $\frac{56}{2} = 28$; question 7, $\frac{53}{2} = 26\frac{1}{2}$).

APPENDIX B

EXHIBIT 8

Tabulated Responses from Retail Chemists Questionnaire

Question 1 Part i) Total number of respondents = 56 (39)*
% response = 27.0% (18.8%)*

Proximity of Wholesaler with whom Chemist places most of his orders	No. of Responses
Within 5 miles	17
5 - 10 miles	10
10 - 15 miles	12
15 - 25 miles	4
25 - 50 miles	8
> 50 miles	5

Question 1 Part ii) Total number of respondents = 57 (39)
% response = 27.5% (18.8%)

Proximity of Wholesaler with whom Chemist places his next highest number of orders	No. of Responses
Within 5 miles	14
5 - 10 miles	7
10 - 15 miles	8
15 - 25 miles	14
25 - 50 miles	8
> 50 miles	6

* Figures in brackets refer to the response rate prior to sending out the reminder letters.

Question 2 Part i) | Total number of respondents = 57 (39)
% response = 27.5% (18.8%)

Frequency of Deliveries by First Wholesaler	No. of Responses
4 times a day	2
3 times a day	19
Twice a day	25
Once a day	9
Every other day	-
Twice a week	1
Once a week	1

Question 2 Part ii) | Total number of respondents = 55 (38)
% response = 26.5% (18.4%)

Frequency of Deliveries by Second Wholesaler	No. of Responses
4 times a day	1
3 times a day	11
Twice a day	23
Once a day	15
Every other day	2
Twice a week	3
Once a week	-

Question 3 Part i) Total number of respondents = 59 (41)
% response = 28.5% (19.8%)

Ordering Frequency with First Wholesaler	No. of Responses
4 times a day	2
3 times a day	9
Twice a day	32
Once a day	14
Every other day	-
Twice a week	1
Once a week	1

Question 3 Part ii) Total number of respondents = 54 (37)
% response = 26.1% (17.9%)

Ordering Frequency with Second Wholesaler	No. of Responses
4 times a day	-
3 times a day	6
Twice a day	23
Once a day	18
Every other day	3
Twice a week	3
Once a week	1

Question 4 Total number of respondents = 51 (36)
% response = 24.6% (17.4%)

Alternative Wholesalers	A	B	C	D	E	F
A	25½	2	5	0	1	0
B	49	25½	34	0	0	0
C	46	17	25½	0	2	0
D	51	51	51	25½	41	31
E	50	51	49	10	25½	9
F	51	51	51	20	42	25½

The cell entries in the above matrix are the numbers of retail chemist respondents who preferred the "column" to the "row" alternative.

The diagonal cells are given a value N/2 ($\frac{51}{2}$ = 25½)

Question 5 Total number of respondents = 57 (40)
% response = 27.5% (19.3%)

Proportion of medicines, by value, bought direct from manufacturers.	No. of Responses
< 5%	29
5 - 10%	16
10 - 20%	9
20 - 30%	3

Question 6 Total number of respondents = 56 (39)
% response = 27.0% (18.8%)

Proportion of medicines, by number of orders, bought direct from manufacturers	No. of Responses
< 5%	49
5 - 10%	4
10 - 20%	2
20 - 30%	1

Question 7 Total number of respondents = 52 (37)
% response = 25.1% (17.9%)

Average turnover grading of direct purchases from Manufacturers		No. of Responses
Highest	Grade 5	23
	Grade 4	14
Average	Grade 3	8
	Grade 2	3
Lowest	Grade 1	4

Question 8 Total number of respondents = 46 (33)
% response = 22.2% (15.9%)

Proportion of Medicines, by price, bought direct from Manufacturers		No. of Responses
Highest	Grade 5	14
	Grade 4	9
Average	Grade 3	22
	Grade 2	1
Lowest	Grade 1	-

Question 9 Total number of respondents = 46 (31)
% response = 22.2% (15.0%)

Alternative Manufacturers	1	2	3	4	5	6
1	23	11	21	0	7	0
2	35	23	31	14	0	12
3	25	15	23	2	1	0
4	46	32	44	23	30	6
5	39	46	45	16	23	0
6	46	34	46	40	46	23

The cell entries in the above matrix are the numbers of retail chemist respondents who preferred the "column" to the "row" alternative.

The diagonal cells are given a value $\frac{N}{2}$ $\left(\frac{46}{2} = 23.0\right)$

<u>Question 10</u> Total number of respondents = 57 (39)
% response = 27.5% (18.8%)

Average number of prescription items dispensed daily	No. of responses
< 40	3
40 - 80	22
80 - 150	22
150 - 250	7
> 250	3

APPENDIX B

EXHIBIT 9

Tabular Analysis to Convert Ordinal Paired Comparisons of Customers' Responses into Interval Scales.

Hospital Pharmacists Responses

Question 6

Alternative Wholesalers	A	B	C	D	E	F
A	0.5	0.232	0.482	0	0.125	0.036
B	0.768	0.5	0.750	0.125	0	0.036
C	0.517	0.250	0.5	0	0	0
D	1.000	0.875	1.0	0.5	0.643	0.393
E	0.875	1.0	1.0	0.357	0.5	0.161
F	0.964	0.964	1.0	0.607	0.839	0.5

Alternative Wholesalers	A	B	C	D	E	F
A	.000	-.733	-.045	-3.300	-1.150	-1.799
B	.733	.000	.674	-1.150	-3.300	-1.799
C	.045	-.674	.000	-3.300	-3.300	-3.300
D	3.300	1.150	3.300	.000	.367	-.272
E	1.150	3.300	3.300	-.367	.000	-.990
F	1.799	1.799	3.300	.272	.990	.000

Σ	=	7.027	4.842	10.529	-7.845	-6.393	-8.160
Mean	=	1.171	.807	1.755	-1.308	-1.066	-1.360
+1.360	=	2.531	2.167	3.115	.052	.294	0

Question 7

Alternative Manufacturers	1	2	3	4	5	6
1	0.5	0.208	0.660	0	0.396	0.076
2	0.792	0.5	0.868	0.302	0	0.283
3	0.340	0.132	0.5	0	0.019	0
4	1.0	0.698	1.0	0.5	0.736	0.245
5	0.604	1.0	0.981	0.264	0.5	0.019
6	0.924	0.717	1.0	0.754	0.981	0.5

Manufacturers		1	2	3	4	5	6
1		.000	-.813	.413	-3.300	-.263	-1.433
2		.813	.000	1.117	-.518	-3.300	-.574
3		-.413	-1.117	.000	-3.300	-2.075	-3.300
4		3.300	.518	3.300	.000	.631	-.690
5		.263	3.300	2.075	-.631	.000	-2.075
6		1.433	.574	3.300	.690	2.075	.000
Σ	=	5.396	2.462	10.205	-7.059	-2.932	-8.072
Mean	=	.899	.410	1.701	-1.177	-.489	-1.345
+1.345	=	2.244	1.755	3.046	.168	.856	0

Retail Chemists' Responses

Question 4

Wholesalers	A	B	C	D	E	F
A	0.5	0.039	0.098	0	0.020	0
B	0.961	0.5	0.667	0	0	0
C	0.902	0.333	0.5	0	0.039	0
D	1.0	1.0	1.0	0.5	0.804	0.608
E	0.980	1.0	0.961	0.196	0.5	0.177
F	1.0	1.0	1.0	0.492	0.823	0.5

Wholesalers	A	B	C	D	E	F
A	.000	-1.762	-1.293	-3.300	-2.054	-3.300
B	1.762	.000	.432	-3.300	-3.300	-3.300
C	1.293	-.432	.000	-3.300	-1.762	-3.300
D	3.300	3.300	3.300	.000	.856	.020
E	2.054	3.300	1.762	-.856	.000	-.926
F	3.300	3.300	3.300	-.020	.926	.000

Σ	=	11.709	7.706	7.501	-10.776	-7.334	-10.806
Mean	=	1.951	1.284	1.250	-1.796	-1.222	-1.801
+1.801	=	3.752	3.085	3.051	.005	0.579	0

Question 9

Manufacturers	1	2	3	4	5	6
1	0.5	0.239	0.457	0	0.152	0
2	0.761	0.5	0.674	0.304	0	0.261
3	0.543	0.326	0.5	0.044	0	0
4	1.0	0.696	0.956	0.5	0.652	0.130
5	0.848	1.0	1.0	0.348	0.5	0
6	1.0	0.739	1.0	0.870	1.0	0.5

Manufacturers	1	2	3	4	5	6
1	.000	-.710	-.108	-3.300	-1.028	-3.300
2	.710	.000	.451	-.513	-3.300	-.640
3	.108	-.451	.000	-1.645	-3.300	-3.300
4	3.300	.513	1.645	.000	.391	-1.127
5	1.028	3.300	3.300	-.391	.000	-3.300
6	3.300	.640	3.300	1.127	3.300	.000

Σ	=	8.446	3.292	8.588	-4.722	-3.937	-11.667
Mean	=	1.408	0.549	1.431	-0.787	-0.656	-1.944
+1.944	=	3.352	2.493	3.375	1.157	1.288	0

APPENDIX B

EXHIBIT 10

Results of Survey Amongst Non-Respondents

Wholesalers

Lead time criterion	Ranking 1st	2nd	3rd	Points*	Position
Lead time duration	2	3	0	12	1
Lead time consistency	3	1	1	11	2
Lead time flexibility	0	1	4	6	3

Represents the numbers of non-respondents who placed criteria against each ranking.

Hospital Pharmacists - via Wholesalers

Lead time criterion	Ranking 1st	2nd	3rd	Points*	Position
Lead time duration	2	3	1	13	1=
Lead time consistency	1	2	3	10	3
Lead time flexibility	3	1	2	13	1=

Hospital Pharmacists - direct from Manufacturers

Lead time criterion	Ranking 1st	2nd	3rd	Points*	Position
Lead time duration	1	4	1	12	2
Lead time consistency	1	1	4	9	3
Lead time flexibility	4	1	1	15	1

Retail Chemists - via Wholesalers

Lead time criterion	Ranking			Points*	Position
	1st	2nd	3rd		
Lead time duration	5	0	1	16	1
Lead time consistency	1	2	3	10	2=
Lead time flexibility	0	4	2	10	2=

Retail Chemists - direct from Manufacturers

Lead time criterion	Ranking			Points*	Position
	1st	2nd	3rd		
Lead time duration	4	2	0	16	1
Lead time consistency	0	2	4	8	3
Lead time flexibility	2	2	2	12	2

* Points scoring: 3 pts - 1st; 2 pts - 2nd; 1 pt - 3rd.

APPENDIX C

EXHIBIT 1

Letter to Doctors

Cranfield

Cranfield School of Management
Cranfield Bedford MK43 0AL England
Telephone 0234-750111 (Bedford 750111) Telex 825072
Gordon Wills BA (Pol Econ) DMS FInstM MBIM
Professor of Marketing and Logistics Studies
and Director of Doctoral Studies

Dear Dr.

I am carrying out a research study (for my Ph.D. degree) of the physical distribution methods of pharmaceutical manufacturers and wholesalers, allied to the service thereby offered to pharmacists and your patients.

I would request your participation in the study by answering the enclosed brief questionnaire, that will prove to be an essential supplement to the information I have already been provided with by manufacturers, wholesalers and pharmacists.

I can assure you of the total anonymity of your response.

The study if purely academic and independently undertaken, with no financial support from any company.

I sincerely hope that you will help me in this study by completing the questionnaire and returning it to me in the enclosed envelope (no stamp required).

If you wish to see a summary of the results of this survey please indicate in the space provided at the end, and I will then later forward a copy to you. If you have any queries would you please write to me at 2, Deal Castle Road, Deal, Kent CT14 7BB.

Yours faithfully

R E Gregson
Research Student
Cranfield School of Management

APPENDIX C

EXHIBIT 2

Questionnaire to Doctors

QUESTIONNAIRE

1. Do you practice in a hospital or in general practice?

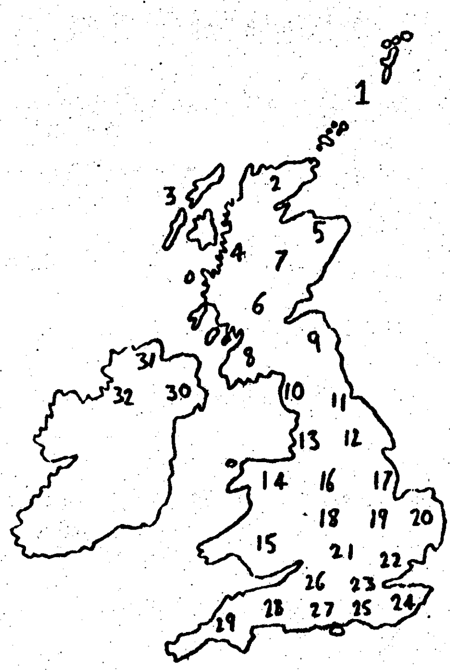
   Please indicate by ticking the appropriate box

   Hospital . . . . . . ☐ General Practice . . . . . . ☐

   Other (please specify) . . . .

   . . . .

2. On the map of the British Isles, below, please circle the number corresponding closest to your district.



3. On average, how many prescriptions would you write a day?

   Please indicate by ticking the appropriate box.

   Less than 10 . . . . ☐

   Between 10 and 25 . . . . ☐

   Between 25 and 40 . . . . ☐

   Between 40 and 60 . . . . ☐

   More than 60 . . . . ☐

4. Sometimes a medicine which you prescribe is out of stock and unavailable at the time. The pharmacist will then contact you to request a substitute.

On average, how long an out-of-stock period of a product would you tolerate before permanently switching allegiance to a comparable substitute, even though the original product was back in stock again.

Please indicate one of the out of stock periods below by ticking the appropriate box for each of the types of medicines, a) to d).

a) Specialist medicines with very few comparable substitutes. Urgently required for patient's welfare. e.g. Phenergan ampoules, Intal capsules

- 1 day . . . . ☐
- 2 - 7 days . . . . ☐
- 1 - 4 weeks . . . . ☐
- 1 - 3 months . . . . ☐
- Greater than 3 months . . . . ☐

b) Specialist medicines with very few comparable substitutes. Patient's health will not suffer if he waits until next day for medicine, e.g. Cortelan tablets, Indocid capsules.

- 1 day . . . . ☐
- 2 - 7 days . . . . ☐
- 1 - 4 weeks . . . . ☐
- 1 - 3 months . . . . ☐
- Greater than 3 months . . . . ☐

c) Medicines with many comparable substitutes. Urgently required though, for patient's welfare, e.g. Aludrox S.A., Mucaine

- 1 day . . . . ☐
- 2 - 7 days . . . . ☐
- 1 - 4 weeks . . . . ☐
- 1 - 3 months . . . . ☐
- Greater than 3 months . . . . ☐

d) Medicines with many comparable substitutes. Patient's health will not suffer if he waits until next day for medicine, e.g. Valium, Librium capsules, Gevral capsules

- 1 day . . . . ☐
- 2 - 7 days . . . . ☐
- 1 - 4 weeks . . . . ☐
- 1 - 3 months . . . . ☐
- Greater than 3 months . . . . ☐

5. How many times a <u>month</u> approximately, are you informed that a medicine is out of stock?

Please indicate below by ticking the appropriate box for each of the types of medicines, (A) to (D).

(A) Specialist medicines with very few comparable substitutes, urgently required for patient's welfare. e.g. Phenergan ampoules, Intal capsules

- None . . . . ☐
- Once or Twice. . . . . . ☐
- 3 or 4 times . . . . . . ☐
- 5 or 6 times . . . . . . ☐
- More than 6 times. . . . ☐

(B) Specialist medicines with very few comparable substitutes. Patient's health will not suffer if he waits until next day for medicine e.g. Cortelan Tablets, Indocid capsules

- None . . . . ☐
- Once or Twice. . . . . . ☐
- 3 or 4 times . . . . . . ☐
- 5 or 6 times . . . . . . ☐
- More than 6 times. . . . ☐

(C) Medicines with many comparable substitutes. Urgently required, though, for patient's welfare, e.g. Aludrox S.A., Mucaine.

- None . . . . ☐
- Once or Twice. . . . . . ☐
- 3 or 4 times . . . . . . ☐
- 5 or 6 times . . . . . . ☐
- More than 6 times. . . . ☐

(D) Medicines with many comparable substitutes. Patient's health will not suffer if he waits until next day for medicine, e.g. Valium, Librium capsules, Gevral capsules.

- None . . . . ☐
- Once or Twice. . . . . . ☐
- 3 or 4 times . . . . . . ☐
- 5 or 6 times . . . . . . ☐
- More than 6 times. . . . ☐

Do you regularly dispense medicines?   YES / NO

If you feel that the answers you have been able to give require further qualification, I would appreciate any comments you may wish to make.

From your answers, and those of other respondents, I hope to understand better the implications to the manufacturer of out-of-stock situations.

Thank you very much for your assistance.

Please tick if you would like me to later forward you a summary of the results   (   )

APPENDIX C

EXHIBIT 3

Tabulated Responses from Doctors Questionnaire

Question 1 Total number of respondents = 66
% response = 32.8%

Practicing Situation	No. of Responses
Hospital	11
General Practice	41
Hospital and General Practice	12
Clinic only	1
Private only	1

Question 2 Total number of respondents = 66
% response = 32.8%

Regional Location	No.of Resp-onses	Regional Location	No.of Resp-onses	Regional Location	No.of Resp-onses	Regional Location	No.of Resp-onses
1	-	9	2	17	1	25	5
2	-	10	-	18	6	26	3
3	-	11	5	19	2	27	1
4	1	12	5	20	1	28	-
5	1	13	5	21	5	29	-
6	3	14	-	22	4	30	1
7	-	15	1	23	9	31	-
8	1	16	2	24	2	32	-

Question 3 Total number of respondents = 66
% response = 32.8%

Number of Prescriptions written each day	No. of Responses
< 10	10
10 - 25	7
25 - 40	18
40 - 60	22
> 60	9

Question 4

Tolerable Stock out periods	Product Category			
	A	B	C	D
1 day	20	6	20	12
2 - 7 days	19	32	19	21
1 - 4 weeks	11	13	14	18
1 - 3 months	4	4	1	3
> 3 months	2	1	1	1

Cell entries in the above matrix are the number of doctor respondents.
Total number of respondents - Product Category A = 56; % response = 27.9%
" " " " - " " B = 56; % response = 27.9%
" " " " - " " C = 55; % response = 27.4%
" " " " - " " D = 55; % response = 27.4%

Question 5

No. of Stock outs per month	Product Category A	B	C	D
None	38	36	36	34
Once or twice	19	19	20	23
3 or 4 times	-	1	2	-
5 or 6 times	-	1	-	1
More than 6 times	1	-	-	-

Cell entries in the above matrix are the number of doctor respondents.

Total number of respondents - Product Category A = 58; % response = 28.9%
" " " " - " " B = 57; % response = 28.4%
" " " " - " " C = 58; % response = 28.9%
" " " " - " " D = 58; % response = 28.9%

Regular Dispensers of Medicines?	No. of Responses
Yes	16
No	47

Total number of respondents = 63
% response = 31.3%