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An Empirical Study into Joint and By-Product Costing in the U.K.

by

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ABSTRACT

An Empirical Study into Joint and By-Product Costing in the U.K.

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The aim of the research was to establish the nature of the current methods used by industry to apportion joint costs to joint and by-products, with particular reference to the chemical and food sectors. The study attempts to determine whether there is any particular apportionment method related to a particular industry or section of the industries concerned and to establish the reasons for the particular choice of technique used. The findings were not intended to answer specific costing problems, but to clarify the extent to which generally accepted theoretical apportionment methods are employed in the two industries and to reveal any alternatives used in practice.

A second objective was to determine the effect the various apportionment techniques employed have on stock valuations and the reporting of profit margins; and to assess the importance that the companies involved, place on the resulting cost data in aiding management in decision-making areas such as determination of product mix, pricing and further processing decisions.

The empirical data, obtained mainly from field interviews, is analysed on an inter and intra industry basis, the costing techniques adopted by sampled companies being described in detail.

Previous writers have expressed a variety of opinions on the objectives of joint cost apportionment and the extent of the usefulness of the individual product cost data for decision making purposes; These views are compared with those of the companies interviewed, revealing the nature of alternative cost figures used in practice.

Declaration

While registered as a candidate for the degree of Master of Philosophy, the author has not been a registered candidate for another award of the C.N.A.A. or of a University, nor has the material contained in this Thesis been used in any other submission for an academic award. Though the company interviews were undertaken jointly by the candidate and research supervisor, this submission is entirely the work of the candidate.

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CONTENTS

CHAPTER 1. AN INTRODUCTION TO COSTING

1.1. Definition of Cost Accounting

The Terminology published by the Institute of Cost and Management Accountants gives the following definition of Cost Accounting:

"The application of accounting and costing principles, methods and techniques in the ascertainment of costs and the analysis of savings and/or excesses as compared with previous experience or with standards".

Cost accounting is concerned mainly with how accounting can serve the internal decision makers of an organization, such as management. This is in contrast to the role of the financial accounting system which is primarily concerned with the external financial aspects of the organization.

1.2. Business Objectives

Usually, the main business objective will be the manufacture and/or sale of goods and services in order to earn a profit. This objective is the concern of both the financial and cost accountant. Profits are commonly taken as the criterion of business efficiency and there are various reasons why their attainment is so important. Profit enables a business to pay an adequate dividend to its shareholders in order that sufficient funds might be invested in the business. It also allows expansion to take place and reserves to be built up.

The economists' goal of 'profit maximization' has frequently been criticized and rejected in literature on the subject of business objectives. However, although

the alternative theories emphasize goals other than profits, most do not exclude profit as a constraint within which the firm pursues these other goals. Profit may not be the only goal of the business, but it is an extremely important one. While 'profit maximization' is no longer accepted as a realistic management objective, a 'satisfactory and reasonable profit' is still acknowledged as being an important indicator of business efficiency.

Consequently, within the limits and constraints of given resources, a given economic environment and a given business policy, management will tend to seek a satisfactory profit.

1.3. Management and the need for Cost Information

The major function of management is one of decision maker. The manager, by way of some kind of decision-model determines which particular course of action to follow in any given situation. Information with respect to the financial aspects of performance is provided by the costing system in order to assist in that decision.

Therefore a costing system is designed to provide the financial data, which will form the basis of decisions at all levels of management, decisions, which in various ways will ultimately affect the overall profit performance of the business.

The costing system should not only provide information for decision making but it should also provide data for the purposes of planning and control. Company objectives are stated in financial terms along with the means ofor achieving them in the form of a plan. After the implementation of

decisions, the control systems are designed to receive from the various decision-making areas, feedback, identifying problem areas and deviations from pre-determined norms, that might subsequently affect future decisions and their implementation.

1.4. Costing Systems

The term "system" in cost accounting normally relates to a major set of procedures set up to achieve a number of objectives.

One of the purposes of a costing system is to obtain the cost of individual products, and perhaps the most important feature of a costing system is the attention paid to detail in the data it provides. The traditional accounting approach is to classify costs by function, such as, production, administration, selling and distribution etc. and by nature, such as, materials, labour and expenses. Further subdivisions take place within these categories according to the particular requirements of the organization. Even within the main classifications, additional re-arrangement of costs is frequently required in order to relate them to the particular problem under consideration.

However, the system is not limited to the classification of costs for planning and control purposes. Included in the sphere are the valuation of stocks, various exercises to reveal an optimum output position, and obtaining a reliable basis for predicting the consequences of many other decisions.

Ultimately, each business requires a unique costing

system, tailored to the needs of management, enabling them to carry out their functions as efficiently as possible. The system should not represent a static entity, but one subject to change, showing adaptation to a changing environment. Although individual costing systems may be unique in some respects, varying from their contemporaries in detail, they operate within a fundamental accounting framework.

There are two basic systems of cost accounting, namely, job costing and process costing, all others being variations of these. The technical processes involved in the production of the goods and services made by the company determines the type of costing system employed.

1.4.1 Job Costing defined

Job costing is used where work is undertaken to customers' special requirements. The essential feature of this system is the attempt to apply costs to specific jobs, consisting of either a single cost unit or a few like units in a distinct batch. In other words the product is not standardized, resulting in each order having different characteristics from the next. Examples of job production are found in the following types of business:- heavy engineering, civil engineering, building contracting, foundries, furniture manufacture.

1.4.2 Process Costing defined

Process costing is used by firms having a continuous flow of identical products, where it is not possible to distinguish one unit from another. The finished product of one process becomes the raw material of the next until

the final products are completed. This system is used to determine the cost of the product at each process or stage of manufacture, where the process costs per unit are essentially average costs for a specified period of time. A few examples of industries involved in process production are:- Chemical processing, food manufacturing, brewing, paint and plastics manufacture, textiles manufacturing. It is within the sphere of the process cost system that joint and by-products emerge. The term joint product is applied in the remaining sections of this chapter to include by-products because they are also jointly produced. Detailed definitions of the various categories of joint products are discussed in Chapter 2.

1.5. The Common Cost Problem

In any multi-product industry, there are always cases where some items of cost are common to several products. This causes a difficulty in identifying certain costs with specific products, a problem which must be overcome if the full cost of a product is to be determined. Two types of common costs can be distinguished. Within any organization there will be certain facilities such as personnel, administration, equipment etc. which will be involved in the production of many different products. The costs of these facilities are generally described as indirect costs. The accountant is faced with problems in making an equitable apportionment of the indirect costs between the relevant products, functions or activities within the organization. The bases for apportionment have to be carefully selected,

because any apportionment introduces a measure of arbitrariness into the costs, and subsequently, the accuracy of the resulting figures can be questioned.

The second category of common costs can be identified in the situation where the simultaneous production of two or more products results from a common manufacturing operation. Where a process yields more than one product, the outputs are termed joint products. These products will not be separately identifiable until a certain stage of processing is reached, termed the split-off point, and the common costs incurred up to that point are known as joint costs. It is not possible to determine positively what proportion of these pre-separation costs relates to each of the products emerging from the process. If product costs are to be obtained, it is necessary to use arbitrary methods of apportioning the pre-separation costs over the different products. As with indirect costs this exercise introduces to a greater or lesser extent an element of unreliability as to the accuracy of the costs of each product. Beyond the split-off point, the products become separately identifiable and thus capable of being separately processed, so that post-separation costs are readily attributable to the individual products.

In a joint product process, the accountant is faced with the dual common cost problem of :-

(a) Making an equitable apportionment of the fixed costs between the relevant products and

(b) Making an equitable apportionment of the joint variable costs between the joint product outputs.

The study is concerned with the second category of common cost which is peculiar to joint product situations, and isolates this particular apportionment problem from the more widespread indirect cost apportionment problem.

1.6. Relevance of Product Costs

There is no 'correct' method of apportioning joint costs to joint products and while a chosen basis can be rationalized, there is no objective measurement to prove one method more just than another. Consequently, two different accountants may arrive at different costs for the same product.

Given the subjective judgement involved, it is frequently argued that apportionment of joint costs is an unnecessary exercise, producing product cost information which is of no relevance in decision-making, a major function of management. Decisions relating to the future are characterized by the need to choose between alternatives, and pre-separation costs which are not changed by a particular decision are not relevant to that decision. The problem is one of identifying the appropriate costs and measuring the effect of the alternative courses of action upon those costs.

In decision making areas, such as output volume, product mix, how far to process a joint product before sale etc. it is argued that the marginal or incremental cost in a given situation is the significant factor, and not, how historical joint costs are to be split amongst various products.

Another major decision-making area is that of pricing. In a competitive market the individual product cost may have no direct bearing on prices, but in a situation where there are no established market prices, the seller may have scope for independent pricing, for which he might use product costs as a guide. However, the suggestion that product costs calculated from arbitrary apportionments might be used as some kind of basis for pricing decisions in certain situations is in itself criticized. Criticism of using any joint product cost information for pricing decisions is particularly prevalent when joint costs have been apportioned on some basis relating to sales value. A circular reasoning results whereby prices are used to set costs and costs then used to set prices.

Despite the questionable usefulness of joint product cost information for managerial decisions, it is argued that some arbitrary apportionment is needed to fulfil the requirements of the financial reporting system. The income and financial position of the organization have to be quantified for each given period of time. It is unlikely that all joint products will be sold in the same accounting period, and therefore some value has to be given to the joint products that are still in stock and to those which have been sold.

Apportionment can also be justified on organizational grounds. The operation of the organizational structure may improve with the preparation of joint product costs. For example, separate product profit figures may act as an incentive to sales management and may assist in the

measurement of deviations from pre-established standards. For the purposes of internal control there is a necessity for joint products to be transferred between responsibility areas at some pre-determined price, and even if a market valuation is employed, some internal cost concept might influence the final valuation.

Although the apportionment of joint costs to joint products may perhaps be justified, there has to be recognition that the resulting figures are no more than estimates and hence their usefulness can be debated.

1.7. The Scope of the Study

The first objective of the study was to establish the nature of the current methods used by industry to apportion joint costs to joint products with particular reference to the chemical and food sectors. The intent of the project was to attempt to determine whether there is any particular allocation method related to a particular industry or section of the industries concerned, to establish the reasons for the particular choice of technique used and to study the sophistication of those techniques related to various sizes of organizations. The findings were not intended to answer specific costing problems, but to clarify the extent to which the various generally accepted textbook apportionment methods are employed in the industries concerned and to reveal any alternatives used in practice.

A second objective was to determine the effect the various apportionment techniques employed have on stock valuations and the reporting of profit margins. The fact,

that in a joint cost situation, individual product costs are not objectively determinable, is significant when considering cost and profit figures as a guide to managerial decisions.

The analysis was further extended to assessing the importance that the companies involved, place on the resulting cost data in aiding management in decision making. The possible reasons considered for cost assignment to products were:-

1) To provide stock valuations for income determination.
2) To aid in pricing decisions.
3) To aid management in determining output quantities and product mix.
4) To determine whether a product should be processed further.

It has been suggested that no attempt should be made to determine the cost of individual products up to the split-off point, but that it is more important to calculate the profit margin in terms of total combined units. The study evaluates the extent to which this view is upheld in practice with reference to the chemical and food processing sectors of industry.

In addition to revealing the current methods of apportioning joint and by-product costs and indicating the practical relevance of the resulting cost data for decision-making purposes, the study incorporates the following information:-

1) The evolution of the joint product costing system

within each company.

2) The extent to which recently developed models have been incorporated into joint product costing systems.

3) The various factors influencing the manufacture and nature of the joint product outputs e.g. technological characteristics and markets available for the products.

CHAPTER 2. JOINT AND BY-PRODUCTS IN PERSPECTIVE

2.1. Introduction

It is typical in many manufacturing industries for situations to arise where two or more products are produced simultaneously from a common input of factors of production.

Examples of industries encountering such situations are:

1) Extractive industries (coal-mining, oil extraction and refining, logging and lumbering etc.).
2) Agricultural product industries (meat-packing, the dairy industry, milling etc.).
3) Chemical process industries (manufacture of solvents, soap, fertilizers, various chemicals etc.).

The product outputs may have completely separate identities or they may represent different grades of the same product. Table 1 shows examples of joint and by-products produced in the chemical (including mineral oil refining) and food processing industries.

2.2. Joint and By-Products - Definition and Classification

The ICMA Terminology (1) defines joint products and by-products as follows:-

Joint Products represent "two or more products separated in the course of processing, each having a sufficiently high saleable value to merit recognition as a main product."

A By-Product is one "which is recovered incidentally from the material used in the manufacture of recognized main products, such by-product

Table 1. Examples of Joint and By-Products

Input	Joint and By-Products
Crude Oil	Naphtha, Gas Oil, Fuel Oil, Kerosene etc.
Naphtha	Ethylene, propylene, methane, ethane, butane etc.
Coal	Coke, gas, sulphate of ammonia, benzol, coal tar.
Salt	Hydrogen, chlorine, caustic soda.
Milk	Cream, skim, buttermilk, buttergrains, whey etc.
Vegetable and Animal Oils	Glycerine, fatty acids, olene, stearine, etc.
Whole beast (cow, pig)	Meat, hides, fats, bones, glands etc.

> having either a net realizable value or a usable value, such value being relatively unimportant in comparison with the saleable value of the main products. By-products are usually subjected to further processing after separation from the main product."

From the definition it is seen that joint products are unavoidably produced together, resulting from manufacturing operations common to all the product outputs. In addition, joint products are defined as having substantially equal importance (in value) to the company. After the different products have been separated they may be sold in their existing state or further processed in order to give them a higher sales value. The post-separation costs are readily identifiable with a particular product whereas the pre-separation costs have to be apportioned on some arbitrary basis.

Whereas joint products are considered to be of equal importance, by-products are of comparatively trivial value at their point of separation. Similarly, to joint products, they may be sold at the separation point or processed further in order to increase their value, although the profit obtained from the sale is by definition lower than that of the main or joint product.

There is often difficulty in distinguishing between by-products on one side and scrap and waste on the other. The ICMA definitions of the latter terms are as follows:-

Scrap is "discarded material, having some recovery value,

> which is usually either disposed of without further treatment (other than reclamation and handling), or re-introduced into the production process in place of raw material."

Waste represents "discarded substances having no value."

In practice, a clear distinction between these terms is not always possible or even essential. In theory, waste is that product which has no known value either within the organization where it was produced or outside. In comparison, scrap does have some value, although it has no capacity to earn a profit. Relating this to the definition of a by-product, it would appear that where the sales value of a by-product is very small, it is treated virtually as scrap. It would seem that the distinction between scrap in particular, and a by-product, is one of degree. The valuation and treatment of the item in the accounts is more important than the specific term applied to it.

Similar to the difficulties encountered in distinguishing between by-products and scrap, there are no hard and fast rules regarding which products should be treated as joint products and which should be deemed by-products. Sometimes it is even difficult to draw the line between a main product and a by-product. It is possible for the main product in one company to be the by-product of another, according to the 'business' the individual company professes to be a part of. While a distinction between by-products and main products may be made in theory, the final classification must be made by each business for its own purposes.

The relationship between products is often not a static one. A number of factors may affect the relative importance of products, resulting in a need to consider re-classification and a subsequent modification of costing methods in order to reflect the changing situation.

The overall policy and manufacturing objectives of the company will influence the original classification of a product. The policy may be one of diversification, in which case the majority of product outputs may be classified as joint. On the other hand, management may concentrate its attentions on one main product, categorizing the remaining items as by-products.

Changes in market price, competition, the increase in demand for a minor product, and developments in technology are some instances requiring consideration for a possible re-classification. For example, milk is separated into skim and cream. Skim, once regarded as a waste product is now commonly classed as a by-product, the market for which has increased dramatically with the advent of powdered products. In the near future it is possible that some companies may re-classify skim and cream to joint products, rather than by-product and main product respectively. Similar types of example are rife in the oil and petrochemical industry, where the ranks of various products have been altered, as their significance to the economy, the market and the refinery in question changes. Due to the enormous numbers of product outputs from oil and petrochemical processes it would be impossible to maintain a list of the joint and by-products applicable to all refinery

costing systems.

Therefore, the definition of joint products is subject to variation from time to time and from one business to another. What is perhaps a by-product in one company can be classified as a joint product in an almost identical company. The treatment depends upon the objectives and policies being pursued by the company in question.

2.3. The Nature of Joint Product Outputs

2.3.1. Fixed and Variable Proportions

Although joint products have a definite quantitative relationship to each other, this relationship may take different forms. The nature of the joint product outputs can either be in fixed or variable proportions. The relationship between the products is fixed if an increase in the output of one product of a group results in a proportionate increase in output of the other products. In contrast, if the increase in output of one product results in a decrease in the output of one or more of the remaining products then the relationship between the outputs is one of variable proportions. This variation in output proportions may only be controlled within certain limits and only arises in certain processes. The classic example cited in literature of a joint product output in variable proportions is the oil refining process. However, it will be seen from the empirical research undertaken in this study, that in practice, the extent of the variability can be questioned, and in many cases the product outputs were considered to be fixed, given a particular input and a

particular processing plant. Some variation in proportions might be possible by modifying the basic processing techniques, normally associated with investment in new plant and equipment, and therefore considered as a long term objective.

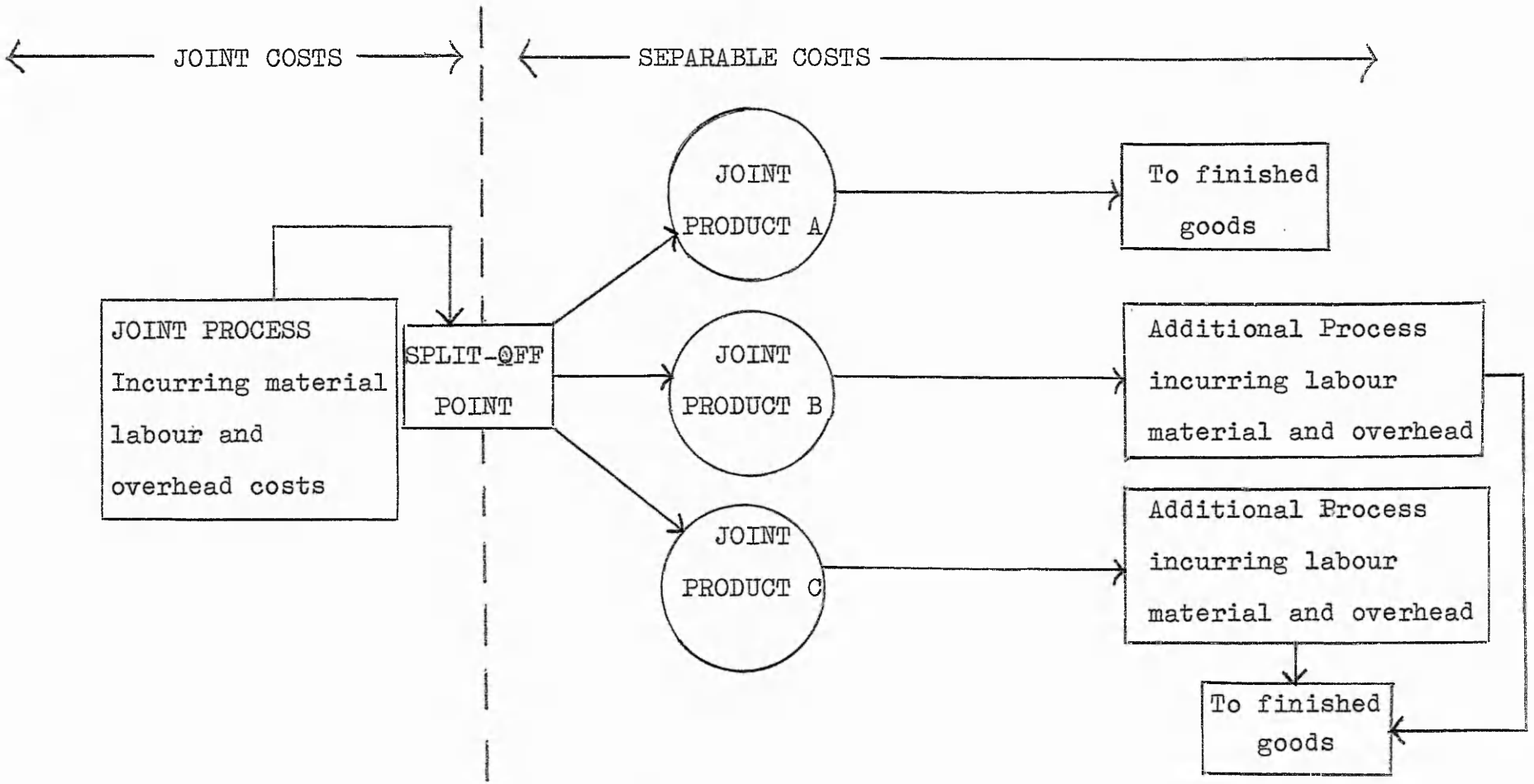
2.3.2. Intermediate and final products

Joint products arise from a common process or series of processes, the latter giving rise to intermediate products. Intermediate products can be defined as those products to be further treated and processed to produce main products, where the main products encompass finished products selling at a relatively high market value. Therefore, joint products in a multi-process operation may take the form of intermediate products at certain stages of production and finished products at the final stage of production.

2.4. Joint and Separable costs

The fundamental feature of joint products is that they incur joint costs up to a certain stage of production, known as the split-off point, when they become recognizable as separable products. Figure 1 shows a very simplified form of joint product process, illustrating the split-off point. The joint process produces three products, A, B and C becoming identifiable at the split-off point. Product A is completed in the one process and emerges in a saleable form. Products B and C require further processing before becoming saleable products. The costs incurred in the joint process cannot be separately

Figure 1. Split-off point in a Joint Product Process



traced to the individual product outputs, i.e. the cost of the three products is incurred as a lump sum for the combination and not separately for the individual products. Therefore up to the split-off point all costs are joint costs. It should be noted that the split-off point is determined by the physical relationships of the products and is not determined by the existence of market values for individual products.

Subsequent to the split-off point any costs incurred e.g. the additional processing costs, can be identified with specific products and may be termed separable or attributable costs. For a cost to be separable, it must be possible to trace it with reasonable certainty to a single product. Therefore, in a joint product process the separable costs do not pose a particular costing problem as they may be identified with a specific product and charged accordingly.

The essence of the joint product cost problem is one of assigning the joint processing costs to the individual products produced in as equitable a manner as possible.

2.5. The Joint and By-Product Cost Problem.

The major difficulty inherent in joint costs is the fact that true joint costs are indivisible, and if they are to be apportioned between individual products the assignment must be made on some logical basis. Accounting theory for joint and by-product accounting is incomplete and there is recognition that no one method can give a high degree of accuracy. Consequently, preference for any particular

method might simply be based on convenience. If the resulting costs are to be used in any form of managerial decision-making, they should be as accurate as possible to permit maximum efficiency. Whatever apportionment method is employed, to reveal the individual cost of a joint product, the profit or loss figure for the total combination of products will not be affected. The total cost of this combination can be readily determined and used for reporting purposes.

Another difficulty in the costing of joint and by-products is associated with the use to which the resulting cost information should be put. Reasons offered for requiring a correct knowledge of product costs might be for pricing purposes, product mix decisions, further processing decisions, in addition to stock valuation and income determination. It can be argued that for all decision-making purposes in a joint product situation alternative information is more relevant. This area of controversy will be discussed in Chapter 4.

There is an essential difference between the treatment of joint and by-products in the accounts, although in the sense that by-products are produced jointly with a main product, they possess the chief characteristics of joint products. A fundamentally different concept is apparent when considering by-products. Although by-products appear at the split-off point, there is generally no attempt made to apportion any pre-separation costs onto that by-product. The reason for this lies in the definition of a by-product

which states that it has a value which is relatively unimportant in comparison to the value of the main product(s). The full amount of the raw material and processing or conversion cost is charged to the principal product(s). The problem in accounting for by-products is to either ascertain some arbitrary value to assign to them, or, to establish their revenue-earning capacity, in order to credit the main product with the relevant value. The majority of methods for by-product costing recognize that by-products somehow reduce the cost of the main products.

There are various arguments put forward for the preference of one apportionment method rather than another, whether the product be a joint product or a by-product. Although many of the arguments can be justified there is still no one method giving complete accuracy. In the light of this, each individual business should select the method most suited to its particular circumstances, reflecting the products, processes and objectives of the organization.

CHAPTER 3. ACCOUNTING FOR JOINT AND BY-PRODUCTS

3.1. Generally Accepted Joint Cost Apportionment Methods

Accounting literature is filled with descriptions of methods for apportioning joint costs to joint products. Generally, suggested techniques can be categorized into two principal types of bases. These are:-

(1) Bases assumed to measure the ability to absorb joint costs, where the resulting product costs are related to some market value of the products

(2) Bases assumed to measure the benefits received by individual products from the common inputs where the benefits are usually measured by physical units e.g. weight, length, volume etc.

Within these two broad categories, there are differing applications of the respective methods. The sales value basis, for example, may reflect the sales value at the point of separation, the final sales value or the final sales value less post-separation costs, according to the particular process and product outputs in question. The choice of sales value to be applied does not pose a problem when further processing is not employed, and the product is sold in its existing state. The problems arise when post separation costs are incurred and differing sales values may be applied.

The suitability of a physical measurement basis is determined by the nature of the product outputs. A common unit of measurement should be applicable to all products

or alternatively a form of weighting may be introduced in order to reduce the outputs to a common basis. A common example can be used to illustrate the individual product costs and subsequent profit positions resulting from the applications of the sales value and physical measurement bases.

Figure 2 shows the details relating to a company producing three joint products (A, B and C) which result from a common process. All three products may be further processed in order to be sold at higher prices. The pre-separation costs total £60,000 and the post-separation details relating to both physical units and sales values are indicated.

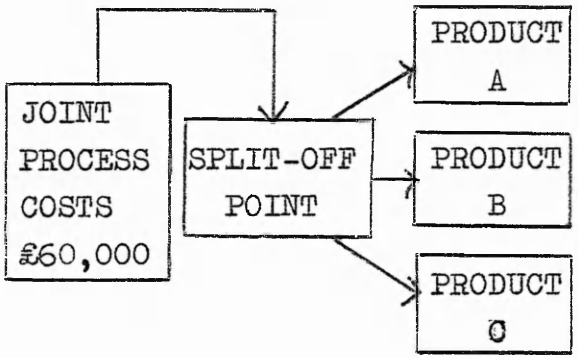
The two following sections relate the joint product cost information given in Figure 2, to the principal apportionment bases.

3.1.1. Physical Unit Bases

When selecting physical measurement as the basis for apportionment, care must be taken to ensure that all the products are capable of being measured in similar units. This particular method of apportionment is often used where a significant part of the total joint cost represents raw material cost, which can be traced into the joint products. The resulting individual product costs are proportional to the weight, cubic capacity, or some other common unit used to measure the output such as heat or gravity content.

In industries where joint products emerge in different physical states and are therefore measured in differing

Figure 2. A Joint Product Costing Example



	Proportions of total output weight or volume	Output Units	Weight (Statistical)	Sales Value at split-off point)	Additional Processing Costs	Final Sales Value
	%			£	£	£
PRODUCT A	40	9,000	4	14,250	3,000	18,000
PRODUCT B	25	24,000	6	45,750	21,000	72,000
PRODUCT C	35	6,000	2	15,000	36,000	60,000
	100%	39,000		75,000	60,000	150,000

physical units, a problem may arise in establishing a common denominator. However, even in cases where the outputs emerge as solids, liquids and gases, a common unit or physical coefficient such as weight can normally be found as a conversion factor (the weight of a gas is calculated given the volume, temperature and pressure).

It can be seen from Table 2, that by apportioning the joint costs on a physical units basis using weight or volume as a common denominator, Product A apparently makes a loss of £9,000, while Product B and C report a profit of £36,000 and £3,000 respectively.

Another form of physical unit basis is the weighted average method based on pre-determined standards. Some technical estimation is used to reduce all output to a common denominator. The weights are arbitrary, possibly based on size of unit, time consumed in making it, material consumption etc. The working of the weighted average basis is illustrated in Table 3. The actual number of output units are multiplied by the weight factors to arrive at the weighted units, on which the joint cost apportionment is based.

By comparing the apportionment using the weighted unit method with that of the basic physical unit method, the variations in the profit figures can be noted. Product A is now seen to be making a profit of £3,750 against a loss of £9,000 in the previous example. The profits for Products B and C have also dramatically changed, emphasizing the value characteristic of weights.

Table 2. Joint Cost Apportioned on Physical Measurement

Product	Final Sales Value	Proportion of total Output Weight or Volume	Joint Costs	Post-Separation Costs	Total Costs	Profit or Loss	Profit or Loss Percentage
	£	%	£	£	£	£	%
A	18,000	40	24,000	3,000	27,000	(9,000)	50%
B	72,000	25	15,000	21,000	36,000	36,000	50%
C	60,000	35	21,000	36,000	57,000	3,000	5%
	150,000	100	60,000	60,000	120,000	30,000	

Table 3. Joint Cost Apportioned on Weighted Unit

Product	Final Sales Value	Output Units	Weight	Weighted Units	Joint Costs	Post-Separation Costs	Total Costs	Profit or Loss	Profit or Loss Percentage
	£				£	£	£	£	%
A	18,000	9,000	4	36,000	11,250	3,000	14,250	3,750	21
B	72,000	24,000	6	144,000	45,000	21,000	66,000	6,000	8
C	60,000	6,000	2	12,000	3,750	36,000	39,750	20,250	34
	150,000	39,000		192,000	60,000	60,000	120,000	30,000	

3.1.2. Sales Value Bases

Under this method distributing joint costs, the total cost of manufacture is apportioned among the joint products on the basis of their relative sales values. Justification for employing this method is based on the argument that since it is not possible to objectively determine the cost of a joint product, the most logical assumption is that each monetary unit invested in joint costs is equally profitable. The implication of this assumption is that joint products should absorb joint costs according to their ability to pay as reflected by the market values of the individual products.

Three differing applications of the sales value method may be considered. These are:-

(i) Market value at the point of separation

(ii) Market value after further processing i.e. the final sales value.

(iii) Net realizable value i.e. the final sales value less the further processing costs.

Table 4 shows the cost apportionment based on the market value at the point of separation. It will be seen that this basis produces the same profit percentage for each product, unlike any of the alternative sales value methods or physical units techniques.

A difficulty experienced with this method is the determination of the market values of the various products at the split-off point. Usually, joint cost apportionments have to be applied at the point of separation, but some

Table 4. Joint Cost Apportioned on Market Value at Point of Separation

Product	Final Sales Value	Sales Value at Point of Separation	Joint Costs	Post-Separation Costs	Total Costs	Profit or Loss	Profit Percentage
	£	£	£	£	£	£	%
A	18,000	14,250	11,400	3,000	14,400	3,600	20
B	72,000	45,750	36,600	21,000	57,600	14,400	20
C	60,000	15,000	12,000	36,000	48,000	12,000	20
	150,000	75,000	60,000	60,000	120,000	30,000	

products may have no saleable value at this stage. In this situation there are the two potential alternative valuations. Table 5 illustrates apportionment using the final sales value method and Table 6 shows the net realizable value approach.

In a situation where all products are sold at the split-off point, where there are no additional costs of completion and disposal, the net realizable value is equal to the final sales value. The complication arises when the joint products receive further processing after separation and have no market value at the split-off point.

The final sales value method as illustrated in Table 5 is generally criticized because of the distortions in the resulting figures where the different products incur varying amounts of cost in further processing beyond the split-off point. In the example product C apparently makes no profit at all under this method, whereas product A and product B appear to be making £7,800 and £22,200 respectively. Joint costs are being apportioned on sales values which include the selling value of subsequent processing and therefore, the profit figures and the apportionment of joint cost is subject to gross distortion.

A more equitable valuation is to deduct the further processing costs from the respective final sales values of each product before any apportionment is made. This method is illustrated in Table 6 and is known as the net realizable value approach, recognized as the conventional textbook approach, to apportioning joint costs where one or more of the joint products is not saleable at the split-off point.

Table 5. Joint Cost Apportioned on Final Sales Value

Product	Final Sales Value	Joint Costs	Post-Separation Costs	Total Costs	Profit or Loss	Profit Percentage
	£	£	£	£	£	%
A	18,000	7,200	3,000	10,200	7,800	43
B	72,000	28,800	21,000	49,800	22,200	31
C	60,000	24,000	36,000	60,000	NIL	-
	150,000	60,000	60,000	120,000	30,000	

Table 6. Joint Cost Apportioned on Net Realizable Value

Product	Final Sales Value	Post-Separation Costs	Net Realizable Value	Joint Costs	Profit or Loss	Profit Percentage
	£	£	£	£	£	%
A	18,000	3,000	15,000	10,000	5,000	28
B	72,000	21,000	51,000	34,000	17,000	24
C	60,000	36,000	24,000	16,000	8,000	13
	150,000	60,000	90,000	60,000	30,000	

It is considered that, although market values at the split-off point cannot be directly obtained they can be derived by subtracting any separable costs from the final market values. Although this method has general acceptability, it can be criticized as it contains the implicit assumption that all the profit is applicable to the joint production process and none is attributable to subsequent processing. It is reasonable to assume that profit is earned by all the production stages and not just the joint process.

To remedy the above criticism of the net realizable value approach, an extension of the method has been suggested, namely the net realizable value less overall profit margin approach. In order to obtain a joint cost apportionment, the overall profit margin for the company is subtracted from the final sales values of each product to arrive at the total cost figure for each product. The additional processing costs are then deducted from the total cost to find the final joint cost apportionment. This extension of the net realizable value approach can be directly related to the original application of the sales value basis as illustrated in Table 4, showing the market value at point of separation. It rests on the dubious assumption that costs and market values possess a uniform relationship. Clearly in practice few companies manufacture products which earn the same profit margins.

The arbitrariness of the various apportionment bases leaves them open to many valid criticizms.

3.2. Apportionment Bases - An Appraisal

No method of apportionment, whether it be classified under the physical measurement basis or the sales value basis can be described as purely objective nor can it be proved correct. The methods previously described vary with one another in the degree of arbitrariness introduced. An N.A.C.A. field study (1957) quoted the words of one company representative interviewed, "It is possible to determine a cost, but there is no way to determine the cost of a co-product." It was also stated that "so long as income statements are wanted for arbitrarily chosen periods of time, joint costs must be allocated to products in opening and closing inventories and some arbitrary actions must be taken in splitting up costs which are joint as to periods and products. The value of periodic financial reports is not necessarily destroyed by the fact that apportionment of joint costs between goods in the closing inventory and goods sold during the period is arrived at by approximation." Although it is recognized that some joint cost apportionment can be justified it must be remembered that there are limitations inherent in the joint product cost and profit figures, and no more precision than they possess should be attributed to them. If used in inappropriate situations, the joint product costs may prove to be misleading rather than helpful.

An apportionment basis should be chosen because of the "reasonablemess of the underlying assumptions" but in the end, the choice is purely a matter of judgement.

Ordinarily, a physical units basis might be the first

basis to be considered on the grounds that since all units are derived from the same factors of production, it seems a logical assumption that no one unit of product should cost more or less than any other. The suitability of this method depends on the nature of the product outputs, but if acceptable it is easy to use and has a measure of logic to support it.

Despite the logic of the physical measurement basis, the average unit cost method is criticized for its simplistic assumption that the average cost per unit is the same for all products emerging from the common process. There may be no justification in assuming that physical measure denotes cost responsibility. The method completely ignores the effect that volume is likely to have on unit costs. An example might be found in the chemical industry where one chemical output might carry a significantly greater weight than another. The consequence of applying the same unit cost might be enormous profits shown on one product and consistent losses on the other (see Table 2). In these instances it cannot be said that quantity cost apportionments are equitable. The N.A.C.A. field study reported that "A basis which causes associated co-products to differ widely in profitability is usually rejected. In the study several company representatives commented that management generally questions the costing procedures when one or more co-products in a jointly produced group appear to be consistently unprofitable while the others are profitable." If there are obviously wide differences in the relative value of the content of the different products, it may be

that the sales value method might be more appropriate.

Bowles (1965) suggests that from a theoretical point of view, the physical units basis of apportioning joint costs to joint products gives acceptable results only when:-

(1) the benefits received, as measured in physical terms, are in the same ratio as the selling values, or

(2) the quantities of the inventories at the end of the period are in the ratio of their production.

He indicates that inventory values are "out of line" when the cost assignment to one joint product exceeds the market value and that resulting differences in profitability will cause a shifting of periodic income, if inventories at the endoof the period are not in the same ratio as their production.

The traditional argument supporting the sales value basis rests on the concept that total costs are incurred to produce total revenue, where each monetary unit of cost results in equal revenue. It can be argued that this method simply apportions the cost on what the market will stand since the higher the market value the greater the cost apportioned to the product.

Horngren (1977) suggests that the majority of accountants "support allocation in proportion to some measure of the relative revenue-generating power identifiable with the individual products. The most popular measure that results in a cost indicative of revenue-generating power is some approximation of net realizable value." Although product costs determined by reference to selling prices are of some

use for stock valuation purposes, all sales value methods are circular in reasoning and so are generally unusable for decision making purposes.

Attempts to justify the sales value method have been based on the supposition that in the long run, selling prices are governed by, and ultimately reflect costs. The assumption that selling price is determined by cost and that all products earn the same profit margins can be refuted. Where prices charged are determined primarily by the forces of supply and demand in the market, there may be a wide gap between costs and revenues. It cannot be assumed that selling values reflect costs. Chui and De Coster (1966) stated that the sales value method can be considered not primarily as a way of allocating the costs among the products, but, as a way of allocating the profit. They quote one writer as suggesting "this is an arbitrary method of allocation and does not necessarily reflect the true cost of any particular type and grade of product. It simply spreads the cost in such a manner as to assign the same percentage of gross profit to each product produced. Thus, it does not provide a reliable yardstick for planning and directing manufacturing operations."

Fluctuations in selling prices generated by market influences upset the relationship between products, automatically causing a change in the cost apportionment figures, even though no change has occurred in the methods of production or total cost. Distorted income measurements may result as a consequence of some of the joint products' market value remaining stable while others fluctuate.

A further problem related to the cost/price relationship is the size of the profit margin. Even if it is felt that such a relationship does exist there is no way of telling what percentage of profit is earned by the individual product. The net realizable value less overall profit margin approach brings an additional complication to the method. Although the relationship between total cost and total profit for all joint products will be known, it is unlikely that this will act as a true guide to the profit earned by the individual joint products.

Although it can be argued that the use of sales value avoids the apportionment issue as far as cost determination is concerned, simply becoming a matter of convenience, it can also be concluded that the problem is so involved that sales value is no worse than any other basis. The method is generally accepted as being useful for stock valuation purposes, allowing the stock to be rated at a "cost" which allows it to be sold at a "normal" profit in some future period.

Despite the criticizms of the two principal types of apportionment bases, if individual product cost figures are required for financial reporting purposes, then a choice of method must be made in order to achieve that aim. Once the type of basis has been adopted, various methods may be adapted to suit the particular requirements of the organization. For example, numerous physical measurements may be applied when apportioning by the physical unit basis. Many industries can find unique physical attributes such as the petroleum industry has done with the gravity-heat and

British Thermal Unit (BTU) measurements. Satyamurthi (1974) describes the gravity-heat method as one which distributes "only crude oil costs on the basis of gravity content. To these costs are added the refinery operating expenses distributed on the basis of the heat unit applied. The heat units are expressed as a percent of the total heat units applied to obtain each product from the distillation process, as shown by records kept for that purpose." The BTU apportionment method uses the relative heat content of products expressed in British Thermal Units. This is based on readily ascertainable physical data and can be applied to all the products associated with the petroleum industry.

Gnosh (1976) also discusses the apportionment of joint costs in process industries, with reference to several methods and industries. Taking the food industry as an instance, he suggests that it may be possible to apportion pre-separation costs in terms of food values, particularly in the cases of flour milling and dairy processes.

3.2.1. Apportionment based on factor evaluation

It will be apparent from what has been said that many factors may be taken to serve as a guide to the apportionment of joint cost. Rather than rely on one factor alone, it has been suggested that all the factors denoting responsibility for cost should be considered and then an apportionment made on this basis. This method can be seen as an extension of the weighted average approach. Whereas the weighted average method is concerned only with technical factors, an apportionment based on factor evaluation

considers other relevant facts, such as sales value, types of product, marketing problems associated with a product etc. An extensive survey would be undertaken to evaluate all the important factors. Information would be accumulated from the production departments regarding the volume of the product, from engineering and planning departments with reference to technical problems involved in joint production, and from administration and sales departments for information on prices and marketing problems.

There are two possible ways of arriving at a final apportionment figure, the first involves a schedule of percentages showing managements' appraisal of the proportionate amount of the total joint costs that should be borne by each product, whereas the second method involves the use of point values or weights.

When similar products are being made it is possible to regard one product as 'standard', nominating a value of 100 per cent. The remaining joint products are then compared with this standard product with reference to the relevant factors and are assigned a percentage, reflecting the evaluation made by management. An example of the possible type of calculation is illustrated in Table 7 where the total joint costs are £60,000. The percentage evaluations for the three products are converted into effective units and the joint cost is apportioned on the basis of these effective units.

The alternative way of expressing factor evaluation is to use point values. Each relevant factor is designated 10 points and each product is rated on the scale in relation

Table 7. Joint Cost Apportioned by Percentage Factor Evaluation

Product	Actual Output Units	Percentage Evaluation of factors %	Effective Units	Joint Costs Apportioned £
A	9000	100%	9000	14,286
B	24000	90%	21600	34,286
C	6000	120%	7200	11,428
	39,000		37800	60,000

Table 8. Joint Cost Apportioned by Point Values

Product	Point Value for sales, technical aspects and weight	Total Point Values	Joint Costs Apportioned £
A	6, 8, 9	23	21,231
B	9, 5, 6	20	18,461
C	8, 7, 7	22	20,308
		65	60,000

to each factor. If for example three factors were to be considered, namely sales value, technical aspects of production and weight, each of products A, B and C would be awarded points relating to each of the three factors. These would then be added together and expressed as a fraction of the total. Table 8 illustrates a possible outcome of apportioning joint costs by this method.

Apportionment based on factor evaluation therefore uses a combination of related factors to determine the apportionment of joint costs. Although this method is no less arbitrary than any other approach, it can be argued that with full knowledge of the relevant data, and a logical approach to the problem, there is no reason to suppose that this method does not provide the most accurate results. It does take into account factors relating to both the physical measurement and sales value bases, in addition to other relevant information. On the other hand, if great care is not taken in the selection and evaluation of factors, the resulting figures may be far from accurate.

Any apportionment method may be justified in certain circumstances, but no method will ever achieve totally accurate results due to the very nature of the joint cost apportionment problem. Recognizing the degree of arbitrariness inherent in any method, the one which is the most convenient to apply might establish the final preference. Boulding (1962) states:-

"There is something to be said also for a certain naivete and simplicity in accounting practice. If accounts are bound to be untruths anyhow, as I have argued, there is much

to be said for the simple untruth as against a complicated untruth, for if the untruth is simple, it seems to me that we have a fair chance of knowing what kind of untruth it is."

3.3. By-Product Accounting Methods

It is generally accepted that the distinction between joint products and main and by-products is one of relative values. By-products can be defined as items of relatively small market value that are produced in conjunction with a main product which has a significant value. As with joint products, by-products may be sold either in their split-off state or after further processing.

In practice, two principal characteristics distinguish a by-product from a major product (N.A.C.A., 1957). These are:-

1) Aggregate value of a by-product is low in comparison with the value of the related major product. This may be the result of either low unit value for the by-product or a small output of the by-product.
2) By-products are incidental and sometimes undesired items which unavoidably accompany production of products which are the major objectives of the manufacturing process. Ordinarily the process would not be carried on for the by-products alone.

The distinction between products is one of degree or point of view and the classification of an item may vary among different companies.

Another distinction which is often difficult to establish is between scrap and by-products. A view sometimes taken

is that by-products have relatively more sales value than scrap, and, are subject to further processing and/or marketing strategy before being sold. In contrast, scrap, is usually sold without any further treatment. Whatever terminology chosen, the basic accounting for scrap and by-products is the same.

Generally by-productsaccounting methods recognize that by-products somehow reduce the cost of the main product. Usual methods employ a market value approach, where the recoverable value of the by-product is credited to or deducted from, the total cost, leaving a remaining balance of cost which is considered to be the cost of producing the main product. The principal problems in accounting for production of by-products centres around the determination of values at which by-products are entered in the accounts.

The origin of the market value approach lies in the characteristic evolution of by-products from waste. The costs of materials, labour and overhead represented in a waste product are of necessity charged against the income producing products, and additional costs incurred for disposing of the waste are added to other costs of the saleable products. In the event of a market or use being found for the original waste materials, they become scrap products. Initially, income realized from these products reduces the disposal cost of that item. When the income from the product exceeds the disposal cost, the accounting entry becomes a credit rather than a debit to the cost of the main product, the interpretation of this credit being a reduction in the main products' cost. The item is now viewed as a by-product.

3.3.1. Valuation of by-products

There are numerous variations in procedures applied in order to determine a value for by-products. Valuation practice depends on a number of factors such as: The markets in which the by-products are sold; if the product is not sold externally, the conditions under which it is internally used; company policy with regard to the kind of cost information required for internal reporting purposes.

Where by-products have a saleable value they may be treated as separate products for dealing with revenue either when actually sold or when produced, irrespective of when the product is sold. The first method entails subtracting the post-separation costs, such as further processing and marketing costs, from the gross revenue earned by the by-product. The by-product net revenue is then deducted from the cost of the major product(s) sold. This method is relevant where the saleability of the product is uncertain or where reliable guides to the value of the product are unobtainable at the time of production. As a consequence, the value of the by-product is only recognized when it is sold, a sale which may take place in a period following the period of production. In this situation no value is assigned to the by-product stocks and the actual income from the by-product is credited to the main product when the sale is actually made. Although it has practical appeal, this method suffers from the conceptual failure to match the value of the by-product with the cost of the major related products.

The second general method involves the recognition of

the by-product value on production. This type of approach is suitable when the products are known to be saleable or usable and reasonably reliable values can be established. In this case, the post-separation costs either incurred or to be incurred are deducted from the sales value of the by-product produced and the resulting net realizable value is subtracted from the cost of the major product(s) produced. Therefore, this method eliminates the effect of any time lag between production and sales. Unlike the previous method it matches directly the by-product revenue with the production costs of the main product. This method is supported for two main reasons. Firstly, products having a substantial value should be included in stock figures in order to reflect correctly, the financial position of the firm. In this method the by-product stock is carried forward at net realizable value (or net realizable value less normal profit margin). Secondly, it provides a prompt determination of profit on major products, information which might be vital to management to enable them to take efficient decisions.

In many cases by-products are not sold, but are used internally as substitutes for raw materials or for fuel. The valuation of the product in these cases is usually determined by its replacement value. In a similar way to the other by-product accounting methods, the cost of the main product is reduced by the same amount. An example might be a by-product used for fuel, the value assigned to this item being the cost of the fuel oil replaced.

In practice, there are numerous variations of the main

types of by-product accounting methods, adaptations being made to suit particular circumstances. There are also exceptions to the practice of crediting the main products with the value realizable from by-products. Where the value of the by-product is relatively insignificant any sale may be credited to the profit and loss account as miscellaneous income. In this case the whole of the cost is borne by the main product. This method is generally considered to be unsatisfactory except where the by-product value is extremely small. The other extreme represents the case where the pre-separation costs are apportioned between the main product and by-product on some common basis such as sales value or equivalent weight in terms of the original material. This method is more in the mode of joint product costing where it has its supporters. However, by applying a technique generally considered to be related to joint product costing, the classification of the product as a by-product in the first instance, might be questioned.

3.3.2 Treatment of revenue

Revenue from a by-product may be used to reduce the cost of the main products or it might be recorded as a separate source of revenue, the latter approach possibly being considered when the amount involved represents a substantial figure.

Management may prefer to have a separate net profit or loss shown on each by-product rather than have the by-product values combined with the costs and profits from the main products. In this case no value would be assigned to the by-product when produced and no credit for their income would

be attributed to the main product. The profit or loss assigned to the by-product is calculated by subtracting the post-separation costs from the ultimate sales revenue of the by-product. This is not completely satisfactory as the main products are still absorbing all the pre-separation costs. However, the method does indicate whether the recovery of a by-product is worthwhile and the subsequent profitability of the further processing and marketing procedures applied. Table 9 shows a comparison between by-product revenue used to reduce main product costs and its treatment as a separate source of revenue. Two products result from a joint production process, product A is treated as the main product and B represents the by-product. 10,000 units of A and 1,000 units of B are associated with the process. It can be seen from this example that the unit cost of the main product, product A, increases from £4.62 per unit to £5 per unit with the change in treatment of the by-product revenue. In a) no profit or loss is attributed to the by-product whereas in b) it is. The exact way that the revenue is registered depends on whether stocks are to be recorded. Assuming 1,000 units of B, any units remaining in stock could be valued at £3.80, but a preferred valuation might be one that deducts some profit margin in order to avoid an over-valuation of stocks.

Method a) has been criticized in situations where the output of the by-product is irregular or if its saleable value is subject to to marked fluctuations. The consequence of crediting irregular amounts of revenue to the process in order to reduce the effective cost of the main product is

Table 9. The Treatment of By-product Revenue

a) Reduction in main product costs

	£	£
Joint costs of producing A and B		50,000
Revenue from sales of by-product (B)	5,000	
Less Post-separation costs	1,200	
Net realizable value of B		3,800
Net cost of Product A		46,200

Unit cost of A = £46,200 / 10,000 units = £4.62 per unit.

b) As a separate source of revenue

	£
Pre-separation costs.	
i.e. cost borne by product A	50,000

Unit cost of A = £50,000 / 10,000 units = £5.00 per unit.

Revenue from product B	5,000
Less post-separation costs	1,200
Net realizable value	3,800

distorted cost figures. One way to minimize this distortion is to credit the main product with a standard by-product value and transfer any profit or loss on the by-product to the profit and loss account. The result of this procedure is to isolate any price changes in the by-product from the main product.

In method b) the profit performance of a main product is not affected by price fluctuations of by-products and it can therefore be evaluated independently. Also, by calculating the profit or loss on each by-product, management can determine the extent to which additional expenditure on recovering, processing and marketing the by-product is justified. A net profit shown on processing and selling by-products might be considered an important incentive to sell the by-product, particularly where by-products are further processed and sold by divisions other than those which produce the by-product.

When determining a by-product accounting method management has to take various factors into account, adopting a procedure which suits their circumstances. The valuation and treatment of by-products must be under continuous review as must be the classification of a particular product as a main product or a by-product, in order to reflect their importance to the company.

CHAPTER 4. JOINT COSTS AND DECISION MAKING

4.1. Objectives of accounting for joint products

In general, the preparation of individual product cost figures provides information for profit measurement, planning, control, pricing and general decision making. The existence of joint products, and hence joint costs, creates difficulties in supplying useful unit cost figures for these aims. Most accounting textbooks recognize only a limited role for joint cost apportionment, in the areas of income determination and stock valuation. Because joint costs by their very nature can only be arbitrarily traced to individual products they are generally regarded as being unreliable and unhelpful for other purposes.

If there were no period end stocks it may be argued that apportionment of joint costs would be unnecessary. Income for the period would be ascertained by deducting the total joint cost (plus any post-separation costs) from the total revenue without any regard to individual product costs. Although some products might be incurring a loss which was being absorbed in the profit from other products, as there is no way of checking, apportionment would serve no useful purpose. However, the existence of period end stocks is the most likely situation and as long as financial statements are prepared for specific time periods, some value must be given to each joint product. Therefore, the basic objective of accounting for joint products would seem to be to find a "cost" for each product that will produce logical and sensible results for stock valuation and periodic income

measurements.

Due to the criticizms directed at any apportionment attempt, there is a view that stocks resulting from a joint process should be held at sales values or net realizable values (i.e. final sales value less estimated post-separation costs). By using this approach, the joint process costs are disregarded altogether. However, this approach can also be criticized because profit is being recognized before sales are made. To counteract this criticizm stocks might be carried at net realizable values less a normal profit margin, a practice found to occur particularly in the oil industry. Despite the opinion that any joint cost apportionment is unnecessary even for stock valuation purposes, established accounting procedures generally require "cost" figures for valuing unsold stocks.

If the need for tracing joint costs to individual units for financial reporting purposes is accepted, the relevance of the resulting figures for managerial decision making can be questioned. Chui and DeCoster (1966) agree that "The accounting motivation for developing product costs from joint costs has been primarily periodic financial reporting ..... where the results from an approximate method of cost allocation are not ideal, they can be tolerated where it is believed that the actual results will have a minimum variance from the ideal situation". They suggest that this will happen when the method is applied consistently over time periods and the stocks experience relatively small fluctuations. In addition the authors give a "warning" in using these cost allocations for managerial decision purposes.

Hye (1970) states that, "The product costs so computed are not suitable for use in management decision making and the accountant makes no pretence about it". He draws two conclusions from this:-

1) "The accountant has so far failed to find a way for allocating the joint cost to the product so as to make the product cost useful for decision making concerning product pricing and so on."
2) "The accountant feels that managerial decisions concerning joint products do not call for the allocation of the joint cost to the products."

Harris and Chapin (1973) accept that costs must be assigned to products to provide stock valuations for income determination and suggest two additional reasons. Firstly, they point out, that, to the extent that the products enter a less than purely competitive market, management needs cost information to make pricing decisions. They suggest that "even when price is essentially determined by competition, management must have some idea of the relationship of 'cost' to the externally imposed price if only to indicate the 'shut down' point." Secondly, the authors state that some cost assignment is necessary in order to aid management in determining output quantities. They do however conclude that extreme care must be exercised in any joint cost apportionment, since improper cost assignment may lead management to erroneous decisions with respect to output and prices.

Thomas (1974) stresses that joint-cost allocations are arbitrary and serve no positive information or decision

purpose. He excuses some apportionment when required by law or "authoritative custom" and recognizes that it may be unavoidable when management press for full product cost and profit information. His paper suggests that where joint cost apportionment is necessary a way can be found to make it harmless for any single specific purpose. He illustrates this point with respect to the further processing decision. Thomas concludes by saying, "To say that an allocation method's primary merit is that, under precisely specified circumstances, it is harmless is faint praise indeed. But this is the best we can do, and a harmless approach is preferable to one that misguides decision makers."

It is suggested by Moriarity (1975) that practicing accountants faced with the need to allocate costs, but dissatisfied with current allocation schemes must take one of two routes namely:-

1) "Continue using current techniques until a revolution in accounting theory obviates the need for allocation or
2) Search for better allocation schemes until the revolution arrives."

Moriarity assumes that accountants will continue to be required to allocate costs for reporting purposes and suggests that the search for "more efficient or less dysfunctional allocation procedures should continue."

Mepham (1978) takes an alternative view and aims, in his article, to justify the relative - sales - value method of apportioning joint variable costs. He suggests that the resulting unit cost figures can be utilized for profit measurement, planning and control, acknowledging that the

method cannot be used for pricing decisions. He does not advocate the apportionment of joint fixed costs and uses a marginal costing approach. Mepham does not dispute "that it is possible to devise adequate operating, planning and control procedures which do not require apportionments of joint variable cost, but (he claims) that it may be more convenient to use an appropriate apportionment method that is consistent with profit measurement procedures and that the relative sales value basis is the best basis."

Writers have expressed a variety of views on the objectives of joint cost apportionment and on the suitability of the resulting figures as an aid in decision making. Some authors are of the opinion that joint cost apportionment is a necessity for financial reporting purposes. Having accepted this need, their opinions differ as to whether there is any role for the resulting individual product cost figures in decision making areas such as output quantities, product mix, further processing, pricing etc. and if so, the extent of that role. Other writers take the view that an arbitrary joint cost apportionment is not even necessary for stock valuation and income determination purposes. They suggest that alternative stock valuation methods are sufficient for financial reporting, and that individual product cost information serves no useful purpose in any decision making area. Having examined the information requirements, they then identify alternative procedures that will meet those requirements without any reference to individual joint product cost figures.

4.2. N.A.C.A. Research Report

In 1957 the National Association of Cost Accountants (New York) published a report on joint product costing. The report had two main objectives:-

1) "To define the field and to explore the nature of joint costs.
2) To show how useful costs can be developed for joint products."

It was intended that the findings from the inquiry should "help to broaden understanding and to clarify thinking about cost behaviour where costs are joint." The information was derived principally from field interviews in which forty companies ("characterized by joint production") participated, with previously published sources and earlier N.A.C.A. research studies supplying background and illustrations. Although the emphasis of the report was upon manufacturing joint costs, illustrations from non-manufacturing operations were included to indicate the "general applicability of the ideas presented."

The report states that the accountant's responsibility encompasses two distinguishably different types of cost data. These are:-

1) "Historical costs which are recorded in the account and summarized in periodic reports and
2) Prospective future costs determined when needed to guide decisions with respect to alternatives."

The report suggested that previous accounting literature had dealt largely with the apportionment of joint costs

to products for periodic financial reporting, and that comparatively little attention had been paid to methods for developing appropriate cost figures and for interpreting these figures in terms of future managerial actions.

After describing and defining joint and by-products, the report deals with the "repetitive procedures" employed at the time to record costs. It then takes up the development and interpretation of cost data for selected types of managerial decisions with respect to the future. It is pointed out that "a company's books are kept to provide necessary historical financial statements while special studies are made as needed to assist management in making decisions (of a certain type)." One company representative at the time is quoted as saying, "The analyses requested by management are prepared to help solve specific problems and therefore no uniform analysis procedure can be used." Nevertheless, it is suggested that there are definite patterns in the approaches employed in the various decision making areas.

The real problem of accounting for joint products is seen not so much as the working out of apportionment bases for distributing joint ocsts but of establishing when and how much cost is relevant to a given question. The investigation was limited to five questions related to industries featuring joint products. These were:-

1) How to determine the effect which increases or decreases in output of jointly produced products have on costs and profits.

2) How to ascertain the most profitable mix of jointly

produced products.

3) How to determine whether it is more profitable to sell a joint product or to process it further.

4) What cost data to use as a guide in pricing jointly produced products.

5) What cost and profit data are helpful in internal control of operations where costs are joint.

The report then discusses these five areas in relation to the empirical findings from the forty companies interviewed. The cases cited in the study are of a wide range, illustrating the broad definition of joint products used. The companies are not related to any specific sectors but are nominated from industries "characterized by joint production." Included in this definition are:-

a) Companies which split common raw materials into different products e.g. oil and petrochemical refining.

b) Situations where a group of jointly produced products consist of a single basic material in different grades, qualities or sizes e.g. fruit canning, pickle processing.

c) Joint costs arising from the common use of manufacturing facilities and services.

No general conclusions were drawn from the study but it would appear that companies which made some attempt at determining separate product profit or loss figures, did not usually utilize them when making output and product mix decisions. The report states that "joint costs incurred prior to separation have no bearing on decisions with

respect to what use to make of the products after separation, because the costs are not changed by the decisions that can be made." The costs relevant to the further processing decision are those incurred for an individual product subsequent to the split-off point, and not the pre-separation costs. In the area of pricing, opinions as to the relevance of product costs were varied. However, it was stated that while costs determined for individual products may be useful guides to pricing in some situations, it seems essential that in making pricing decisions, management should always consider the whole picture presented by a group of joint products.

The empirical evidence presented no uniform view with regard to the usefulness of individual profit or loss figures for joint products when considering the internal control of operations. Apportionments of joint costs were considered unhelpful for cost control purposes as they introduced fluctuations in costs unrelated to managerial performance. In addition it was commented that as a result, managerial attention is focused on the method of cost assignment rather than on the amount of cost which should be controlled. However, in other circumstances apportionments were considered to be useful. For example, when the sales of the two joint products were handled by separate divisions, product profit figures were thought to provide a substantial incentive to sales personnel, where attention was focused upon changes in the product profit margins rather than on the base figures from which changes are measured. It was stated that any reasonable and consistent

method of apportionment would be satisfactory because a high degree of exactness was not essential in such a situation.

Since the undertaking of the N.A.C.A. research study, several authors have expressed their opinions on the usefulness of individual joint product costs for decision-making purposes, some adapting established procedures and others developing alternative theories to provide relevant information for management. The next section outlines some of the more recent thoughts concerning decision making for joint products particularly in the areas of output, product mix, further processing pricing and internal control.

4.3. Decision Making for Joint Products

Inspite of the N.A.C.A. research report of 1957, Brock (1963) stressed that, "In general, accounting literature has failed to emphasize adequately the limited usefulness of allocated costs and to make it known that allocation techniques suggested are almost solely concerned with determining a value to be assigned to inventories for financial statement purposes." Bowles (1965) pointed out that "although many of the decisions faced by managements of businesses producing joint products are identical with those faced by businesses producing independent products - certain decisions are peculiar to jointly produced products. But regardless of the type of decision or whether output proportions are fixed or variable, the conventional principles of cost analysis should be used." He stated that

management decisions involve the consideration of alternatives and that the relevant elements to such decisions comprise "the incremental cost and incremental revenue related to the incremental investment." He considered the amount of joint cost apportioned to joint products, "irrespective of the apparent objectivity of the base used", to be irrelevant.

4.3.1. The Further Processing Decision

A decision making problem that is discussed in most management accounting textbooks is the one requiring an assessment of the desirability of processing joint products beyond their split-off point. Horngren (1977) states that "No technique for allocating joint-product costs should be used for managerial decisions regarding whether a product should be sold or processed further." This represents the view expressed by the N.A.C.A. study. The decision to process a joint product further is not influenced by either the size of the total joint costs or the part of those costs assigned to particular products. The decision to incur post-separation costs depends on a comparison of:

a) the revenue available (if any) at the split-off point;
b) the revenue less post-separation costs (i.e. the 'differential income') becoming available if further processing is carried out.

Therefore, the only justification for subjecting a particular product to further processing would be the fact that the additional sales value arising from the further processing is greater than the additional costs.

The following example adapted from Horngren illustrates the significance of the incremental costs in the further processing decision. A chemical is processed at a joint process cost of £400. Two products emerge from the process, product A and product B. Figure 3 illustrates the details relating to this particular example.

Figure 3. The sell or process further decision

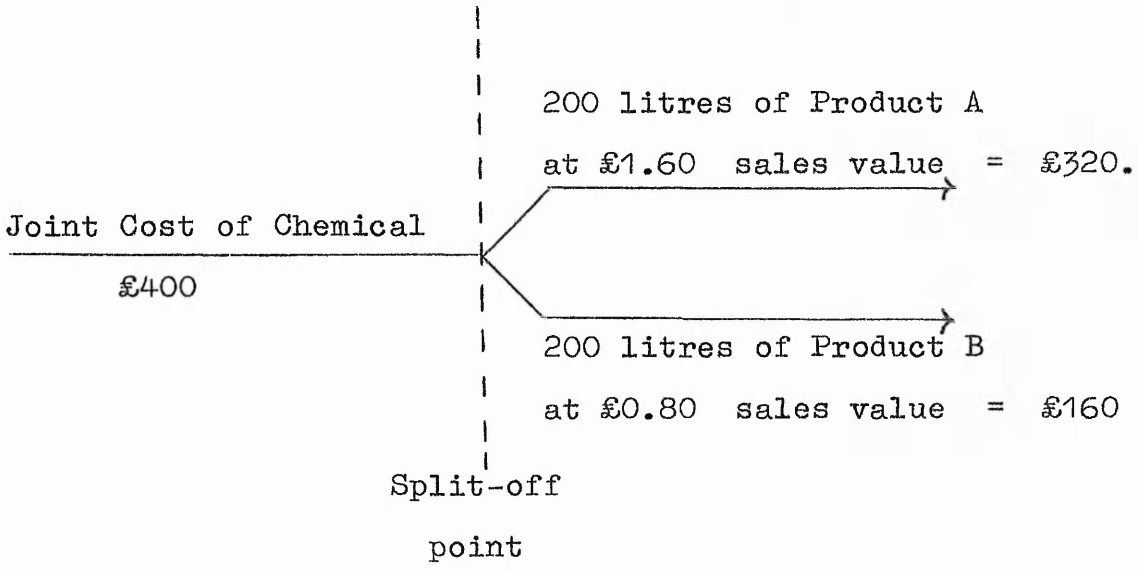


Table 10 shows the resulting figures from the application of the two conventional joint cost apportionment bases, namely by weight and sales value.

The company is faced with the choice of selling the 200 litres of Product B at £0.80 per litre or bottling and perfuming the product as 200 bottles of Product C. The total additional costs of converting Product B into Product C would be £50, while the sale price per bottle would be £1.20 giving a total revenue of £240 compared with the original £160.

Table 10. Conventional Joint Cost Apportionment

By Weight

	Litres	Weighting	Joint Cost
Product A	200	2/4 x £400	£200
Product B	200	2/4 x £400	£200
	400		£400

By Sales Value

	Sales Value	Weighting	Joint Cost
Product A	£320	32/48 x £400	£267
Product B	£160	16/48 x £400	£133
	£480		£400

- -

Table 11. The Inconsistencies of Joint Cost Apportionment

	By Weight		By Net Realizable Value	
Product C	£	£	£	£
Sales 200 pints at £1.20		240		240
Joint Cost	200		133	
Incremental Cost	50		50	
Total Cost		250		183
Profit (Loss)		(10)		57

It can be shown that conventional methods of joint cost apportionment are not only irrelevant to the decision but that if they are allowed to influence the decision, they will yield inconsistent results. For example, the weight method would show a loss for product C while the net realizable value method would show a profit as illustrated in Table 11.

The only approach that will give valid results is to compare the incremental revenue with the incremental costs. In this example:-

Incremental Revenue, £0.40 x 200 bottles	£80
Incremental Costs, added processing	£50
Additional profit	£30

The soundness of this approach can be proved by looking at the total income calculations for the process, comparing the decision to sell Product B with the alternative of converting Product B to Product C.

Total Income Computations

	Sell Product B
Sales of A and B	£480
Total Costs i.e. Joint costs	£400
Profit	£ 80

	Sell Product C	
Sales of A and C		£560
Joint Costs	£400	
Incremental Costs	£50	
Total Costs		£450
Profit		£110

The difference in profit is £30 which represents the excess of incremental revenue over incremental cost. In summary, as long as the incremental revenue exceeds incremental costs (including the "cost" of capital) then it is profitable to extend processing beyond the split-off point.

Hartley (1971) acknowledges that the one decision-making problem discussed in most management accounting textbooks is the one concerning whether it is desirable to process beyond the split-off point. However, he then suggests that "The problem is typically found in a very simple setting and, as a result, a reader, in all probability will conclude his study of this problem area with a set of misleading decision rules." Hartley states the purpose of his paper to be the consideration of the further processing decision in a more complicated setting than is generally illustrated in textbooks. He also admits that, "the cases considered here are not totally realistic but the analysis employed should suggest the appropriate methodology for finding a solution to any such problem that might be encountered." Hartley uses five different cases to illustrate possible further-processing decision-making situations.

Case 1 provides an example of the 'typical' problem whereby a joint process yields two products which can be sold or processed further. As a given amount of production is assumed to have been completed through the joint process, any costs incurred prior to the split-off point are irrelevant to the decision about further processing. Hartley then suggests that the type of analysis employed in the simple case is not sufficient to solve more complicated

situations.

The second case introduces "bottleneck resources". The simple process from case 1 is complicated by the assumption that a particular type of equipment is used in the joint process and in the further processing of both products and that the available time for its use is limited. It is suggested that linear programming represents a "manageable approach" to this kind of problem, although Hartley points out that while the formulation adopted is a useful start in the model building process, it has limitations, and is not an appropriate model to use in the general case.

Case 3 is defined as case 2 except that the market and/or production capacities limit the maximum weekly sales of one product. The author then demonstrates that the "option of inventorying or disposing" of products must be permitted if an optimal situation is to be found.

Case 4 considers the situation where the output ratios of the joint products may be varied and the model is developed further.

The final case with "additional complications" is introduced in a general form, the problem involving several more constraints. Hartley therefore, demonstrates that the process of deciding whether or not to produce beyond the split-off point is not as simple as set forth in textbooks. He suggests that linear programming can be used in these situations as long as the production relationships remain fairly constant. However, he points out that in applying linear programming it is necessary "to allow for inventories of unused intermediate outputs or optimality may not be

truly found". Although it is not possible to construct a general model, the author aims to establish a methodology of formulating decision models where joint products are involved.

Thomas (1974) agrees that a product should be further processed if its net realizable value is positive. However, he also points out that "if the firm calculates divisional incomes, the book profits of individual products may affect further processing decisions (if only because managers are reluctant to run operations at what the firm's official score-keeping system indicates to be a loss)". He then states that when joint costs are apportioned in proportion to relative weights of products (or gross selling price), the resulting book profits of individual products may misguide management into making further-processing decisions that are not to the firm's advantage. Thomas suggests that the remedy in such cases is to persuade management to stop calculating profits for individual joint products, but he recognizes that management cannot always be persuaded. Whenever, further-processing decisions are based upon book profits, he says the next best remedy is to make sure that these book profits do not misguide the decision makers. He suggests that misguidance will be avoided as long as two criteria are satisfied:-

1) Whenever a product's net realizable value is positive, its book profit should be positive.
2) Whenever a product's net realizable value is zero or negative, its book profit should be zero or negative.

Thomas believes that, in practice, only one joint cost apportionment approach that satisfies these criteria, is widely recommended, namely the net realizable value approach (although he does emphasize that it would be preferable to make no apportionment at all). However, he does alert the reader to some major limitations of this approach in solving problems. He states that there is no reason to expect net realizable value joint cost apportionments to be appropriate in any other decisions except those relating to further processing. In addition there are four assumptions required if the approach is "reliably to avoid misleading makers of further-processing decisions". These are as follows:-

1) Sales of the individual joint products are independent of each other.
2) All products are unsaleable at the split-off point.
3) All products may be disposed of without cost at the split-off point.
4) Total net realizable values exceed the joint cost.

It can be seen that these assumptions, particularly the second and third are highly unrealistic. Thomas then proceeds in his article to adopt a more comprehensive approach, relaxing assumptions two and three, and hence modifying his original criteria to take account of this. His "extended approach" is again restricted to certain circumstances for it to operate in a "mechanically satisfactory fashion".

Thomas concludes his article by stressing that joint

cost apportionments are arbitrary and serve no information purpose, but if the decision maker is sufficiently misguided to use allocated data, a way can be devised to make those data harmless. However, it must be pointed out that any practical applications of the approach suggested by Thomas can be questioned.

4.3.2. Joint Product Decisions relating to price and output

The N.A.C.A. research study suggests that when products are produced in fixed proportions, the allocation of joint costs to individual products does not assist in making output decisions. This is because an increase or decrease in the output of one product is necessarily accompanied by a proportionate increase or decrease in output of other products in this group, in which case management has no alternative product mixes to consider. Therefore, in order to measure the profitability of a given output, the total cost of the group products needs to be compared with the combined sales revenue.

The N.A.C.A. relates other cases where the proportions in which joint products emerge can be controlled, noting that the scope for control over output may be restricted at a given time. However, in such cases, where the output of one or more products is obtained at the expense of reduced yields of other products, the attainment of an optimum mix represents an important objective. Again, it is said that allocations of joint costs to individual products do not assist in determining the most profitable product mix. "While costs of individual joint products cannot be measured with certainty, changes in total joint cost attributable to

changes in operating alternatives can be measured". According to the report there are two basic approaches to this decision-making problem:-

1) Prepare comprehensive budgets for each product mix under consideration. These budgets indicate which alternative promises the largest total profit.
2) Work only with costs that will fluctuate as a result of the change or the decision. Here the decision rests upon a comparison of increments in cost with related increments in sales revenues to determine the resulting increment in profit.

It is then suggested that the second approach is likely to be simpler, although a comparison of differentials should yield the same net result as could be obtained by comparing over-all budgets for operations or all products combined.

Harris and Chapin (1973) comment on the two basic approaches specified by the N.A.C.A. indicating that the first method "is again taking a discrete look at a situation that varies on a continuous basis; we might arrive at a good usable solution which is only an approximation of the optimal solution". They therefore employ mathematical techniques needed to compare incremental revenue with the incremental costs directly related to changing the relative proportion of output. They conclude that "When revenue, proportion, and cost function can be quantified with accuracy, we may portray the relationships quantitatively and seek an optimal solution through dependable mathematical analysis. The word 'dependable' is used advisedly, as obviously the solutions are only as good as the quality of the input (i.e.

the quality of the functional relationships used)".

Bierman and Dyckman (1976) note that it is frequently assumed that the pricing policy for joint products requires a cost allocation of an arbitrary nature. They suggest such an allocation to be unnecessary and that "it is possible to establish a theoretically sound framework for determining price and output decisions for joint products". They offer a mathematical solution to the joint price - output problem, accepting the criticizm that all the information necessary for this solution is seldom known in practice. However, they indicate that the importance of their presentation is not in terms of its being applied exactly as they illustrate, but rather in terms of a method of reasoning, where the reasoning shows that the allocations of joint costs is not essential to a "clear and definite solution to the problems of output and pricing of joint products".

Companies interviewed by the N.A.C.A. research team often stated that the costs computed for individual products had little or no influence on pricing decisions. In the words of the study, "It is necessary to dispose of the output of all products, and prices of individual products are accordingly adjusted to sell the products in the proportions in which they are produced". However, it also suggests that the costs determined for individual products may be useful guides to pricing in some situations, although it is essential when making pricing decisions to consider "the whole picture presented by a group of joint products".

Hye (1970) points out that the need to know the product

cost for price setting purposes is often under-estimated because of the argument that, "in a perfectly competitive situation, the individual firms are 'price-takers' - thus, there is no price setting problem!" He continues to say that, in perfect competition it is the industry that helps to set the market price, i.e. the market price is determined by the inter-action of the industry's supply curve and the industry's demand curve. Hye then emphasizes that, "the supply curve of a product, be it that of an individual firm or that of the industry cannot be intelligently determined without the knowledge of the product cost." Taking the plywood manufacturing industry as an example, the writer then suggests that in a perfectly competitive situation, the plywood industry, therefore, appears to have guessed the required product cost in arriving at the market price. In his own words, "The inputed product cost might not be at all realistic and yet no one may be wise to the fact."

Hye then mentions the "price-leader" situation, where he suggests that a knowledge of the product cost of the plywood panels will help the price-leader to know the profit margin he is placing on the panels when setting prices. For the price follower, a knowledge of the profit margins on panels will help him to determine the best product emphasis in his production and sale effort.

The author, using plywood manufacture as his example, states the problem as follows:

"There is, therefore, the need to know the production cost of the various types of panels in order to intelligently set the sale price, or in order to determine their profit-

ability so as to produce the most profitable combination of panels, whichever is applicable." The objective of his paper is not to attempt to find a suitable way for allocating the wood cost to the plywood panels, but to illustrate, how, without allocating the joint wood cost to the product, linear programming analysis may be used to give a good indication of the profit margins of the various types of plywood panels produced. The writer states that as far as he knows, linear programming is the one practical way for the firm to arrive at the optimum position even without knowing the full product costs.

4.3.3. Internal Control of Operations

The N.A.C.A. study stated that "allocations of joint costs are not helpful where cost control is the objective because they introduce fluctuations in costs which are unrelated to managerial performance and because they tend to focus managerial attention upon method of cost allocation rather than upon the amount of cost which should be controlled." However examples were cited where company representatives pointed out that allocations were helpful. These were particularly typical in situations where the joint product outputs were sold in different markets and handled by separate sales departments.

Savage and Small (1977) suggest that the organizational structure may operate more efficiently if unit costs are prepared, particularly when joint products require different methods of finishing, packing, marketing etc., and where autonomous selling companies are established for each product line. They point out that in such circumstances,

an attempt must be made to calculate unit costs in order to establish intra-company prices. In addition they state that "even if a market valuation or market price method is adopted, this is usually allied to some internal cost concept". Horngren (1977) who considers the net realizable value approach to be the most popular, says that in general, pricing decisions should not be influenced by joint cost allocations. He emphasizes the circular reasoning under such a method, where prices are used to set costs and costs then used to set prices. Savage and Small recognize the problems involved and the possible misinterpretation of the resulting unit costs, but they believe that "an arbitrary measurement is better than none at all and that the problems which arise if this is not done are more serious than if it is".

Mepham (1978) aims in his article to justify the relative sales value method of apportioning joint variable costs, by showing the utility of the resulting unit cost figures for profit measurement, planning and control, acknowledging that the method cannot be used for pricing decisions. He relates the two general reasons for preferring the relative-sales value method to other procedures:-

1) "The method is considered to be useful for inventory valuation.
2) It is claimed that, although it does not aid, the method does not hinder decision-making in that it makes no judgement as to the relative profitability of the product lines."

He then suggests that "an advantage of the neutrality of the sales value apportionment method is the suitability of

the resulting cost figures for use with the conventional form of cost-volume-profit analysis." He considers that most managers will undertake some form of cost-volume-profit analysis to estimate the likely profit for operating programmes and stresses how important it is that any cost figures supplied by the costing system can be incorporated into the managers' analysis without leading to the possibility of bad decisions. The importance of this is further emphasized "by the role that the cost function plays in the planning and control aspects of flexible budgeting." Mepham then discusses the use of the break-even chart in a joint-product firm, justifying the relative sales value method of apportionment.

4.4. A Change of Emphasis - from output to input

The N.A.C.A. study said that costs and profit margins were sometimes expressed in terms of an input unit instead of output units. Waters (1942) is quoted by the N.A.C.A., where he relates the input unit emphasis to an oil refinery. "a refinery should not attempt to determine the cost of individual products; ..... It is further believed that the majority of cost methods place too much emphasis on the net profit per barrel of individual products. The vitally important item is the profit on a barrel of crude oil, which includes all the products."

Given the assumption that the joint product outputs from an oil refinery are obtainable in variable proportions Satyamurthi (1974) sees the problem as "not one of determining the part of the cost of crude oil which we charge to each of

the products, but rather the more important problem of telling the operating people in the refinery which products they should make to return the greatest profit to the company." He does recognize, however, that management can control, only to some extent, both the ratios in which products are produced and the costs.

The "composite product" is introduced by Butler (1971) as a "somewhat abstract product as opposed to the physical items produced." This abstract product is defined as a single unit composed of the common input, in contrast with the "traditional method of accounting" where the main emphasis is one of placing a value on the individual finished products. An objective of management is seen as striving to attain an 'acceptable' profit for each of the products it manufactures. With the introduction of the composite product concept, Butler shifts the emphasis from a unit of output to a unit of basic input. Using the oil refinery example, the emphasis is transferred from the number of gallons of kerosene and gasoline to the number of barrels of crude oil, an input quantity which is called "the input measure composite product". The writer suggests that it is this product for which management should strive to show an acceptable profit. Butler then says that management should identify all the "feasible, alternative combinations of users for the input" and rank them as follows:-

$$\text{Rank number} = \frac{\text{Total profit of the combination}}{\text{Number of units of basic input required}}$$

This, he says, will allow a comparison of alternatives that require different amounts of the basic input. By treating

the basic input as a scarce resource he sees the objective of the firm as one of yielding the greatest return from that scarce resource.

Feller (1977) concentrates on the problems encountered specifically by the petroleum industry. He discusses the complexities of the refining process, stressing the fact that one generally cannot segregate the costs relating to the joint products emerging at the original split-off point, from those relating to the joint products emerging after further processing, due to the nature of the refinery process. With particular reference to the United States, Feller states that when the oil companies were forced by government agencies to report costs by product line, they adopted a heavy bias in favour of cost allocations based on volume. He makes the point that, "while the use of volume does appear to be a logical basis for allocating operating costs, they can become quite illogical for allocating input costs" (i.e. the cost of the barrel of input crude). He asks the questions, "Can it be logically argued that the purchaser of the barrel of oil is willing to pay the same price for the lowest revenue potential in the barrel as for the highest? If the components could be purchased separately, would any knowledgeable purchaser pay more for the residual-fuel-oil portion than it could be sold for after processing?" He suggests that the use of volume-based assignment causes greater conflicts than even the "price-relative cost allocation".

The oil refining operation represents "a classic" case of a joint product situation and so the complexities of

this particular problem have been tackled numerous times. The general view held is that any apportionment method is not only arbitrary, but also time consuming, producing unnecessary and irrelevant information. The shift in emphasis from the output unit to the input unit and the use of mathematical techniques such as linear programming for the solution to decision-making problems is generally accepted.

In spite of this, in 1982, Al-Saffar, the Budget and Accounts Officer with OPEC, produced a paper, presenting a general view of an oil refinery and of the role of the management accountant, in which he suggests that the joint costs are split amongst the various product outputs by one of the generally accepted textbook methods. It is only as a final comment that he remarks on the existence of various research and studies, "under review to ascertain total output and product cost analysis, such as input - output models which are computer orientated methods".

Wilson (1982) replies to the article presented by Al-Saffar suggesting that "he has failed to deal clearly with one big problem. This is essentially the production of joint products and the determination of the cost attributable to each separate product". His comments on the kind of apportionments suggested by Al-Saffar are, "All this was old hat over 20 years ago". Wilson contends that a more logical approach to management accounting in an oil refinery is based on two premises:-

1) Within the parameters of the total cost of the refinery production, it is impossible to ascertain the cost of the

different products but it is possible to attribute to these products values which represent significant information for management purposes.

2) The general premise that full value cannot be obtained from information which is absolute, but only when it is presented in relation to a standard, ideally the plan or budget.

It would seem that in general, writers on the usefulness of joint costs for decision-making purposes recognize only a limited role for the resulting product costs and only in certain circumstances.

CHAPTER 5. RESEARCH METHODOLOGY

5.1. Introduction

From the review of the existing literature concerned with joint and by-product costing, it can be seen that only one empirical research study has been published in this field. The research project undertaken by the N.A.C.A. (New York) in 1957 contained information derived from field interviews in which forty companies participated, and also included illustrations from previously published sources. The companies interviewed were related to no specific industry, although the emphasis of the report was on manufacturing operations. This multi-industry approach was coupled with a broad definition of joint production which included; the splitting of raw materials into different products; the splitting of raw materials into different grades of the same product, and 'joint' costs associated with shared facilities and services. The information resulting from the N.A.C.A. study was therefore from a very broad based sample, providing no detailed analysis of any one specific joint product situation. It was with this point in mind that the present research project was initiated.

For the purposes of this investigation a decision was made to restrict the definition of a joint product, and to concentrate on two specific industries, in an attempt to provide a more detailed analysis of a precise problem area.

5.1.1. Joint and By-Product Definitions Used

At the onset of the study joint and by-products were

defined as follows:-

a) Joint products are individual products of significant sales value produced simultaneously as a result of a common process or series of processes. Joint product costs are those which arise in the course of such common processes involving common raw materials.

b) By-products are those products produced in the same type of processes as joint products but which have a limited sales value.

The aim of the study was to concentrate on manufacturing operations and to isolate the specific joint product situation arising from the splitting of a raw material into individual, different products, from the case where the product outputs were in the form of different grades of the same product. In addition, the study was not concerned with the problems associated with the apportionment of indirect costs (generally referred to as overheads or fixed costs), an area considered to be completely separate from the joint product cost question as defined.

5.2. The Industries and the Companies

It was decided to concentrate on two contrasting industries to allow comparisons to be made between the two. The industries selected were chemicals and food. It was considered that these represented two areas where joint product costing is of particular significance due to the nature of the production processes. However, at the commencement of the study it was impossible to accurately

identify the sections of these industries that would be relevant to the research, due to the complexity of the processes involved, particularly with respect to the chemical industry.

Although the origins of the chemical industry can be traced back to the earliest of times, it is also a modern industry which has made rapid advances over the last century. The industry is heavily dependent on research and development, with innovations in the production of new products and in the efficiency of manufacture of established products. The Central Office of Information (HMSO) 1978, in a pamphlet relating to the chemical industry, stated that approximately 4 million new chemicals had been identified in the previous decade. The areas of the industry applicable to the investigation will be discussed in ensuing sections.

The food industry is not one coherent industry but a collection of diverse industries each dependent on processing the produce of the land or the sea. The food processing industry can be seen as covering all the treatments received by a food from its origin to the point of consumption. Processing to make potential foods edible and to preserve foods has been practised since before the beginning of recorded history. The difference between early methods and modern methods is the level of controllability of the treatments, more knowledge of their effects and more certainty of producing foods of consistent quality as a result of technological advances. Similarly to the chemical industry not all sections of the food industry conf-

orm to the joint product situation specified for the study purposes. The relevant areas will be detailed in subsequent sections.

Therefore, although companies were selected from two contrasting industries, the very essence of the production processes involed dictated the bias towards specific product groups. Although it was originally hoped that similar numbers of small, medium and large firms should be involved in the research, providing an additional basis for comparison, it soon became evident that the consideration of firm size was inapplicable. The reasons for this were as follows:-

1) Given the specific industry sectors relevant to the study, the limited number of firms within those areas which were involved in a manufacturing activity (as opposed to a non-manufacturing activity), meant that it was necessary to contact every appropriate firm regardless of size. Any element of 'choice' of firms did not apply.

2) As a result of a series of mergers within the chemical industry, production has to a considerable extent become concentrated in the hands of leading companies, and very large firms with a wide range of products are responsible for much of the output of the industry as a whole. Because of the very diverse activities of the larger companies in the chemical industry, it is not practicable to group them under any one product sector. Therefore, situations were to arise where companies operated joint product processes in more than one product sector. In such circumstances the various company product divisions coped with the joint

cost apportionment problem in a variety of ways, related to the specific field of operation rather than the overall company size.

3) An additional complication arose because some firms were involved in areas of operation outside the sample scope. Two general situations can be specified:-

a) For some firms it was apparent that chemical or food processing was just one facet of their area of operation and they were also involved in the manufacture of products outside of these areas.

b) Firms operating within the appropriate areas of the two industries, were engaged, to varying degrees, both in processes that did yield joint products, along with processes that did not.

Therefore, taking these points into account, it was felt that firm size was an irrelevant factor in the analysis of joint production processes. In addition, it became apparent that for an intra-industry analysis, the emphasis should be shifted from a comparison of the apportionment techniques according to size of firm, to a comparison according to product area.

5.3. Data Collection

5.3.1. Introduction

The data base for the research came from more than one source but mainly from personal interviews with willing firms. It was felt that a questionaire approach would not be adequate for the detailed nature of the study and would not yield sufficient information for analysis purposes.

Additional information for inclusion in the research was received by letter and by telephone when personal interviews were not feasible.

A pilot study was initially carried out in the East Midlands area, with the aim of gaining a knowledge of the types of processes yielding joint products within the chemical and food processing industries. In addition the pilot study was intended to provide a sufficient depth of insight into the current practice within this sample to allow a more detailed programme to be carried out more effectively. It was considered that geographical factors would be unlikely to have any effect on the subject in question and the initial area was chosen on the basis of convenience for research, particularly as the main investigation technique was to be one of personal interview rather than questionnaire.

Following the pilot study, the project was extended geographically as far afield as necessary to provide sufficient data. The objective was to derive information from approximately fifty companies within the two industries, with the proviso that if there were insufficient firms able or willing to participate for various reasons, then the inclusion of related industries would become necessary. Bearing in mind the N.A.C.A. research study which involved:-

a) a far wider definition of joint products than the one advocated for this particular study,

b) data drawn from several industries,

c) field interviews with forty companies,

it was considered that fifty companies would provide a

detailed insight into the joint cost apportionment problem experienced by the appropriate sectors of the chemical and food processing industries.

5.3.2. The Pilot Study

The pilot study concentrated in the East Midlands area, took two forms:-

1) The Nottingham, Derby and District Branch of the Institute of Cost and Management Accountants (ICMA) co-operated with and gave assistance to the researchers during the pilot study and throughout the course of the research. A letter containing a brief outline of the nature of the investigation was forwarded to the ICMA branch membership (approx 550), postage being paid for by the local branch. Members able to assist in the study were requested to complete the short form accompanying the letter, in order that they might be contacted by telephone in the near future. A copy of the letter and form is contained in Appendix A.

2) In the meantime, telephone contact was made with local chemical and food processing companies, with the aim of arranging a few sample interviews.

Only 1% of the ICMA membership responded to the initial contact, from which two interviews were arranged, the remaining respondents being unable to assist. Of the total members in this area, it is probable that only a very small percentage would be involved with joint product processes, a fact which might explain the low response rate.

An additional three interviews were arranged as a result of the telephone contact with local industry. Of

the initial five interviews held, four were in the chemical industry and one was in the food industry. The unintentional bias against the food industry, found in the pilot study, was not as a result of geographical factors as might be supposed. It was to continue throughout the research for the following main reasons:-

1) Many food processing operations produced an abundance of product outputs in the form of different grades of the same product, areas not covered by this study. The occurrence of processes yielding different product outputs was more limited in the food processing industry than in the chemical industry.

2) In general, the chemical industry was far more responsive to the research than the food industry. To some extent this could be attributed to the presence of a high proportion of very small firms in certain of the food processing areas who either viewed any researchers with suspicion or considered themselves too small and 'unsophisticated' to assist.

The pilot study revealed some useful points for further consideration before embarking upon the main body of research. A general observation was related to terminology. Some misunderstanding was evident amongst certain interviewees, regarding the exact definition of a joint product process, as required for the research purposes. Misinterpretation arose in situations where several outputs were produced from common manufacturing facilities. For example, one chemical company visited was involved in the manufacture of paints and varnishes. The process suggested by the interviewee as being 'joint' was a mixing operation, which

involved the blending of materials to produce various product outputs. However, this process did not yield the outputs simultaneously (a requirement for the research purposes), but entailed the allocation of mixing time to the various products required, the allocation being based on a pre-determined product mix. The interviewee saw the problem as one of how to apportion the mixing costs to the variety of product outputs. It was considered that additional clarity was required in order to overcome the apparent tendency to automatically relate a joint product cost problem with some form of overhead apportionment.

Another factor revealed by the pilot study, particularly related to the chemical industry, was the need to understand in some depth the nature of chemical processes. The initial interviews disclosed several instances of by-products, but no processes yielding joint products. Inspite of the original notion that the chemical industry would reveal numerous examples of joint product processes, it became increasingly obvious that such situations were mainly centered around specific product areas. All the companies visited pointed the researcher to various chemical product sectors which might be relevant to the study. Some detailed knowledge of the nature of the processes and the various outputs related to these areas, was accumulated, both before, and during the subsequent research programme. This knowledge was considered essential in order to understand the problems encountered by companies operating extremely complicated processes.

A knowledge of process details was not limited to the

chemical industry, but was also necessary in order to recognise the difficulties experienced by sections of the food industry, where cases of very involved operations were also found.

5.3.3. The Sample

1) Chemicals

The products of the chemical industry can be broadly divided into three main groups which correspond to the principal steps in manufacture (Chemicals Information Handbook 1980 - 1981):-

i) Base chemicals are normally manufactured on a large scale, up to several million tonnes per year and are generally converted to other chemicals. Examples are, acids, alkalis and salts, organic compounds such as ethylene, propylene, butadiene and benzene.

ii) Intermediates are derived from base chemicals. Most intermediate chemicals require further processing in the chemical industry but some are used as they are. Examples of intermediates are solvents and many industrial chemicals.

iii) The intermediates are chemically converted or physically blended or processed into final products. Some of these represent direct consumer products such as drugs, cosmetics and soap while others are processed still further such as fibres, dyes and plastics.

The pilot study was concentrated on companies operating mainly in the third stage of manufacture, where by-products were prominent. The majority of joint product processes (in contrast to by-product processes) in the chemical industry,

were to be found in the category of base chemicals with a few relevant operations in the intermediate section. However, it was also found necessary to broaden the scope of the survey to include the processing of products prior to the base chemical stage, comprising the refining of mineral oil and the manufacture of coal products.

Telephone contacts were made with a selection of large firms in the majority of specific chemical product areas, in order to eliminate as many sections as possible not relevant to the study. It was hoped that this exercise would decrease the number of letters sent to companies who were obviously unable to assist.

Having established the appropriate chemical areas, company information was then compiled. For this purpose two major sources were selected, the Kompass Industrial Information Service Directory, and the Classified List of Manufacturing Businesses in the Business Monitor Series. Kompass registrations are open to all companies, being used as a method of industrial advertising. The Classified List represents a compilation from the register of manufacturing businesses in the United Kingdom maintained by the Business Statistics Office, primarily for conducting statistical inquiries (all contributors consenting to the inclusion of the name and address of their business). It was felt that the use of two sources of information would provide a wider data base, when considering the restricted product areas appropriate to the study.

The sectors of the chemical, mineral oil and coal industries most applicable to the study are shown in Table 12

Table 12. Sub-sections of the chemical, petroleum and coal industries included in the sample

Kompass

31 Chemicals and Chemical Products

Gases, Compressed and Liquefied

Inorganic Chemicals

Organic Chemicals

* (Vegetable and animal oils and greases)

32 Petroleum and Coal Products

Coal Tar, Coke and Other Coal By-Products

Lubricating Oils and Greases, Technical Oils, Petroleum Products

Business Monitor

Chemicals and Allied Industries

Inorganic Chemicals

Organic Chemicals

Miscellaneous Chemicals

Coal and Petroleum Products

Coke Ovens and manufactured fuel

Mineral Oil refining

Lubricating oils and greases

* The category of vegetable and animal oils and greases posed a minor complication for the researcher. The Standard Industrial Classification (the system used for classifying government statistics) contains a section under the chemical industry for the 'chemical treatment' of oils and fats, and a section under the food industry for the 'processing' of oils and fats. Two companies visited were involved in continuous processes which related to both industries. However, for the purposes of the study, they have been categorised under food.

(as illustrated in Kompass and in the Business Monitor).

2) Food

The starting point of a food industry is the produce of the relevant branch of agriculture or fisheries. The primary materials for the food industry can be divided into three main groups:-

1)	Foods of plant origin	a) Cereals
		b) Sugar
		c) Vegetables
		d) Fruits
2)	Foods of animal origin	a) Meats
		b) Dairy Products
		c) Fish
3)	Foods of animal or plant origin.	a) Fats and Oils

The joint product processes applicable to the research were found in categories 2) and 3). As has already been mentioned, other specific areas were eliminated due to the prominence of graded products.

After the relevant product areas had been established, Kompass and the Business Monitor provided the names and addresses of firms operating in those particular sectors. Table 13 illustrates the sub-divisions from which relevant companies were drawn.

Having established the industry sub-sections within which joint product processes are evident, the units engaged in manufacturing processes had to be identified.

Table 13. Sub-sections of the food industry included in the sample

Kompass

20 Agriculture and Food

Dairy Products

Margarines, Edible Fats and Oils

Meat, Poultry and Game Products

Business Monitor

Food

Bacon Curing, meat and fish products

Milk and milk products

Animal and poultry foods

Vegetable and animal oils and fats

As previously mentioned, production in the chemical industry has to a considerable extent become concentrated in the hands of a few very large companies (concentration being highest among the companies producing organic and inorganic chemicals from petroleum). Therefore, for the purposes of the research, it was considered appropriate to use the 'manufacturing unit' as a relevant statistical base, rather than the 'company'. The term 'manufacturing unit' is used in this report to mean an individual factory, plant or site either:-

a) Coinciding with the company,

b) Belonging to the company or,

c) Representing a subsidiary of the company.

Because of the specific nature of the research and the structure of both the Kompass Directory and the Business Monitor, it is difficult to establish the number of relevant manufacturing units contacted.

In Kompass, each sub-section of the main industrial group is further broken down into a detailed classification of individual products, each product being identified by a column contained in a Product Grid. Various symbols are displayed in each column as follows:-

- ● Manufacturer or direct provider of a service.
- ▲ Manufacturer without own works in this country.
- △ Wholesaler, Merchant or indirect provider of a service
- O Distributor or Agent.

The first category (manufacturer or direct provider of a service) was the one relevant to the research. By reading down the column and identifying the symbols and then reading across, the name and address of each of the "suppliers of the product or service in question" could be ascertained. An additional complication arose in separating the 'manufacturers' from the 'direct provider of a service'. In some cases, the exact nature of the business could be determined by referring to Volume 2 of the directory, which contained further information relating to some companies; otherwise, telephone contact was required to verify the function of the unit.

The Business Monitor sets out the names and addresses of "each manufacturing local unit belonging to an establishment covered in the annual censuses of production".

Where a business has more than one manufacturing local unit, the List contains an entry for each unit. It should be noted that non-manufacturing units, in particular units which are offices, are omitted from the list; this means that the head office of a business may not be shown. The complication associated with the Business Monitor was the fact that some units entered in the List were so small that they did not possess an accounting department; Accounting operations were controlled from a central office.

Therefore, a variety of unit-type was initially considered, and/or contacted, generally falling into one of the following categories:-

a) Non-manufacturing unit

b) Manufacturing unit with an accounting function

c) Manufacturing unit without an accounting function.

It is estimated that approximately 750 total units were contained in the original sample as drawn from the sub-sections of the two industries as previously indicated.

It had now become evident that by-product situations were fairly common, and that the standard treatment was to credit the main product(s) with an appropriate value. The research inquiry was concentrated on joint product situations, which would also provide adequate by-product data.

Of the 750 units from the original sample some further sub - product - areas were found not to have joint or by-products and were excluded from the sample. The unit-type categories a) and c) were then eliminated leaving only category b) plus a number of head office accounting functions, not listed in either Kompass or Business Monitor,

but discovered in the inquiries made.

Letters were sent to the revised sample of 187 units, all of which were engaged in process costing, and believed likely to be producing both joint products and by-products.

5.3.4. The Data

The data base for the research project came mainly from personal interviews held with companies who were willing to participate in the study. Supplementary information was obtained by telephone contact or letter where interviews were not feasible.

Initially each company in the original sample was telephoned to ascertain the name of the management accountant (or his equivalent). This enabled a letter to be sent to a named individual with less chance of it being 'lost' in the organization. A letter describing the objectives of the research, stressing the confidentiality of any information disclosed and including a brief outline of the nature of the investigation was sent to each company. A copy of the letter and investigation outline is displayed in Appendix B. As stated in the letter, the companies were contacted by telephone after a lapse of approximately 10 days. By following the letter with a telephone call, the researcher was able to establish whether the company had any processes yielding joint products and if so, whether the accountant was willing to discuss the costing systems related to those processes. Table 14 illustrates the response rates.

The number of processes indicated in Table 14 represents those processes specifically discussed with a particular

Table 14. Research Response Rates

	Total	Chemicals	Food
Letters sent	187	140	47
Total Companies interviewed	49	41	8
Companies interviewed as a percentage of letters sent*	26.2	29.3	17.1
Personal interviews	36	28	8
Positive telephone and letter information	13	13	0
Total number of processes investigated**	70	52	18

* The figure of 26.2% may be artificially low since some of the non-respondents may not have been operating a joint product process. Therefore, it was considered that 26.2% represented a significant proportion of the total relevant sample.

** The term 'process' represents either a single operation or series of operations, undertaken by a manufacturing unit in a specific product area. This definition, of necessity, has to be somewhat 'flexible' because of the complexity of operations encountered.

company.

Having formulated the research objectives and defined the sample size, the author was faced with a choice among several alternative ways to collect the information that would satisfy the research objectives.

Two major decisions had to be made regarding:-

(a) The survey method to employ, ie. whether the target population should be reached by telephone, post or personal interviews and

(b) The research instrument to use ie. questionnaire format, number and type of questions etc.

The Survey Method

Each of the three main survey methods were considered in the context of the research programme, in order to assess their suitability in achieving the stated objectives.

In general, the postal questionnaire is relatively less expensive than the other alternatives and may be the best way to reach potential respondents who would not be prepared to give personal interviews. On the other hand, postal questionnaires require simple and clearly worded questions and the return rate is usually low and/or slow.

Telephone interviewing stands out as the most convenient method for gathering information quickly, permitting the interviewer to clarify questions if they are not understood. However, when contemplating this technique, such factors as expense and time are important considerations. In addition, the nature and possible confidentiality of the information requested, may not lend itself to this approach.

Personal interviewing is the most versatile of the three

methods, whereby the interviewer can ask more questions and can supplement the interview with personal observations. However, it is the most expensive method and requires much more advanced planning and supervision.

After careful thought, the method selected as the basis for the collection of the data was the personal interview. This was considered to be the most effective way of gathering the type of information required. Preliminary investigations (including the pilot survey) had convinced the researcher that detailed information relating to the various joint product processes could not be incorporated into either a postal questionnaire or telephone interview due to the individuality and complexity of the responses. (Although the telephone interview was discounted as the main survey method, it still proved to be a useful device for gaining certain data from a few companies who considered a personal interview to be inappropriate. e.g. Several oil companies specified that they did not make any attempt at apportioning joint costs to joint products. However, they were able to supply data related to stock valuation methods, decision making etc.; the telephone being the quickest and most convenient method of conveying such information).

The Research Instrument

Having decided upon the personal interview as the most appropriate survey technique, a reliable research instrument to gather information had to be devised. Preliminary investigations gave some indication of the variety of individual joint product processes within the chemical and food sectors.

Due to the apparent absence of any standard production process or joint product costing technique, it was felt necessary to design a flexible interview framework (see Appendix C) rather than a formal questionnaire, in order to adapt the questions to a variety of situations. The framework consisted of key points and questions used to guide the discussions in appropriate directions.

Primarily, it was attempted to determine the various techniques used in allocating joint costs to joint products and the extent to which any joint product cost information is used for decision making purposes. Alternative information sources and their usefulness were also considered.

During the course of the interviews, the emphasis was on open-ended questions in order to gain the maximum information possible. The choice between open-ended and close-ended questions affects the thoughtfulness of responses and the quality of the subsequent analysis. It was considered by the researcher that the analysis would be enhanced by the additional information gained from the respondent who was free to answer as he wished. By using a more formal questionnaire, the subtle differences between the processes and the costing techniques applied to them would have been missed.

The exact format of each interview depended, to a large extent, on the type of organisation, its internal structure and the time available. However, in instances where interviewees wished to enlarge on certain areas, although perhaps beyond the scope of the survey, they were not prevented from doing so, where time allowed. Confidentiality of information was stressed and many companies proved very frank in their answers

and opinions on costing techniques used.

Each interview was attended by two researchers, to facilitate data recording, and lasted approximately one hour. The local branch of the ICMA paid for approximately £100 of the expenses incurred, the remainder being financed by Trent Polytechnic. Although the average interview time was one hour, there were several instances of much longer interviews where visits arount the plant were arranged.

Having amassed the data, the next step was to extract meaningful information and patterns of association. It was decided to present the body of the data by way of several case studies. A descriptive approach was favoured over a numerical analysis in order to reveal the complexities and individualities of the application of joint product costing methods in practice. It was felt that too much emphasis on numerical analysis (as outlined in Table 17 and Table 23) would conceal the extent of the problems encountered by firms faced with the joint product situation.

CHAPTER 6. EMPIRICAL DATA

6.1. Classification of data

For the purposes of analysing the empirical data, the 'manufacturing process' has been used as a statistical base and the categorization of these processes has been based on the Standard Industrial Classification (revised 1980) for the United Kingdom. The classification is a framework for grouping economic activities into 'industries', where 'industry' in this context is not restricted to extractive or production activities but extends to the provision of goods and services of all kinds.

A number of different factors have been taken into account in the classification. They include "the nature of the process or of the work done, the principal raw material used, the type or intended use of goods produced or handled and the type of service rendered", The full range of activities is first divided into ten broad Divisions, each denoted by a single digit from 0 to 9. The Divisions are in turn subdivided into classes (each denoted by the addition of a second digit), the Classes into Groups (3 digits) and the Groups into Activity headings (4 digits). The full number of possible subdivisions at each level is not necessarily used but is varied according to the diversity of activities included.

The research was concerned with processes classified in Divisions 1, 2 and 4, although not all of the specific Groups and Activities within those Divisions are relevant. Table 15 indicates the Divisions and the specific Groups

Table 15. Divisions, Groups and Activities of the Standard Industrial Classification related to the Study

DIVISION I Energy and Water Supply Industries

Class	Group		Activity
11	111		Coal Extraction and Manufacture of Solid Fuels
		1115	Manufacture of solid fuels
12	120	1200	Coke Ovens
14	140		Mineral Oil Processing
		1401	Mineral oil refining
		1402	Other treatment of petroleum products (excluding petrochemicals manufacture).

DIVISION II Extraction of Minerals and Ores other than Fuels; Manufacture of Metals, Mineral Products and Chemicals

Class	Group		Activity
25			Chemical Industry
	251		Basic Industrial Chemicals
		2511	Inorganic chemicals except industrial gases
		2512	Basic organic chemicals except specialized pharmaceutical chemicals
	256		Specialized Chemical Products mainly for Industrial and Agricultural Purposes
		2567	Miscellaneous chemical products for industrial use (including industrial gases).

Table 15 (continued)

DIVISION 4 Other Manufacturing Industries

Class	Group	Activity
41/42		Food, Drink and Tobacco Manufacturing Industries
	411	Organic Oils and Fats (Other than crude Animal Fats)
		4116 Processing organic oils and fats (other than crude animal fat production) 1) Crude oils from fish and other marine animals 2) Crude oils, cakes and meals from oil seed and nuts 3) Treated vegetable, marine and animal oils and fats
	412	Slaughtering of Animals and Production of Meat and By-Products
		4121 Slaughterhouses
		4122 Bacon curing and meat processing 2) Frozen meat products
	413	4130 Preparation of Milk and Milk Products 1) Liquid milk and cream 2) Butter and cheese 3) Other milk products

and Activities related to the research.

Table 16 shows the number of joint-product processes identified, which correspond to each of the relevant activities.

Having categorized the processes into Activities, based on the Standard Industrial Classification, it is necessary to identify the product relationships between Division 1 and Division 2 i.e. the energy industry and the chemical industry. It is considered important to put these manufacturing processes into some context in order to facilitate understanding of the analysis of the joint cost apportionment problem in these areas.

6.1.1. Product relationships between the energy and chemical industry

Chemicals fall into two main categories, organic and inorganic. Organic chemicals all contain the element carbon combined with hydrogen and other elements. Over 90 per cent by weight of world production of organic chemicals is ultimately derived from petroleum (crude oil and natural gas), the only other two sources of any significance in tonnage terms being coal and cellulose. (Shell Chemicals Information Handbook 1980 - 1981). The six major petroleum-based organic chemicals are ethylene, propylene, butadiene, benzene, toluene and xylenes. Benzene is now the only base chemical produced in significant tonnages from a non-petroleum source - coal. It can be seen therefore, that the products emerging from the processes undertaken in Division 1 of the Standard Industrial Classification are feedstock for the organic chemical

Table 16. Processes identified with Activities

	Processes Represented
DIVISION 1	
Manufacture of solid fuels and Coke Ovens	5
Mineral Oil Refining and other treatment of petroleum products	9
DIVISION 2	
Inorganic chemicals	8
Basic Organic Chemicals	21
Miscellaneous chemical products	9
DIVISION 4	
Processing organic oils and fats	6
Slaughterhouses	2
Meat processing	1
Milk and Milk Products	9
Total Processes	70

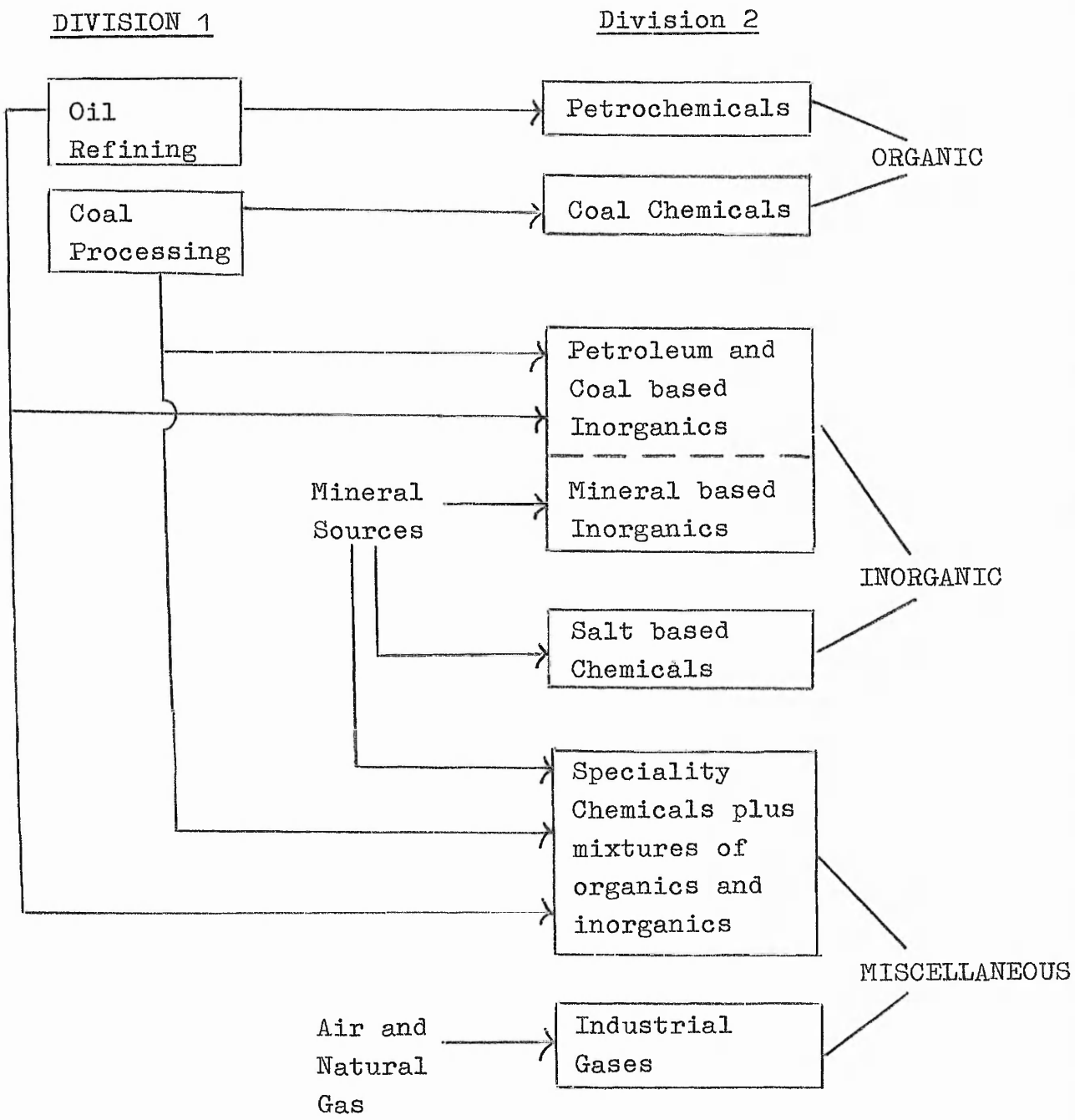
processes undertaken in Division 2.

Inorganic chemicals are derived chiefly from mineral sources. The heavy inorganic chemicals industry is concerned with the conversion of widely available minerals into basic materials for use in many major industries. Raw materials for these products include salt (from brine and rock salt), limestone, dolomite and air. A limited range of 'relatively simple' chemicals, such as sulphuric acid, caustic soda and chlorine is produced in bulk. The remaining output consists of a wide range of chemicals of varying complexity. Although inorganic chemicals originate mainly from mineral sources, there are important exceptions, e.g. the derivation of ammonia from petroleum. Therefore inorganic chemicals are derived from a variety of sources.

The category in Division 2 of the classification, entitled miscellaneous chemical products includes industrial gases, speciality chemicals and other chemical products, not elsewhere specified for industrial use. For the purposes of this research they may be denoted as mixtures or formulations of inorganic or organic chemicals not falling within either of these sectors.

Figure 4 shows the Activity headings from Division 2 further subdivided into more specific product groups which are relevant to the research. Also included are indications of the very general product relationships between Division 1 and the resulting downstream chemicals. For the analysis purposes the term 'chemical industry' will automatically include the Division 1 processes specified.

Figure 4. Organic and Inorganic Chemical Relationships



The analysis in the following sections is based on the three main chemical sectors namely,

1) The Organic sector
2) The Inorganic sector
3) Miscellaneous chemicals and

the three main relevant food sectors namely:-

1) Organic oils and fats
2) Slaughterhouses and meat processing
3) Milk and milk products

6.1.2. Format of Analysis

The analysis of the empirical data is divided into two main sections. The first focuses on the current methods used (if any) by the various sectors of the two industries to apportion joint costs to joint products, including product status and stock valuation. The second section considers the importance placed on the resulting cost data in aiding management in various decision-making areas. In addition, a sub-section is devoted to the accounting for by-products.

Within the two broad sections, each industry and each product area within those industries is considered separately, providing an inter and intra industry based analysis.

6.2. Costing Joint Products

A summary of the apportionment methods presently used in the various product areas of the two industries is shown in Table 17. The next sections contain a discussion of the practices encountered in each area.

Table 17. Summary of Apportionment Methods Used

Product Area	Total Number of Processes	Type of Apportionment Basis Presently Used			
		None	Sales Value	Physical Units/ Chemical Formula	Others*
Chemical Industry					
Organics					
Oil Refining	9	7	-	-	2
Petrochemicals	10	1	5	4	-
Coal Processing	5	-	-	3	2
Coal Chemicals	11	-	1	6	4
Inorganics					
Salt Chemicals	3	-	-	2	1
Other inorganics	5	1	2	-	2
Miscellaneous					
Industrial Gases	3	-	-	3	-
Others	6	-	3	2	1
Food Industry					
Oils and Fats	6	-	-	3	3
Slaughterhouses and meat processing	3	-	-	-	3
Milk and Milk products	9	-	-	-	9

* Others including Main Product/By Product approach.

Historically, several companies in this section had previously operated a joint cost apportionment system.

6.2.1. The Organic Chemical Sector

Crude Oil and Petrochemicals

Crude oils are complex mixtures of a vast number of individual chemical compounds and every separate accumulation of oil is a unique mixture, not matched exactly in composition or properties by any other sample of crude oil. Therefore, on account of the wide range of properties exhibited by different crude oils, each individual one might be expected to possess attractive features for the preparation of some products, but be less suitable with respect to others. The products derived from petroleum, range from liquefied petroleum gases at one end of the spectrum, through petroleum chemicals feedstocks, fuels and lubricants, to bitumen at the other end, in all, representing a vast number of different products.

The crude oil is firstly processed in a refinery, which is a vast plant built around several different operations. The main process is one of distillation. This involves heating the crude oil, and because the various hydrocarbons in it have different boiling points they can be separated out into individual fractions. The boiling range cuts may vary depending on the type of crude oil and processing scheme employed, so there is no fixed way of splitting the crude. The fractions go through further stages of separation and chemical conversion (breaking the original fractions down into further products) as part of the 'refining process'. Products emerging from these operations are joint products. Within narrow limits, refineries (and petrochemical plants) do adjust to changes

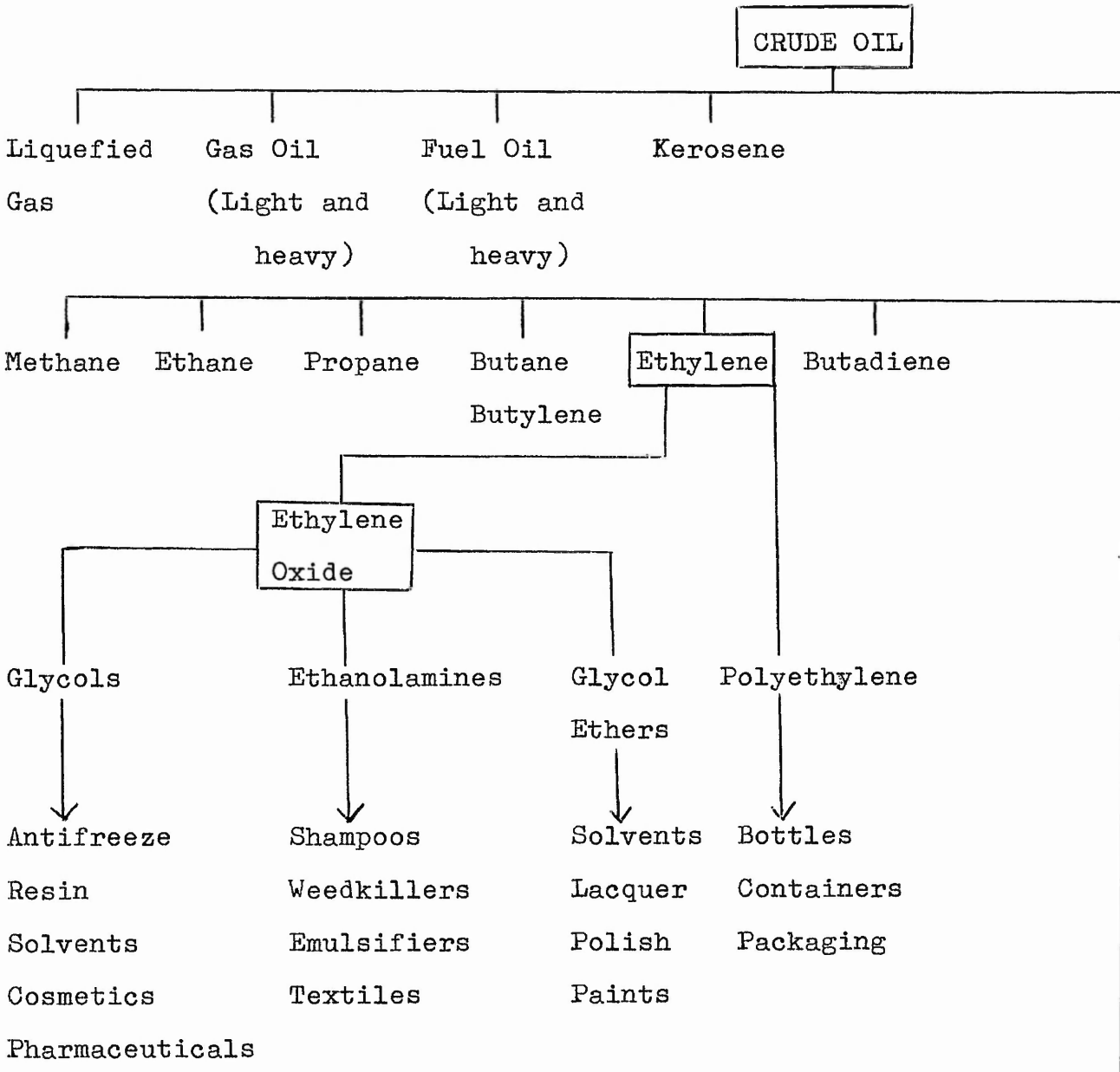
in feed, although they do seek to minimise the changes and ensure that they operate unchanged for periods that are as long as possible.

Therefore, due to the flexible nature of the crude oil inputs both between and within oil refineries and the subsequent variations in procedures, the number of product outputs and the combinations of those products are vast. Chemicals are made from all of the hydrocarbon fractions. However, the fraction most relevant to this study, in the petrochemical field, is that of naphtha. This fraction goes through a process called 'cracking' (breaking down), to produce ethylene and propylene and other joint products in a series of compounds known as olefins - very chemically active and the most important group of organic base chemicals.

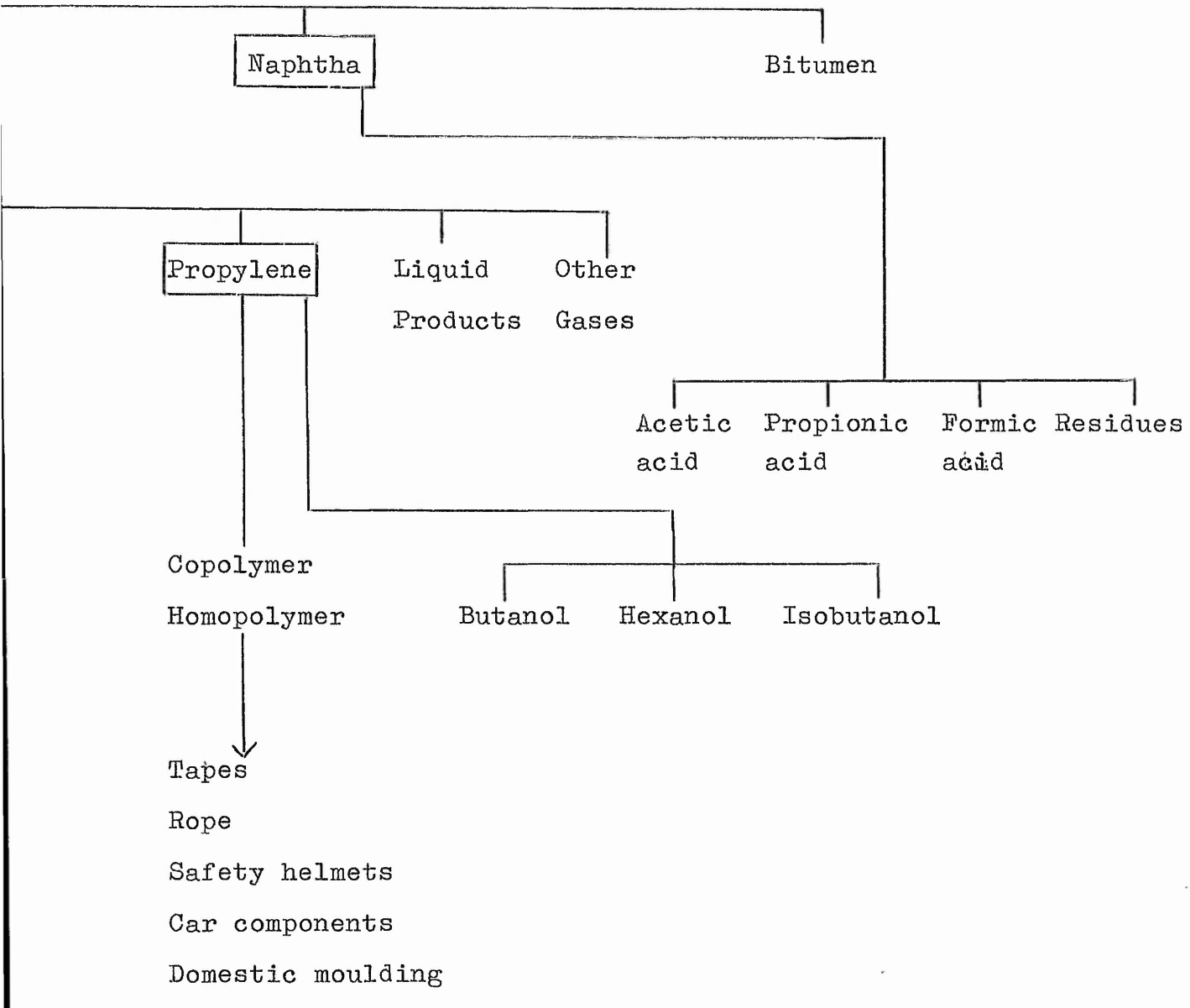
Further complications in attempting to follow the pattern of procedures arise from the fact that a petrochemical feedstock may undergo alternative processing in order to produce different product outputs and in many cases the same chemicals may be derived from different oil refinery fractions. It is this very flexibility that makes it difficult to construct a diagram that is both comprehensive and not too complex to be readily understood.

Figure 5 shows, in extremely simplified form, the major product streams emerging from the refining of crude oil and the jointly produced outputs arising from the cracking of naphtha. Some indication of the final outlets for the two principal products emerging from the latter process is also given. The diagram has been compiled from information obtained from the companies visited in

Figure 5. Some of the main



product streams from crude oil and naphtha



order that costing procedures might be directly related to it. The details have been omitted for illustrative purposes and will be discussed as individual cases in the following sections.

Costing the oil refinery operation

Nine oil refineries are represented in this section and from these a total of seven made no attempt to apportion any joint costs to the joint products emerging from the oil refinery operations. Several companies indicated that they had experimented with various joint costing methods in the past, but that the involved nature of the processes and the vast number of product outputs emerging at different stages made any attempt at apportionment, meaningless. A sample of comments made by these companies is given below:-

'This company does not operate any form of process or product costing. Costs are allocated to specific functions only within the Refinery but no further.'

'Special ad hoc exercises have been undertaken in the past but on the simple basis of all costs being allocated to main stream products only and any by-product found en-route would be charged out a basic rate irrespective of the processing cost.'

'In common with the manufacturing divisions of a number of other oil companies, the manufacturing division of this company does not in fact make any attempt to apportion costs to specific products. The operating cost of the manufacturing division is controlled by individual types of cost because the complex nature of the process makes

it impossible to establish any meaningful cost apportionment between the products. Input of crude oil to the refinery yields a fairly standard product structure and the ability to produce a physically different yield is very limited.'

'We are avoiding the very issue that you are trying to achieve.'

'Although we produce joint products from our refinery processes, we do not have a system of apportioning joint costs to products. Joint product costing has been experimented with in the past but other information has been preferred for making decisions on product mix, pricing, inventory valuations etc.'

'We are interested in the cost per barrel of input, not output. The costs are therefore not spread between each joint product, output, they are associated with each barrel of crude input.

'The aim is to maximise the benefits from the refining cycle.'

The comments made seem to uphold the view expressed by Waters (1942) when he suggested that a refinery should not attempt to determine the cost of individual products, rather "the accounting procedure can be of far greater value to the management where confined to a determination of the direct unit operating costs of the various processes, together with a tabulation of conditions and yields..... The vitally important item is the profit on a barrel of crude oil, which includes all the products."

The reasons given for not apportioning the joint costs to the joint products coincided with the body of literature on the subject. In general it was thought that the complexities of the oil refining process made any attempt at apportionment a time consuming exercise producing unnecessary and irrelevant information. The shift in emphasis from the output unit to the input unit was also apparent amongst the oil refineries. Views expressed gave support to the articles written by Satyamurthi (1974), Butler, (1971), Feller (1977) and Wilson (1982), literature which concentrated on the problems associated with oil refinery accounting (see 4.4.).

Therefore, the majority of opinion saw each joint product as representing a percentage of the initial barrel input, (the percentage spread depending on the type of crude input used) and the aim being to maximize the benefits from the refining cycle. The 'cost' of each joint product played no part in assisting in the achievement of that purpose.

Two of the nine oil refineries represented in the study did make some apportionment of joint costs to the products emerging from the refinery processes. While acknowledging their main purpose as "increasing the final value of a barrel of crude input", they still felt it necessary to calculate a 'joint product cost'.

One of these refineries was relatively small and operated in a specific crude input area, producing a narrow range of outputs. In this case, although the company recognised the outputs as being joint, for simplicity,

one product was given the status of a main product and the remaining outputs were treated as by-products.

The second example relates to a major oil refinery producing a wide range of outputs from a very complex operation. Figure 6 shows a simplified version of the product streams arising out of the refinery processes for the particular company in question and also indicates the status of these outputs as defined by the accountant. A point to note is the change in the status of gas oil within the refinery operation. The distillation of crude oil produces gas oil, as does the further processing of atmospheric residue. An outline of the costing treatment of the various products is given below.

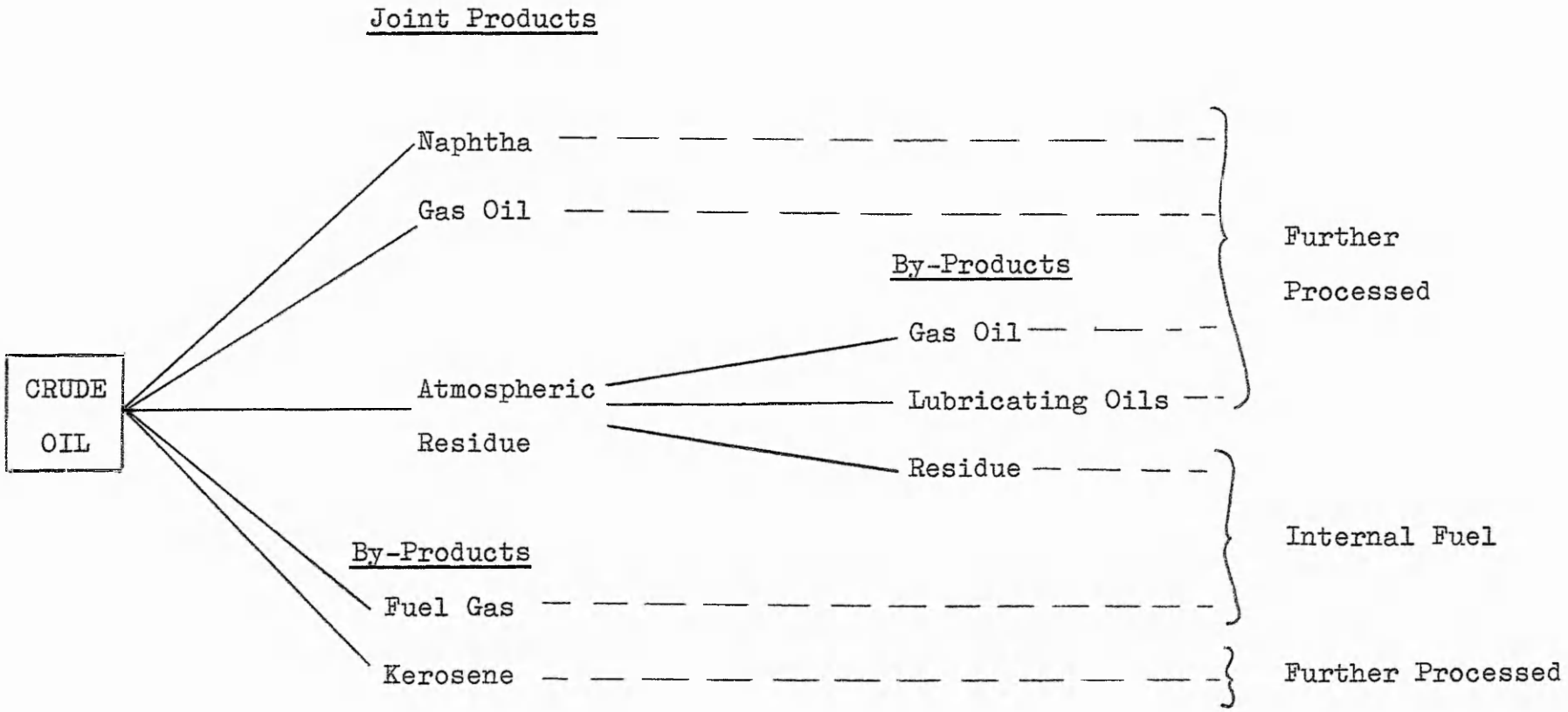
Case I

(a) The treatment applied when atmospheric residue is not further processed:-

The atmospheric residue and fuel gas are costed in relation to calorific fuel value, (i.e. the 'worth' of the product as a fuel) even though atmospheric residue has the status of a joint product and gas, a by-product.

Having established the cost of the atmospheric residue and gas, this is subtracted from the total cost and the remainder is allocated to gas oil, naphtha and kerosene on a physical units basis using weight as the common denominator. It can be seen that the status given to each product bears little relationship to the costing treatment applied.

Figure 6. Case I. Oil refinery product streams used as a basis for joint product costing.



(b) The treatment applied when atmospheric residue is further processed:-

A complication arises when the atmospheric residue is further processed, because gas oil is obtained from this process as well as from the initial distillation of crude oil. The further processing affects the calculated 'cost' of atmospheric residue. In this case the atmospheric residue is considered to be worth more than the calorific value because gas oil is obtained. The new costing of this product represents a weighted average calculated as follows:-

$\frac{1}{3}$ of the fuel value + $\frac{2}{3}$ of the market value of the amount of atmospheric residue to be recycled in the further process.

The treatment of naphtha, gas oil, fuel gas and kerosene obtained from the distillation process is unchanged. The gas oil from the further process is costed on the strength of the original process cost, the calorific value of the residue is credited back to the process and the lubricating oil takes the remainder of the further processing cost.

This particular 'costing system' represents one of a variety of 'unique' ways of apportioning joint costs within the chemical industry as a whole.

Costing Petrochemicals

Ten processes are represented in the petrochemicals area, six of which relate specifically to the cracking of

naphtha and four which relate to the processing of products a stage further down the petroleum based organic chemical line.

All of the companies involved in the naphtha cracking operation used some basis for apportioning joint costs to the product outputs, a contrast to the findings related to the oil refinery operations. Ethylene and propylene were two of the many products emerging from five of the naphtha cracking processes and the concensus of opinion amongst the accountants interviewed was the treatment of these two outputs as joint products. The remaining naphtha cracking process took a different form resulting in a completely different set of outputs, three of which were treated as joint products. The remaining products from the six processes were generally classed as by-products which were given some value, to be credited back to the joint products.

The four companies operating further down the organic chemical line were all involved with the processing of a different feedstock. Joint product costs were calculated for three of these processes, with one company making no apportionment at all.

All nine companies making a joint cost apportionment used variations of the following two bases:-

(1) Sales Value

(2) A chemical formula based on weight.

Sales Value Bases

Five companies used some form of sales value basis for apportioning joint costs to joint products. An application

of this type of method is illustrated in case II. The process discussed is shown in Figure 7. As will be evident from the case details, the costing procedure is further complicated by the recycling of product outputs, the discussion being confined to the main examples.

Case II

This particular company, along with the others operating in the naphtha area said that slight variations in the output proportions were possible. The exact yield of each product depended on the cracking temperature and on the exact make up of the naphtha input. However, the approximate yields per tonne of naphtha and the status given to each product are shown in Table 18. The two most important products emerging from the process are ethylene and propylene which are treated as joint products, the remaining products being by-products.

The cracking plant yields by-products which are either purified for sale or for subsequent use on the site as fuel. In each case the value assigned to the by-product is credited to the two joint products. The variable cost of propylene and ethylene is therefore made up as follows:-

Raw Materials + Processing Materials + Conversion Cost - by product credits (including sales and internally produced fuel value).

The costing of recycled products represents an additional problem which is common in the chemical industry. In this particular case it is illustrated in both the ethane and

Figure 7. Case II An Example of a Naphtha Cracking Process

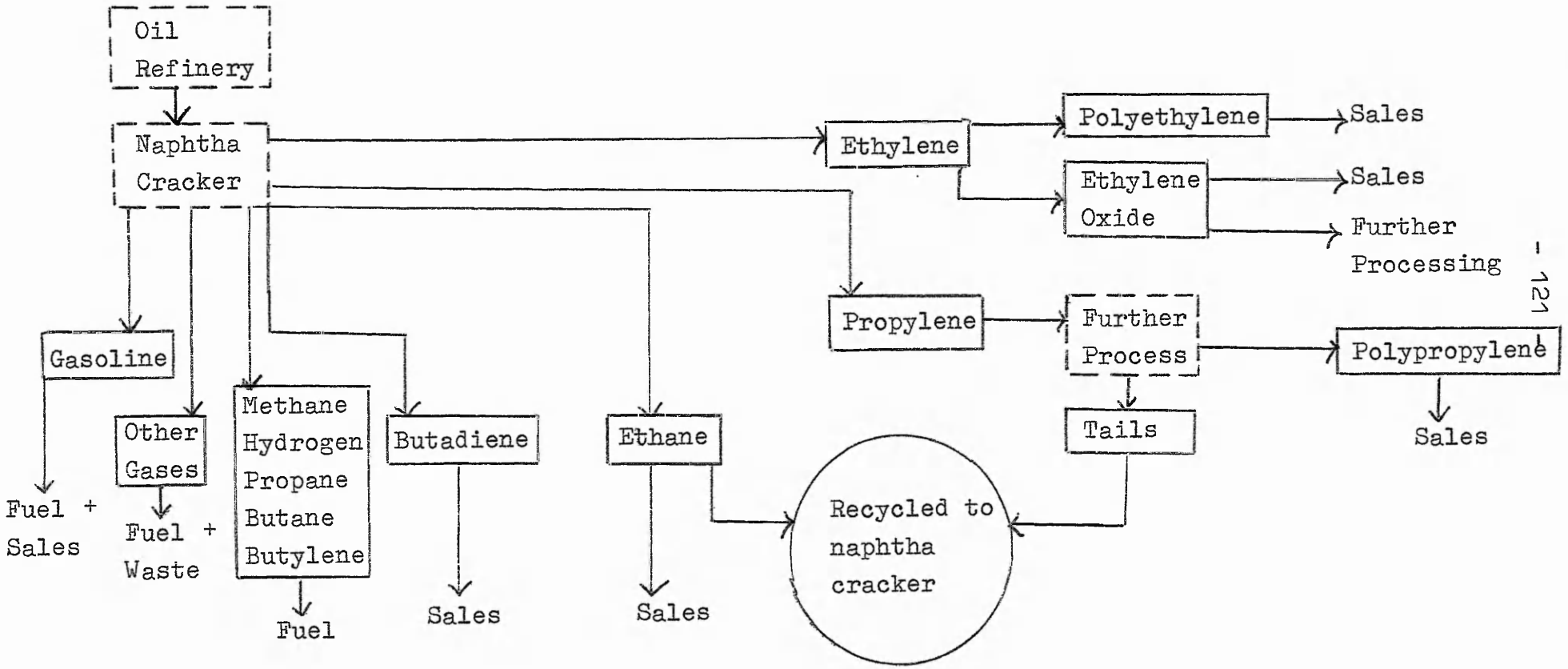


Table 18. Output Yields per tonne of Naphtha.

	Yield (%)	Status
Ethylene	22	Joint Product
Propylene	16	Joint Product
Gasoline	17	By-Products
Methane	17	By-Products
Butene / Butylene	8	By-Products
Ethane	8	By-Products
Hydrogen	5	By-Products
Butadiene	3	By-Products
Other gases / Waste	4	By-Products
	100	

propylene area. Figure 8 shows the situation in more detail than that displayed in Figure 7.

The naphtha cracking process yields approximately 8% ethane, 50% of which is recycled into the cracker, the other 50% being sold. Propylene is further processed, an operation which yields a residue, representing 3% of the propylene input. This residue is also recycled into the naphtha cracker.

Valuations

(1) The ethane recycled is not valued, on the grounds that it is recycled through exactly the same process.

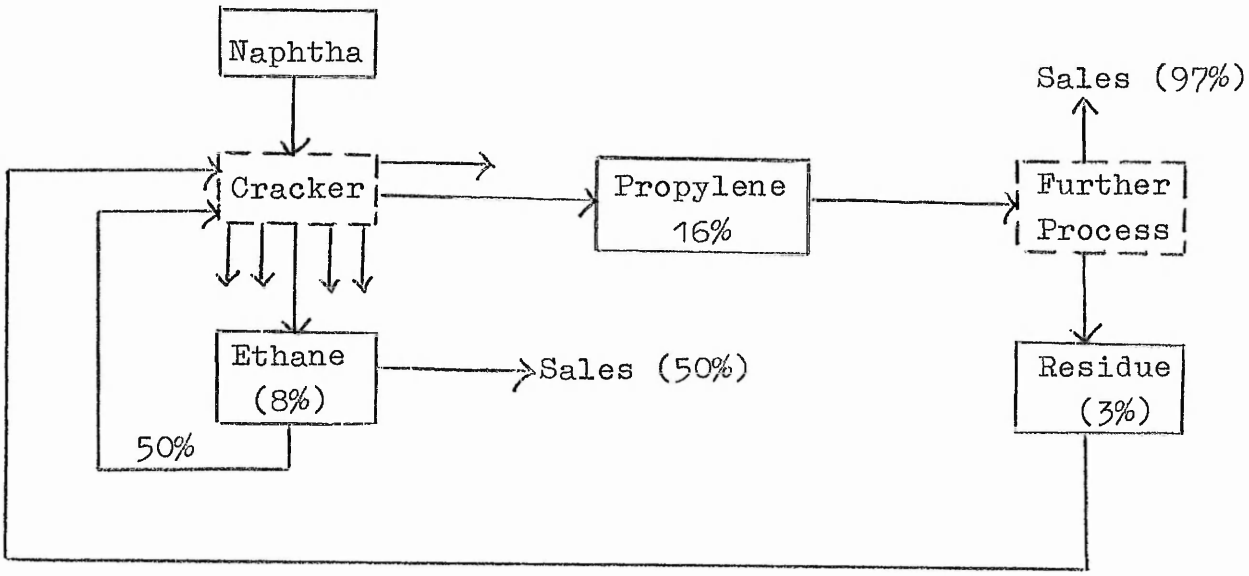
(2) The value of ethane sold, is credited back to the joint products.

(3) The residue is valued at a cost derived through discussion. This generally represents a commercial value which is on par with that of naphtha. This product is given a value because it is recycled through the cracking process in addition to the further process.

The valuations relating to recycled products have to be incorporated into the joint cost total before any apportionments are made between ethylene and propylene. In some cases the number of recycled products and their subsequent different treatments results in a very involved costing exercise.

The final joint cost apportionment is based on the total commercial sales value of ethylene and propylene at the split -off point. The sales value itself is based

Figure 8. An Example of Re-cycled Products.



on the North-West European price per tonne. Therefore, the apportionment would be made as follows:-

	Tonnes	North-West European Price	Total Sales Value	Apportionment
		£	£	£
Ethylene	X	Y	XY	$\frac{XY}{XY + AB}$ x Variable Cost
Propylene	A	B	AB	$\frac{AB}{XY + AB}$ x Variable Cost

Other companies operating a sales value type of apportionment system followed a similar procedure to that described in Case II, although obviously different processes involved a variety of complications.

Physical Units Bases

Four processes were costed using a physical units basis generally incorporating some chemical formula based on weight. Case 3 is an example of another petrochemical process using naphtha as the feedstock.

Case 3

Table 19 shows the products arising from the processing of naphtha in this particular operation, along with the output proportions, and their status.

Inspite of the fact that the proportion of acetic acid arising from the process far exceeds that of the other products, the three acids are treated as joint products.

Table 19. An Alternative Naphtha Process

Outputs	Output Proportion tonnes	Product Status
Acetic Acid	1	Joint Product
Propionic Acid	0.13	Joint Product
Formic Acid	0.07	Joint Product
Residues		By-Product

Table 20. Outputs from the Processing of Cumene

Product	Output Proportion	Old Status	New Status
Phenol	1	Joint Product	Main Product
Acetone	0.6	Joint Product	By-Product
Fuel Products	0.002	By-Product	By-Product

The reason given for this was that the plant was built as a mixed acid plant and not an acetic acid plant which represents the greatest proportion of total output.

The residue from the process is used internally as a fuel and is transported directly from the plant to the boiler house. At the time of the visit it was difficult to measure the amount of residue, as the demand for the acid products had fallen to such an extent that part of those products were also being burned as fuel, and hence being treated as residue.

After crediting the process with a by-product value for the residue, the remaining joint cost was split amongst the three joint products according to the output proportions. Again, the other processes in this section were treated in a similar way, in some cases the output proportions could be varied, in others it was fixed.

Case 4.

One company who had previously used a commercial value approach to apportionment had more recently opted for a main product/by product approach, thereby changing the status of its outputs. The input to the process yielded three products, the output proportions and change in status being shown in Table 20 (Page 126).

The reason given for changing from a joint cost apportionment was that the prices of acetone and phenol fluctuate considerably, and a marked fluctuation in the price of one product was automatically affecting the cost of the other product. It was considered more equitable to treat phenol, which represents the greatest proportion

of total output, as the main product and value acetone as a by-product. This change in product status was not uncommon in both the chemical and food industry where costing systems evolved according to requirements.

Coal Processing and Coal Chemicals

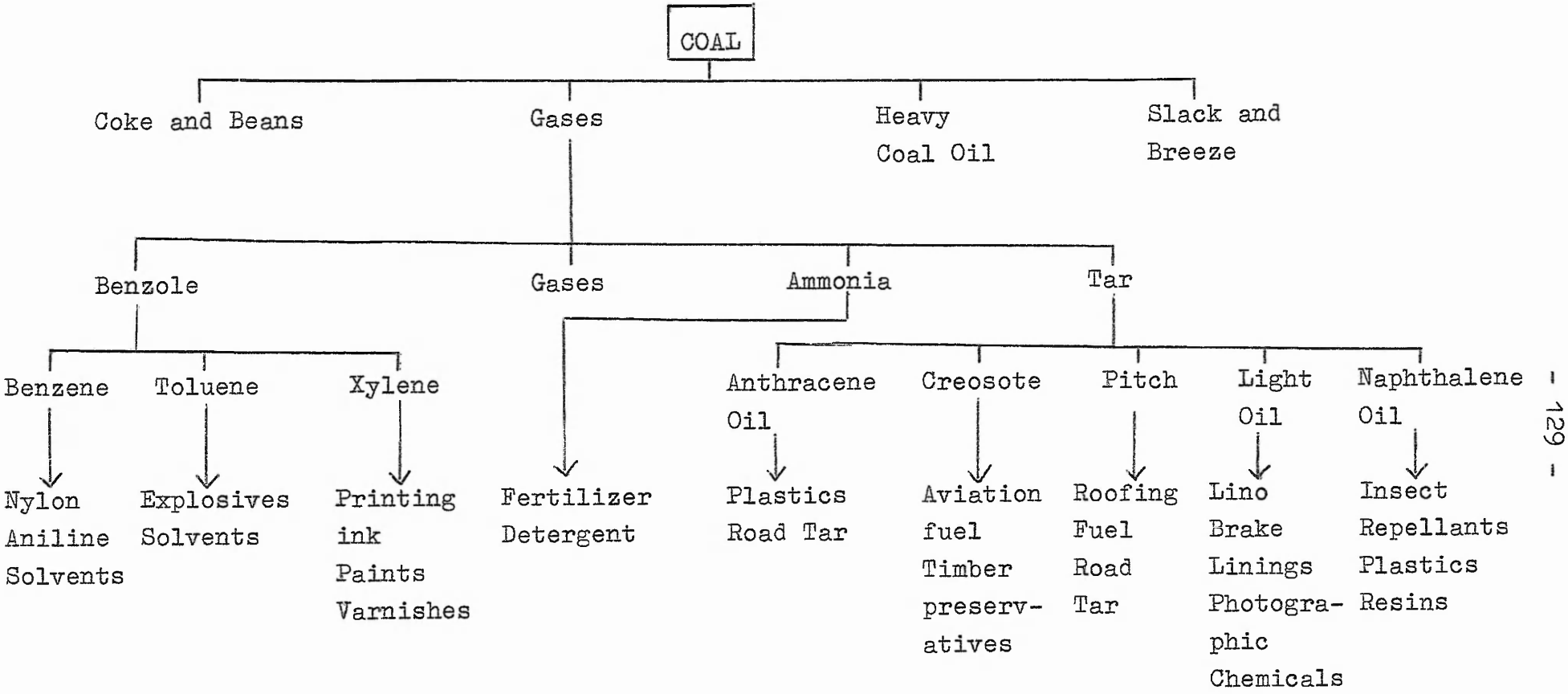
Generally, it is the carbonising of coal for making coke that is the main current source of coal-based chemicals. The process involves heating the coal, without contact with air which converts it into a variety of solid, liquid and gaseous products, the amounts of each product depending on the temperature used and the variety of coal. The principal product by weight is coke. In low temperature carbonisation the quantity of gaseous products is small and liquid products high. In high temperature carbonisation the yield of gaseous products is higher than that of liquid with a relatively low production of tar. The products other than coke are collectively known as coal chemicals.

Figure 9 gives some indication of the chemical streams originating from coal and their final applications. A vast number of individual products arise from the numerous chemical conversion processes applied to the primary coal chemicals.

Costing Coal products

Of the five companies represented in the coal processing area three used a physical units basis for apportioning joint costs. The remaining two companies which had previously applied a weighted unit basis now used a main product/by-product approach.

Figure 9. Some of the main product streams from coal.



It must be noted here that two companies operated processes in both the coal processing and coal chemical product areas which were costed together and not as individual operations. An example is given in a later case.

Several companies in the coal and coal chemicals sections indicated that they had changed their method of cost apportionment to try and achieve a more equitable split between the product outputs.

Case 5 is an example of a company using weight as a basis for apportionment.

Case 5

The company operated a screening and carbonization process using a variety of coal input. The outputs and their status are illustrated in Table 21.

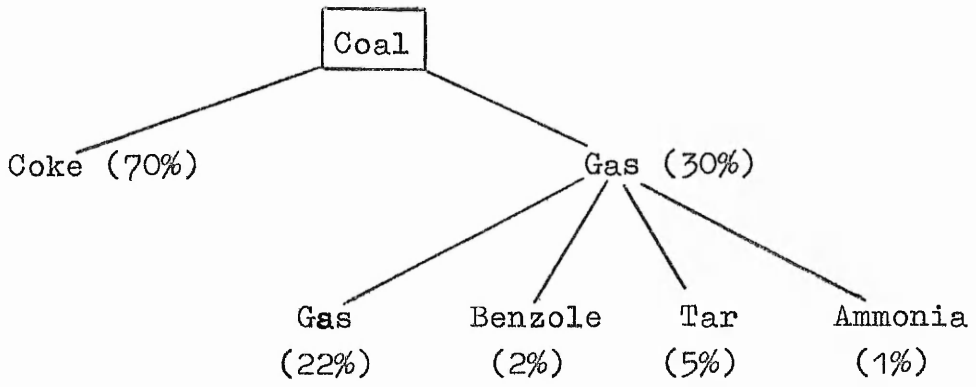
The type and quantity of joint products depended upon the size and type of coal used as an input. The by-products are produced both during the screening and the carbonisation processes. Liquor represented a waste product, having no value, the company having to pay to dispose of it. The by-products were valued at an estimated market value, updated six monthly, and credited to the coal account. The joint cost was then apportioned between the three joint products on a tonnage basis.

The majority of companies processing coal and coal chemicals, who made some apportionment of joint cost, used a physical units basis to do so. This was in contrast to the petrochemical section of industry which favoured some form of sales value method of apportionment.

Table 21. Outputs from Coal Carbonisation

Outputs	Status
Open fire coke	Joint Product
Closed Appliance Coke	Joint Product
Beans	Joint Product
Slack	By-Product
Tar	By-Product
Breeze	By-Product
Liquor	Waste Product

Figure 10. Joint Outputs from processing coal and gas



The next example shows the combined costing procedure undertaken by a company operating in both the coal processing and coal chemical areas. This case also illustrates a change in apportionment method.

Case 6

A simplified version of the process in question is shown in Figure 10 (Page 131), along with the approximate percentage weight of each output per tonne of coal input.

Pre 1960, the company operated a "long, laborious method of joint cost apportionment". All the product outputs were converted to a common denominator for measurement purposes. This involved the conversion of the benzole and gas products to a weight basis.

The 'cost' of coal which represented two thirds of the total cost was then apportioned to each of the five products on the output weight basis (tonnage). The operating cost was calculated through a series of cost centres existing throughout the works, being allocated back to the products on a variety of bases. The method, by its very nature alwaysshowed coke to realize a profit while the remaining products made a loss.

The above system was in operation for seven years during which time it was reviewed by the company. The following observations were made.

(1) "The product cost figures were never used in any decision making area such as pricing.
(2) The government set prices, therefore the product cost figures were not required.
(3) Four out of the five products automatically made a loss

because of the very nature of the method used.

(4) Little benefit was derived from time consuming costing procedures."

As a result, the company now makes an assumption that coke is the main product and the remaining four products are by-products, where the cost of coke per tonne is calculated as follows:-

$$\frac{\text{Cost of Coal + Operating Cost - Credit from sales of by-products}}{\text{Tonnes of coke produced}}$$

Costing Coal Chemicals

Eleven processes are represented in this section, six using a physical units basis of apportionment, one using a sales value approach and the remaining four using a main product/by-product approach. Case 7 gives an example of a process producing three main product outputs all treated as joint products. The company had changed the costing system two years previously from a very arbitrary unit basis to a sales value approach.

Case 7

Heavy coal oil represented the feedstock to the process which yielded three joint products A, B and C. Originally, the three product outputs were each allocated one third of the joint cost regardless of the value or volume of each output. This system was abandoned two years ago due to "its unsatisfactory nature". The present system is based on a sales value approach where the joint cost is allocated

according to the final contribution that A, B and C make to the company. The company considered that the present method "put each responsibility section in a more realistic situation, where the contribution to the company is directly geared to a reporting system".

The method used is illustrated in Figure 11. The company used a net realizable value approach, deducting the further processing cost from the final sales value to find the net realizable value for each product. The joint costs were then apportioned on the basis of these values. This method represents the conventional 'textbook method' for apportioning joint costs using a sales value approach.

If there was a comparable market product available at any particular stage of production, then this was compared with the "work-back price" from the final saleable stage. The company commented that they generally found very little difference between these two figures.

The companies using a physical units basis all used weight as the common denominator for calculating the incidence of joint cost on each product output. The four companies opting for a main product/by-product approach had generally experimented with a joint costing system in the past but had recognized its limitations. They considered that the little benefit derived from the product cost figures did not warrant the amount of work involved in the costing exercise.

Figure 11. Case 7 - Sales Value Approach used in the Distillation of Heavy Coal Oil

Heavy Coal Oil

Joint Products	A	B	C
Further Processing Costs	£300	£10	£900
Final Sales Value	£500	£200	£1000
Net Realizable Value	£200	£190	£100
Percentage Apportionment	$\frac{200}{490} \times 100$	$\frac{190}{490} \times 100$	$\frac{100}{490} \times 100$
	41%	39%	20%

6.2.2. The Inorganic Chemical Sector

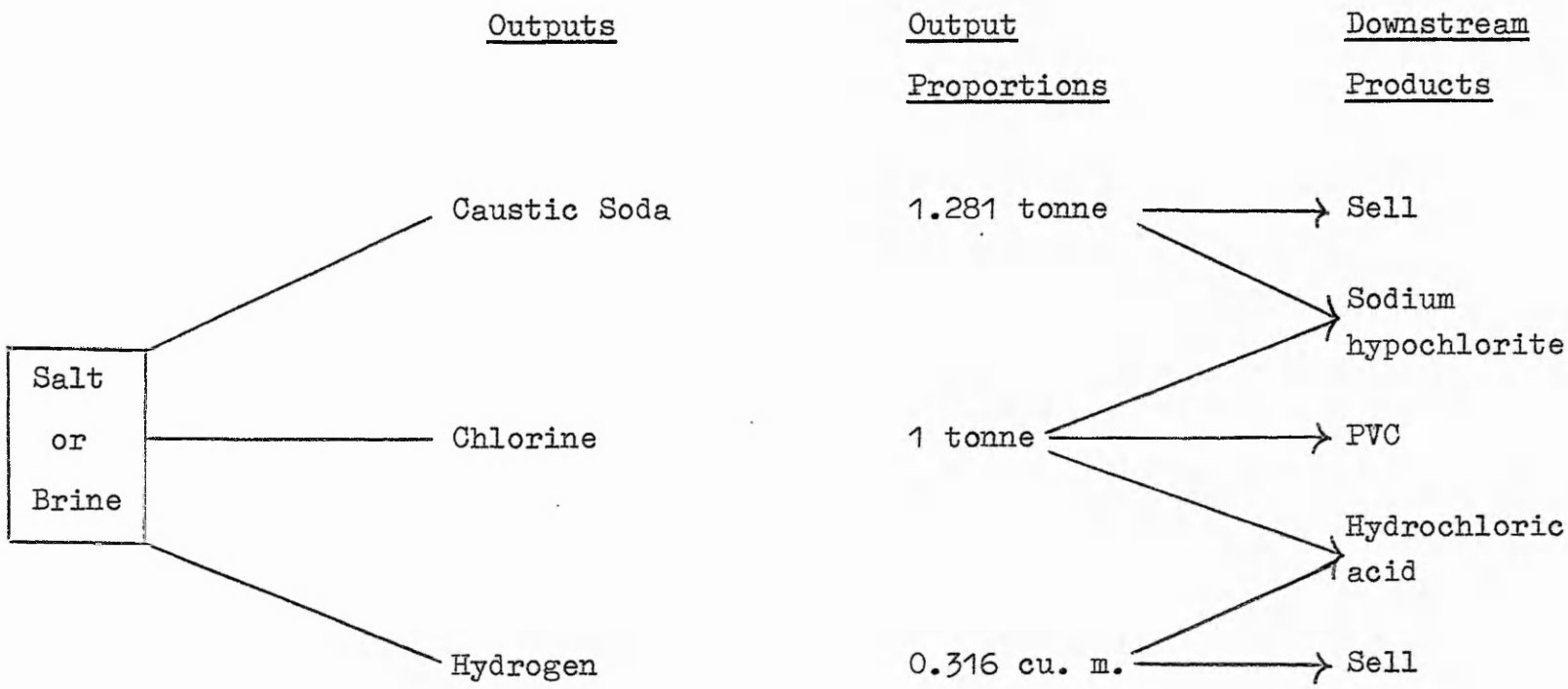
Inorganic chemicals are derived chiefly from mineral sources, the main example of an input producing joint outputs being salt. Three companies operating in this area were visited, all of which had found it necessary to change and modify their system of joint cost apportionment to reflect changing market situations. The input to all three processes was either salt or brine. The basic outputs from the electrolysis of these inputs are illustrated in Figure 12. The output emerges in fixed proportions, and the most common method of apportionment is based on this molecular weight. The one company using a main product/ by-product approach had only recently altered its costing system from a weight basis to take account of a changing market situation. Case 8 gives an example of a company operating in this particular product area, and illustrates the effect of changing market circumstances.

Case 8

In the past chlorine and caustic soda were treated as joint products, the cost of the raw materials and processing being split purely on a weight basis. Hydrogen was a by-product from the process, given a calorific value to be credited to the main products.

Chlorine was used as a raw material in the making of PVC. As the market for PVC escalated, the market became a 'chlorine led' one. Therefore the company changed its costing policy in order to reflect the greater importance of chlorine. The present system was designed to identify

Figure 12. Case 8 - Outputs from the Electrolysis of Salt



the 'cost' of manufacturing chlorine. "By treating both hydrogen and caustic soda as by-products and crediting the process with the revenue from these products, the cost of chlorine is reduced, resulting in a lower transfer price to the PVC process, therefore decreasing the 'final cost' of PVC".

However, the market for PVC has since contracted and at the present time, the market is 'caustic-led'. In spite of this, the costing procedure has remained unaltered, with chlorine still being treated as the main product.

Another company has already reacted to this 'latest' market development by changing the status of caustic soda and chlorine back to joint products, while the third company considered any changes in product status to have adverse effects on the costing systems already in operation. The particular area mentioned was that of transfer pricing, where changes in apportionment methods would automatically alter the calculations on which these prices were set.

Complications to the costing of the electrolysis process arose in situations where products were recycled. For example, caustic is used in the purification of brine before the electrolysis takes place. Therefore, this product has to be recycled at some value calculated by the accounting and technical divisions, who consider the alternative marketing options for the product before deciding on a final valuation.

The remaining five processes represented in the inorganic chemicals area used a variety of different feedstocks

for their manufacturing operations. Two companies opted for a main product/by-product approach, two, a net realizable value apportionment method and one made no attempt at apportionment at all. It would seem that the relationship of product outputs to weight is not so pronounced further down the inorganic chemical line. The concentration of physical unit or chemical formula based apportionment methods is more pronounced in the 'heavy' or 'bulk' chemical areas.

6.2.3. The Miscellaneous Chemicals Sector

Included in the miscellaneous chemicals sector are the processing of air and natural gas, and mixtures of inorganic and organic chemicals, generally representing intermediate chemical processes. Nine processes are contained in this section, three relating to air and natural gas, the remaining six producing an assortment of product outputs from a variety of inputs. In all cases some apportionment of joint costs was made on either a sales value or physical units basis as shown previously in Table 17. All three processes relying on air or natural gas as a raw material were costed using a physical units/chemical formula apportionment method. Case 9 is an example of a costing system applied to the products emerging from the compression of air. The process is illustrated in Figure 13.

Case 9.

The outputs from the process are fairly fixed, assuming a given technology level. Slight variations in output proportions were possible at certain plants where

Figure 13. Case 9 - The Compression of Air

Input	Outputs	Output Proportions	Status
Air plus Energy	Oxygen	21%	Joint Product
	Nitrogen	78%	Joint Product
	Argon	1%	Joint Product

more argon was produced at the expense of oxygen. The costing system in operation had evolved during the previous two years.

The technical department established the 'standard energy usage' required by each product in order to separate it from the remaining products. The proportion of the joint cost borne by each joint product was then related to this figure. Energy was used as the common denominator because it was the major joint cost, due to the absence of any raw material cost. An example of how an apportionment would be made is as follows:-

	Oxygen	Nitrogen	Argon
Standard energy usage per unit of output	25 kilowatts	5 kilowatts	135 kilowatts
Proportion of energy cost borne by each product	25/165 15%	5/165 3%	135/165 82%

There is an inverse relationship between the output proportion yielded and the amount of energy required to

separate a product. Hence, argon, representing the smallest output bears the majority of cost.

The energy standards are basically set by practical application on the commissioning of the plant and they are applied to the volume produced. Therefore the standards can vary between individual plants according to the exact process instigated and the volume produced.

The joint product costing system was introduced with the increase in demand for nitrogen. Historically, oxygen was treated as the main product and nitrogen the by-product. Argon represents a special gas for which demand fluctuates. If this product is required in any substantial quantity then an 'argon run' is made whereby the unwanted oxygen and nitrogen are spilled back into the atmosphere. In this particular case, the cost of 'the spill' is allocated back to argon.

6.2.4. Stock Valuation in the Chemical Industry

As the majority of oil refineries made no attempt at calculating a joint product cost, they had to use an alternative method for valuing their stocks. Most of the refineries appeared to calculate a valuation as follows:- "After comparing prices of products from a barrel of crude with the original cost of crude, the stock is then costed at some figure lower than current value. The sales realizable value is used to reflect the barrel cost, where the value is based on European market prices". The refineries tended to value their unfinished stocks at a standard sales realizable value. Where a joint cost apportionment was made, the average cost per tonne and the average price per tonne were

compared to find the lower valuation.

In general, throughout the chemical industry, the companies who made a cost apportionment valued their stock at standard cost, revaluing the figure monthly to an actual cost based on the joint cost calculations, and making a comparison with the realizable value.

Those companies who did not apportion costs valued stock at market price less an element of profit (calculated as the average profit for the division). By-products were usually valued at an estimated market value, updated approximately every six months.

6.2.5. The Food Industry - Organic Oils and Fats

The most common classification of fats and oils divides them into two major groups; vegetable oils and animal fats. Animal fats can be further divided into land and marine types. Companies operating in this industrial sector are able to select from the world's supplies, diverse kinds of fats and oils, and convert them into forms suitable for use as cooking fat, in butter and margarine, in salad dressings and confectionery coatings etc. A certain amount of substitutability between the raw material inputs enables maximum advantage to be taken of fluctuations in prices and also permits supply problems to be overcome.

Fats and oils, as well as being significant in the food industry, are also important as the basis for a variety of industries which manufacture oils, varnishes, paints, lacquers, soaps, pharmaceutical products etc.

The nature of the product outputs are determined by

the chemical composition of the specific oil or fat and the type of processes applied to them. This particular section of the research is concerned with the processing of oils and fats for subsequent use in the food industry. Examples of the sources from which edible fats and oils are derived are:-

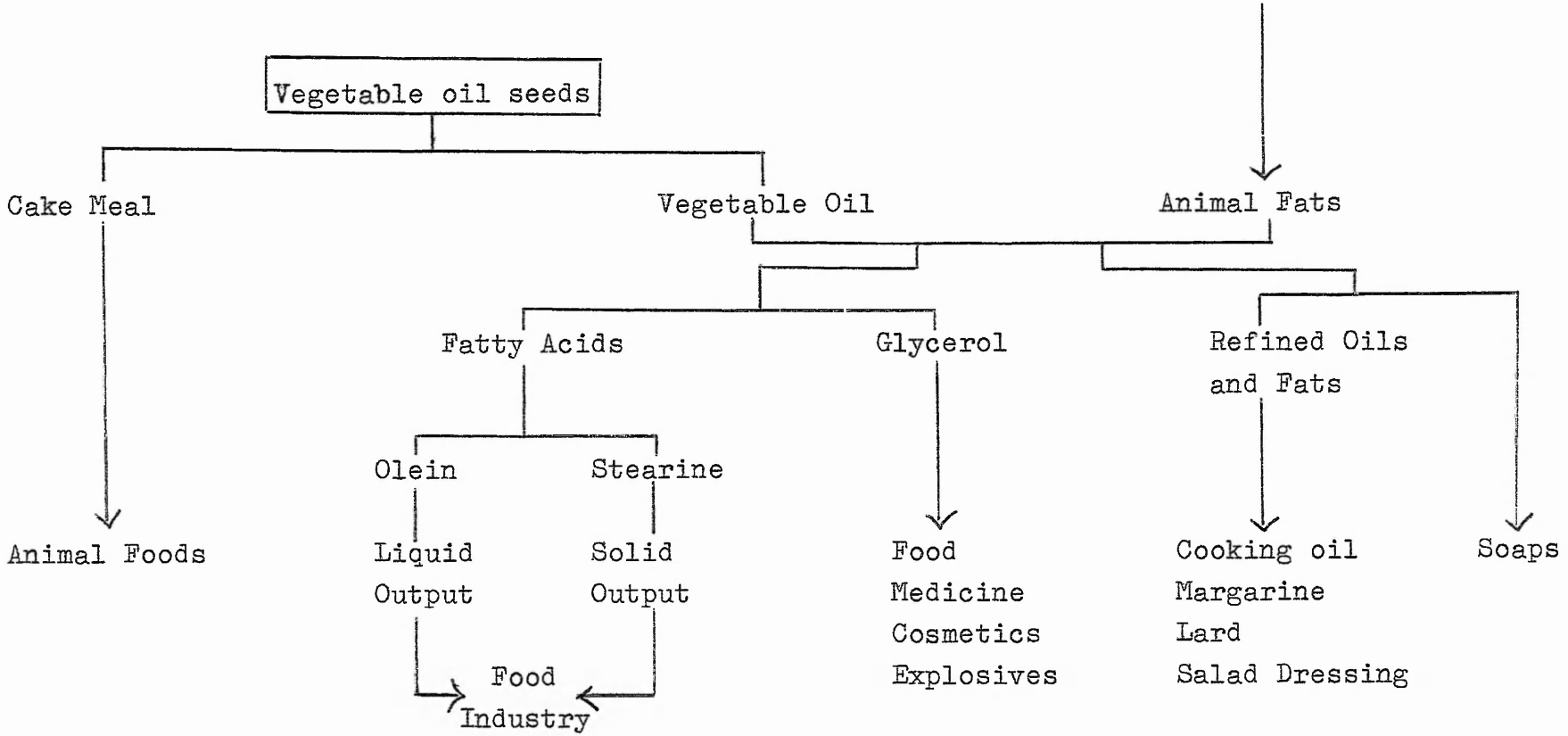
Vegetable Oils	-	Cotton seed, groundnut, coconut, soya bean, olive, palm, sunflower seed etc.
Animal Fats	-	Beef fat, mutton fat etc.
Marine Oils	-	Whale Oil, fish oil etc.

Oils and fats are firstly extracted from vegetable and animal sources by a variety of procedures. Subsequent refining processes can be regarded as a purification of crude oils to make them edible. The 'fatty acids' (of which there are very many) arising from the refining operations may be subjected to a process of hardening (hydrogenation) or separation, for subsequent use in the food industries. The companies interviewed undertook both of these operations.

Figure 14 is a very simplified diagram of the product streams resulting from the processing of oils and fats (compiled from the information obtained from the companies visited). Three main sets of joint product were revealed: cake meal and vegetable oil, fatty acids and glycerol, olein and stearine.

Of the six processes represented in this section, one relates to the initial processing of vegetable oil seeds, and the remaining five to the processing of vegetable oil

Figure 14. Product Streams from the Processing of Oils and Fats



and the subsequent fatty acids. Joint product costs were calculated for three of these processes, using a weight basis, the other three processes being costed by an alternative method (see Table 17).

For two of these latter processes, a joint cost apportionment had previously been made using a weight basis, but the companies had changed the costing system to a main product/by product approach in order to reflect a change in product status.

Two costing complications frequently found in the chemical industry were also apparent in the oils and fats sector. These were:-

(1) The recycling of products

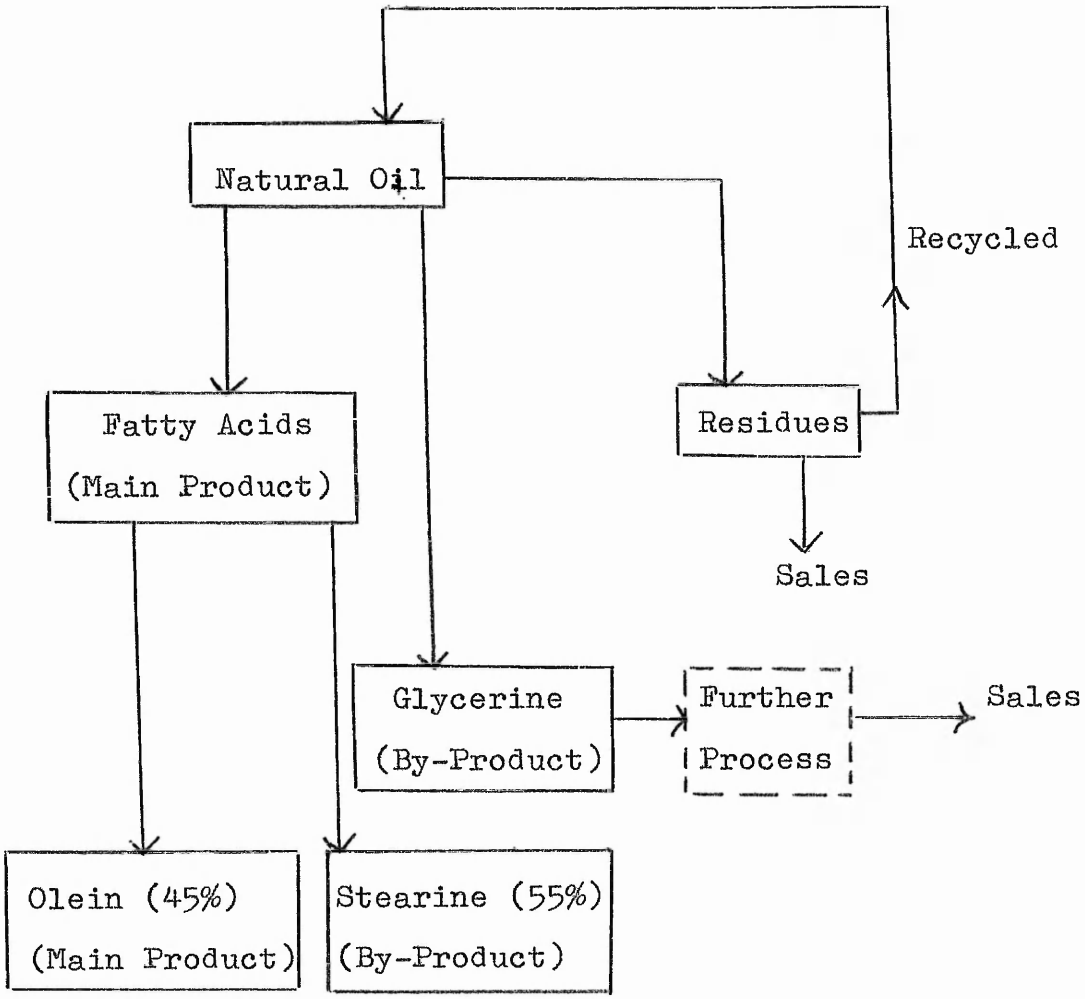
(2) Situations where the same product could be obtained from two consecutive processes (see Case I relating to mineral oil refining) or from two completely separate processes.

Case 10 is an example of the costing system applied by one company to the processing of vegetable oil and fatty acids. The case includes a change in product status, the treatment of recycled products and the costing of a product. which could be manufactured by an alternative route.

Case 10

Figure 15 gives the main outline of the process to which this case relates and includes the present status of the outputs. Historically, olein and stearine were treated as joint products, fifty per cent of the processing cost being allocated to each product, inspite of the fact that generally, more stearine (55%) was yielded from the process.

Figure 15. Case 10 - An example of organic oil processing



The advent of new technology which provided alternative processes for yielding stearine (solid product), and the increase in demand for olein (liquid product), were major reasons influencing the company to rethink its costing procedures. The view now taken by the company is that only one mainstream product should be identified for any particular process and every other product should be treated as a by-product. Hence olein is now given the main product status, and stearine represents the by-product, which is also obtained by the company using an alternative process.

The original oil input is subject to a variety of pressurization and distillation processes in order to obtain the fatty acids, glycerine, and residues which are extracted at various stages.

The residues (depending on their exact composition) could either be sold or re-distilled. If recycled into the distillation process, then the value would represent the original raw material input value plus a recovery charge. The net effect of this would be to slightly increase the total average raw material input cost. The final residue resembled pitch, which could either be burned or sold. If burned, its valuation reflected (according to quality) the calorific value of fuel oil and if it was sold it was given an "estimated valuation reflecting the market price less selling costs".

In general, the by-products were valued using one of the following methods:-

(1) Substitute the 'definitive route product cost', i.e.

the cost incurred in obtaining the product by an alternative process.

(2) Credit the main product with the 'market value' of the by-product.

The definitive route method was preferred where feasible, otherwise, the latter method was employed.

Historically, glycerine was a waste product but its importance increased, hence its present by-product status. The by-product 'value' is credited to the cost of the mainstream product, where the valuation reflects the world crude price for glycerine less the further processing cost incurred in order to put the product in a saleable form. The actual value credited to the main product fluctuated for two main reasons:-

(1) The amount of glycerine yielded from the raw material varies according to the exact chemical composition of the input.

(2) Glycerine prices fluctuate according to supply which is subject to various influences e.g. the amount of synthetic glycerine produced from petroleum.

The fatty acids, which are the mainstream group of products are split into oleins and stearines. Stearine, (the by-product) can be made by a different process, therefore, the 'cost' of stearine represents the cost of the product if it were processed in this definitive route. This value is then subtracted from the total process cost and the balance is allocated to olein. Therefore, it can be seen that both 'cost' and market valuations were adopted in the by-product costing procedures of the company concerned.

In certain circumstances, by-products emerging from the distillation process had a definitive route, but it was found necessary to apply the market valuation because of the existence of a circular costing problem. Figure 16 illustrates a circular costing situation. The processing of the input yields a mainstream product, A, and two by-products B and C. The market value of product C is credited to product A as no definitive route is available. However, product B can be made by an alternative process. The problem arises because this alternative process also yields product F, which is the mainstream product from the original process. Therefore product B cannot be costed until product F has been costed and vice versa. In this case, a market value for B would have to be inserted in place of a definitive route cost.

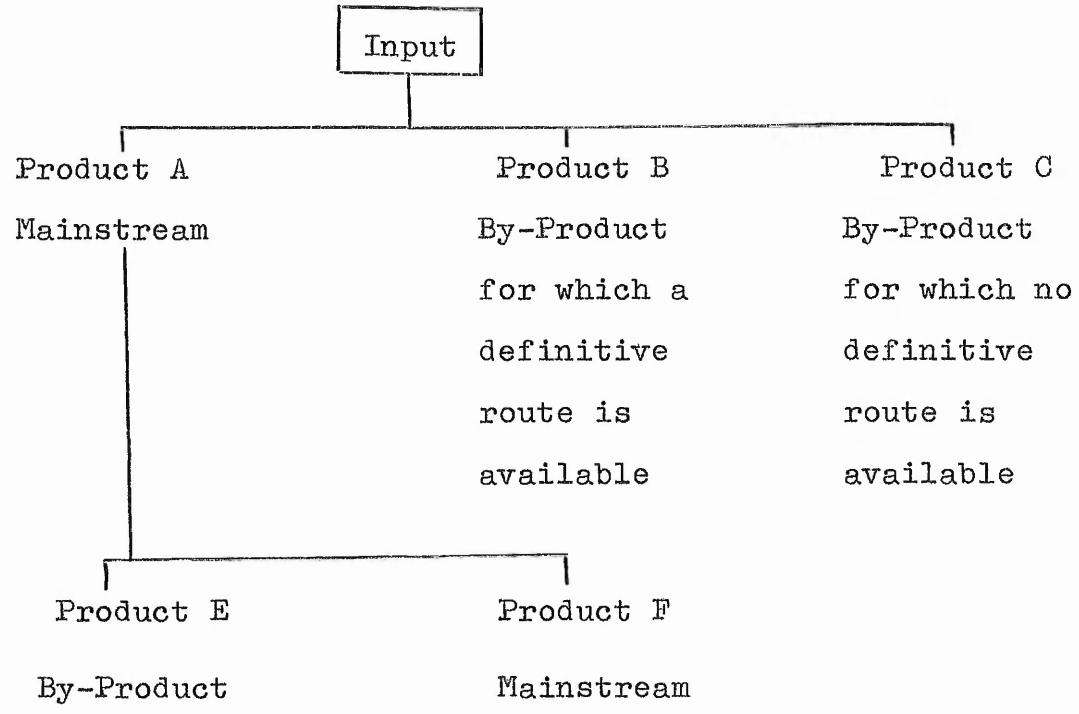
In general, the organic oils and fats sector encountered similar costing problems to those faced by many sections of the chemical industry, due to the nature of the processes. Where an apportionment was made a weight method was favoured, although there did seem to be some indication of a move towards a main product/by product approach as a preferred costing method.

6.2.6 Meat and Meat Products

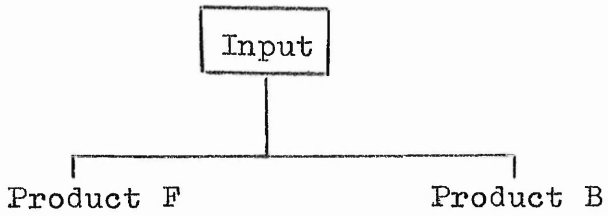
The majority of processes in this area, relevant to the study, were generally undertaken by small firms, many of whom did not employ a full-time accountant and hence felt unable to assist. For this reason only three processes

Figure 16. An Example of a 'circular' costing situation

(a)



(b) The definitive route for product B



are represented in this particular section. All of the processes relate to the butchery process, the input being a cow, sheep or pig carcass (whole or part). In all three cases, a main product was identified, the remaining outputs representing either by-products or waste. There was also general agreement that the 'cost' of individual products was unimportant. The major factor was the comparison between the total cost of the beast and the price obtainable from the end products. It was stated that at the point of purchase, the buyer instinctively knows the probable end market values (before any processing takes place) and that an actual costing process was difficult to quantify.

However, Case 11 illustrates the costing of one butchery process where the inputs were pork shoulders, the main product output being used as an input into a pie-making process.

Case 11

The outputs from a particular section of a butchery process are illustrated in Table 22, along with the output proportions and their product status.

The cost of shoulder meat was derived after crediting the process with the 'market values' of the remaining four products. Bone and hock meat were credited at the selling market price and back fat and rinds (products used internally) were credited at the buying in market price. This provides another example of a case where both 'cost' and 'selling' valuations were used in one costing procedure. Having established the cost of each pound (weight) of

shoulder meat this figure was then transferred to the following pie making process as a raw material cost.

It seemed that in this particular food sector, "intuition" and a "feeling for the market" were far more important than the calculation of a final individual product cost.

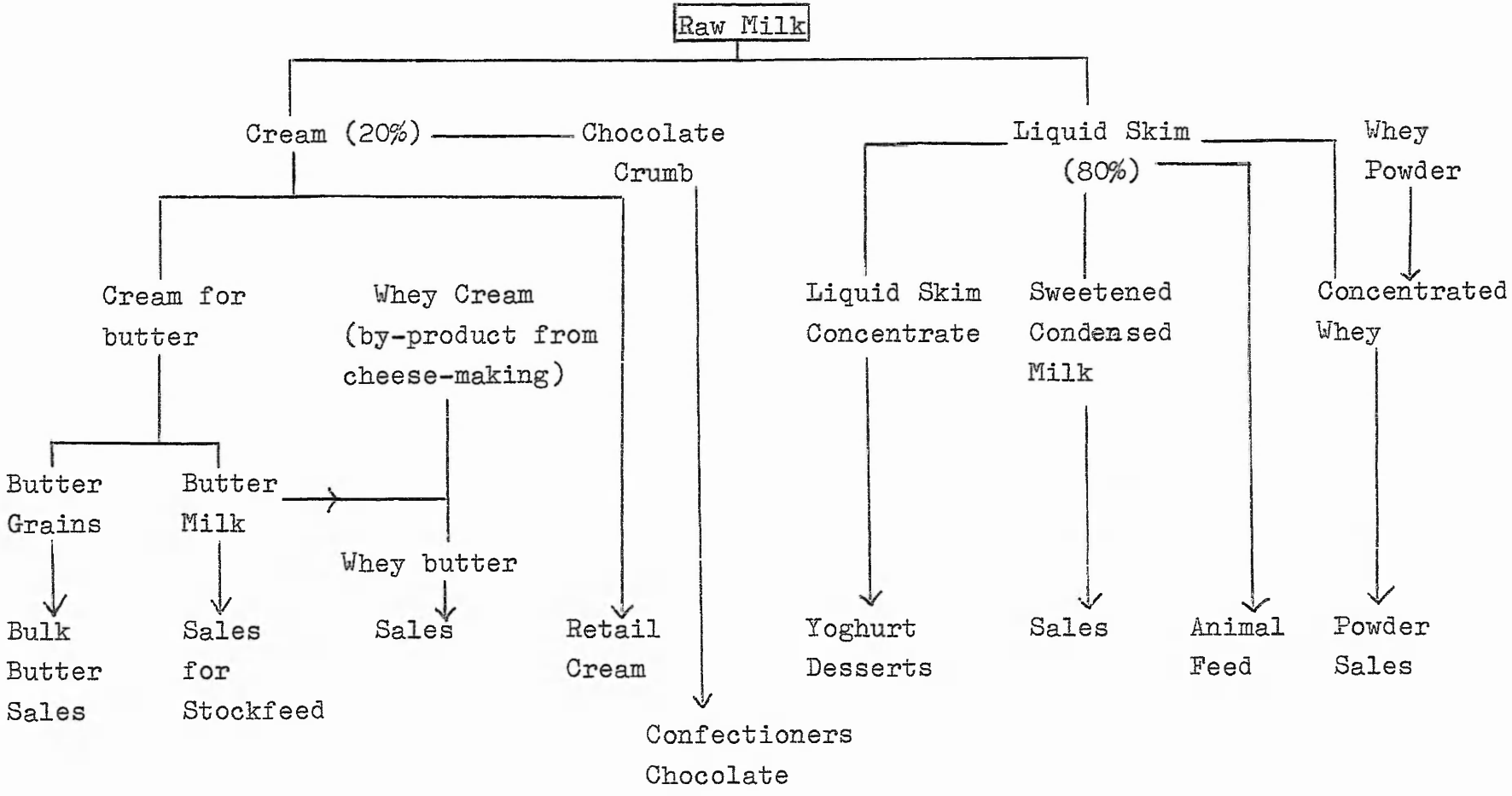
Table 22. Outputs from the processing of pork shoulders

Product	Output Proportion %	Product Status
Shoulder meat	67.4	Main product
Back Fat	7.0	By-Product
Rinds	6.7	By-Product
Hock Meat	3.3	By-Product
Bones	15.6	Waste

6.2.7 Milk and Milk Products

Figure 17 shows the major product streams resulting from the processing of raw milk and also gives an indication of the final uses of the outputs. The first major process is one of separation, resulting in approximately 80% liquid skim and 20% cream (depending on the exact composition of the input and the process used). The cream can then be used for butter making, as the main ingredient for other cream products such as chocolate crumb, or it may be sold as carton cream. The liquid skim also has various uses; it may be sold as animal feed, as a powder (particularly for export to third world countries), or used as the

Figure 17. Product Streams from Milk



main ingredient for yoghurt, vitapint etc.

The main jointly produced products are cream and liquid skim; buttermilk and buttergrains. Nine processes are represented in this section, five relating to the former and four to the latter product groups.

The existence of the Milk Marketing Board influenced to varying degrees, the costing procedures undertaken by creameries operating in this sector. Those units run by the Milk Marketing Board only dealt with the processing costs related to them, other costs such as raw material cost, marketing, stock valuation, pricing decisions etc. were all the responsibility of head office. Other units although having to comply with the policies of the Board, operated their own internal costing procedures.

Inspite of the various unit structures, there was general agreement on the treatment of the jointly produced outputs arising from the milk processing. Case 12 is an illustration of the costing procedures of a creamery not owned by the Milk Marketing Board but represents the general case.

Case 12

The company involved operated in the areas specified in Figure 17. The company stated that the major function of the site could be seen as extracting water, because 88% of a bottle of milk is water (based on litreage). The largest single expense, after the raw material is energy. Oil which was previously treated as a fixed cost is now regarded as an ingredient of the process in the same way as milk. Therefore all energy costs are now allocated to

the products directly.

The operation is a capital intensive one, the separation process yielding two products, cream and skim. Cream is treated as the main product and carries all the process and handling costs and all the overheads. Skim is treated as a by-product and carries no process cost at this stage. This costing system evolved from the time when skim was a waste product, before the present day product range had been developed. Even though the demand for skim-based products has increased rapidly over the past few years and skim is now considered to be worthy of joint product status, it is still treated as a by-product for costing purposes. A change in procedure would obviously affect the calculated individual product costs, hence distorting the present cost - market price relationship of products. However, the company did forsee some change in procedure in the future in order to reflect the changing product status of liquid skim.

All input milk is purchased from the Milk Marketing Board, who have a scale of charges based on the revenue realized by the milk in its final output form. Therefore, the raw material price is paid retrospectively (monthly) according to the end use of the milk.

The other operation, yielding two products is the processing of cream to obtain buttermilk and buttergrains. Buttergrains (bulk butter) are treated as the main product and buttermilk, which represents another form of skim is the by-product. This by-product can be sold or returned to the "skim-bucket" along with the skim from the separation

process, at no transfer cost.

It was mentioned by this particular company, that at another of its productive units, involved in a cheese-making process, milk separation was undertaken specifically to obtain the liquid skim. Therefore, for costing purposes, skim was treated as the main product, bearing all the raw material and processing cost. Hence the same company operated two milk separation processes at two different sites with a reversal of the costing procedure, cream representing the main product at one site and skim at the other. The output status in each case was a reflection of the importance of the product to the particular unit concerned.

Because of the nature of the costing procedures undertaken by the majority of companies represented in the food sector, all those interviewed stated that stock was valued at cost. By-products were generally valued at some estimated market value.

6.2.8 Costing By-Products

Although by-products are theoretically distinguished from major products by their relatively small market value, the distinction in practice is made by each company for its own purposes. All the companies interviewed employed a market value approach, where the recoverable value of the by-product was credited to the total cost, leaving a remaining balance which was considered to be the cost of

producing the main product(s).

The principal problems in accounting for by-products centre around the establishment of an assigned value. There are numerous variations in procedure depending on factors such as: the market in which the by-products are sold; if the product is not sold externally, the conditions under which it is internally used; company policy with regard to the kind of cost information required for internal reporting purposes.

Several by-product situations have of necessity already been discussed, as an integral part of the various joint product costing cases. There follows, in this section, a sample of the comments made by some of the companies visited regarding the valuation and treatment of by-products:-

"The by-products which are used on the site as fuel are valued at their calorific value i.e. the equivalent buying in price of a similar fuel - normally similar to the bought-in value of naphtha."

"The net realisable value after further processing is credited back to the main product."

"The by-product price is based on the European or inter-divisional commercial price."

"At one time the gas was sold to the Gas Board, but now it is transferred straight to local industry - the cost of alternative fuel for the company concerned is used as a

basis for the price."

"The caustic soda is valued at by-product cost which when distribution costs are added will approximate to the selling price. The selling price derived cost (based on variable cost) is credited back to the main product."

"Both the hydrogen for sale and that used in hydrochloric acid is valued at calorific value with heavy fuel oil as the comparative cost fuel. An anachronism from the days when hydrogen was burned in the boilers jointly with heavy fuel oil. No one has suggested an alternative and it does facilitate comparisons."

"The by-product can be sold, consumed, or reconsumed. The by-product value represents a scaled value of chlorine, because it is a substitute for chlorine."

"Residues are placed in stock at estimated saleable value and credit is given to the manufacturing process at the same value."

"The by-product is valued using a technical estimate based on selling price minus selling costs."

"The by-product is re-cycled at a cost based on the original raw material input cost."

"The by-product cost is based on the cost of the product

in its definitive route."

"The sales value represents the world crude price for glycerine."

"The value of the by-product is set by the market."

"In general, most by-products can be substituted for fuel oil or used to generate our own steam, i.e. we can substitute the by-product for a bought in raw material. Meetings between the chemistry and accounting departments establish the efficiency of these substitutions. The by-product is given an equivalent BTU (British Thermal Unit) and the process is credited accordingly."

"The by-product may be of no use to the company and may not have a market value. Therefore payment to dispose of the material would be an additional charge on the process."

The selection of comments gives some indication of the variety of by-product valuations applied by companies operating in the chemical and food industries. The valuation depends on several factors such as the extent of the market for the product or, if it is internally used, whether it represents a fuel substitute or a raw material substitute.

6.2.9 Chemicals and Food - A Review

When comparing the costing methods employed by companies

operating in either the chemical or the food industries, the actual nature of the production processes involved must be appreciated. As has already been indicated in previous sections, the manufacturing operations relating, for example, to oil and petrochemicals, (and in general to many chemical processes) yield many more jointly produced outputs than the majority of processes undertaken in the food industry. Production processes involving recycled products, alternative product routes, variations in the exact composition of raw material inputs etc. are more commonplace in the chemical sectors, and therefore increase the complexities of the costing procedures involved.

The majority of processes, in the chemical sector (as defined previously for the study purposes) yielding two or more products from a common manufacturing operation or series of operations, were found in the organic area where coal and oil represented the two basic raw material inputs. The majority of oil companies made no attempt to apportion any joint costs to joint products emerging from the refinery processes. Although several companies indicated that they had experimented with various joint costing methods in the past, they had concluded that the involved nature of the processes and the vast number of outputs emerging at different stages made any attempt at apportionment meaningless. In contrast to this decision by the oil refineries to refrain from joint product costing companies in the petrochemical, coal and coal chemical areas applied a variety of apportionment methods in order to obtain individual product costs. However, the actual

usefulness of the final calculated figures was debated by the companies concerned (see 6.3.).

Companies in the chemical sector, making an apportionment, generally used some variation on the sales value or physical units bases, where each company tended to operate its own 'unique' costing system, tailored to meet its own specific requirements.

The organic oils and fats section of the food industry represents an area bearing some relationship with the chemical industry, both in the nature of its processes and in the costing procedures applied. Fifty per cent of the processes in this section are presently costed using a physical units basis, with all but one of the remainder having changed from this particular apportionment method to a main product/by-product approach to reflect a change in market situation.

Various companies in both the chemical and food industry had found it necessary to modify their system of joint cost apportionment to reflect a shift in product status arising from a change in the market circumstances e.g. Case 8 - The electrolysis of salt yielding chlorine and caustic soda, originally treated as joint products, now treated as main product and by-product respectively; Case 12 - The separation of raw milk into cream and liquid skim, presently treated as main product and by-product respectively, with consideration being given to a re-classification as joint products.

Table 23 summarizes the apportionment methods presently applied to the seventy processes considered in the study.

Table 23. Summary of apportionment methods applied within the chemical and food industry.

No. of processes related to:-	Apportionment basis presently used			
	None	Sales Value	Physical Units	Others (including main product/by-product)
(a) Chemical Industry	9	11	20	12
(b) Food Industry	0	0	3	15

The processes contained in the 'others' column in Table 23 generally represent one of two situations:-

(1) Situations where companies have modified their costing procedures from a 'generally accepted' joint cost apportionment method to a main product/by-product approach, or

(2) Situations where companies are considering a re-classification of products from main and by-products to joint products.

As the table indicates, the majority of processes in the chemical industry use some kind of joint cost apportionment basis, whereas the food companies interviewed presently favour a main product/by-product approach for calculating individual product costs.

Oil refineries, who represent one end of the spectrum, have concluded that the immense number of products, many having a sufficiently high saleable value to merit recognition as main products, and the complexity of the processes

involved makes any attempt at apportionment a meaningless exercise.

The majority of the companies operating in the food sectors and several chemical producers presently represent the other end of the spectrum. Many of these companies recognised the 'theoretical' joint product status of the outputs arising from a variety of processes, but chose to stipulate one main product stream for costing purposes, treating all other products as by-products. However, as has already been mentioned, this category also represents an area of change reflecting shifts in product status.

Companies operating between the two extremes all used some kind of joint cost apportionment method in order to calculate individual product costs. Many of these processes, centred in the chemical industry, were extremely complex, but the companies concerned still used variations on the generally accepted 'textbook' methods, to apportion joint processing costs.

Having established the actual costing treatment of joint products in the various sectors consideration has to be given to the reasons for making any kind of joint cost apportionment. In general, the preparation of individual product cost figures provides information for profit measurement, planning, control, pricing and general decision making. The existence of joint products, and hence joint costs, creates difficulties in supplying useful unit cost figures. Most accounting text books recognize only a limited role for joint cost apportionment in the areas of profit measurement and stock valuation. The arbitrary

nature of apportionment causes the relevance of the resulting figures for managerial decision-making purposes to be questioned. The next section considers the reasons specified for making joint cost apportionments and the usefulness of the resulting figures for decision-making.

6.3. The usefulness of joint costs for decision-making

Writers have expressed a variety of opinions on the objectives of joint cost apportionment and the extent of the usefulness of the resulting product cost information for managerial decision making purposes. The views of several authors, particularly relating to output, product mix, further processing and pricing decisions have already been discussed in Chapter 4. In this section, these opinions will be compared with the views expressed by the companies visited during the research programme.

Much of the past literature concerning joint product costing has accepted the basic objective of apportionment as being one of, finding a 'cost' for each product that will produce logical and sensible results for stock valuation and periodic income measurement. Having accepted this 'need', their opinions differ as to whether there is any role for the resulting cost data in decision-making areas, and if so, the extent of that role. Writers, such as Chui and DeCoster (1966), Hye (1970) and Thomas (1974) have expressed concern about the possible use of any individual joint product costs for management decisions, whereas Harris and Chapin (1973) and Mepham (1978) are two authors who suggest that there is some limited role for

joint product cost data in certain decision areas.

Other writers take the view that an arbitrary joint cost apportionment is not even necessary for financial reporting purposes. They suggest that alternative stock valuation methods are sufficient and that individual product cost information serves no useful purpose in any decision-making area. Having examined the information requirements for a specific decision they then identify alternative procedures that will meet those requirements without any reference to individual product cost data. Advocates of this view generally use the oil refinery situation as a model, shifting the emphasis from the expression of costs and profit margins in terms of an output unit to an input unit. Authors such as Waters (1942), Butler (1971), Satyamurthi (1974) and Feller (1977) all favour this kind of approach, stressing the importance of the profit on a barrel of crude oil which includes all the products, in contrast to the 'traditional method of accounting' which emphasises individual product values.

All of the major oil refineries visited, emphasized the importance they placed on the cost per barrel of input, in line with the above literature. Even the one refinery making a joint cost apportionment stated that production was, "undertaken in relation to the cost of crude i.e. the aim is to increase the value of a barrel of input". The refineries stressed the significance, particularly for output decisions, of the comparison between incremental cost and incremental revenue arising from the processing

of an additional barrel of crude input. No company admitted to being a price leader, only a price taker, whether it be from another company, the European market or the world market. Therefore, in general, the oil refineries considered that an arbitrary joint cost apportionment would serve no meaningful purpose, alternative cost data being preferred for decision-making and valuation of stocks.

Companies operating in the organic oils and fats sector of the food industry also stressed the importance of input - related costs. In particular, those companies processing seeds to obtain oil and cake meal were interested in maximizing the yield from the original seed, and they therefore emphasized the significance of the combined revenue from cake and oil. The variety of possible seed inputs, made a comparison between the cost of processing alternative seeds and their respective output yields an important exercise. Therefore, although in some cases, an individual product cost was calculated, it was suggested that in practice, this information was irrelevant to the decision making processes of the company concerned, the only reason for such an exercise being for financial reporting purposes.

Other specific firms stating their lack of interest in individual product cost figures for decision-making were those involved in the food sector butchery processes. They minimized the significance of such cost figures suggesting that the original cost and processing of a carcass compared with the final revenues obtained from the outputs were the only necessary data. As was suggested by one interviewee:- 'The buyer instinctively knows the total

prices obtainable for end products at the point of purchase of a beast, i.e. before any processing takes place; the actual costing process is incidental'.

Several sectors, particularly in the chemical industry, did make some form of joint cost apportionment. Companies falling into this category stated that an assignment was necessary mainly for stock valuation purposes. The usefulness of joint product cost data appeared to vary from virtually nil to a minimal role in certain specific decision-making areas.

The sell or process further decision involved a comparison of the incremental revenue and cost figures arising after the split-off point. The majority of chemical companies made use of computer facilities, employinglinear programming techniques to aid in this particular decision and also to assist in product mix decisions where applicable. It was stressed that "costing information has only a very limited use when considering an optimisation problem, decisions about which are governed by the reality of the business situation". The general market situation, in particular the demand for respective products and the number of contracts held by the company for specific outputs, were two additional important considerations related to output decisions. However, the general computer facility to study additional costs and revenues for each alternative production combination, on a "rolled through" basis, (i.e. the computer facility to isolate profits and losses and fixed cost absorption at each production split-off point) was given some emphasis.

The marketing departments of several large companies played a major role in decision-making areas. For example, as stated by one company, if a decision on whether to continue further processing was required, and the linear programme showed a loss on the variable cost, then the option would normally be rejected. However, the marketing department generally had a prerogative to sell at less than variable cost in order to retain the market. The information for these decisions was collected independently by the marketing department, decisions being made with reference to the technical departments.

In one major company, the marketing department actually re-classified product outputs from joint products (as classified by the accounting department) to one main product and several by-products. Ethylene and propylene were treated as joint products by the accounting department, the status of propylene being altered to by-product by the marketing section. The marketeers then used their own by-product valuations and credited these back to ethylene to find the 'cost', and then based their decisions on this information. The accounting department, well aware of the situation, still produced cost data for the marketing department, reflecting a joint product status. The recipients of this information could find no relevance for its use and therefore continually discarded it.

Inspite of a general view that individual joint product cost figures did not assist in output decisions, a few companies, particularly in the coal and coal chemicals sectors, narrated two specific situations where such data

might have some bearing. One such circumstance referred to, involved decisions regarding "one-off cut price orders", a situation suggested as being "particularly relevant" in the present economic climate. This type of decision was generally a short-term one, involving the sale of surplus coke, a product treated as a joint product. In this particular case, it was suggested that the joint product cost did have some use as a "guideline" in the decision.

The other area mentioned relates to a long term decision - plant closure. It was suggested by the company concerned that plant closure decisions were influenced by cost data, but that the emphasis was not on "actual numbers", rather the trend of costs.

In the specific area of pricing decisions, the majority of companies in both the food and chemical sectors suggested they were generally 'price-takers', the prices being set by 'the market' or 'other companies'. A few of the comments relating to the prices of joint products are listed below:-

"Output prices are set by the North-West European market".

"Market forces determine price".

"In general, selling prices are governed by Company X, the market leaders".

"The company is a price taker, because of the European and American competition".

"In the present economic climate, prices cannot be fixed,

therefore in general, the price follows the market".

"The general policy is to sell for what one can get".

"The price follows the international market".

"The price is set according to what the market can bear".

"The product is sold at the highest price possible in any prevailing market situation".

It was found that in many of the major chemical sectors, companies were casting the label of 'price-fixer' on each other. Nevertheless, the consensus of opinion was that joint product cost data was generally not used for price setting purposes. However, a few companies admitted to being price leaders in very specific areas. The areas mentioned were speciality chemicals, gases and some organic oil products.

An additional pricing area referred to was that of transfer pricing. Very little information related to this area was revealed by companies, but an indication of 'general policies' were given. Internal political decisions played a major role in the setting of transfer prices. It was stated that in general, the transfer price was a negotiated one based on the market value of a similar product. Although the market price was used as a basis, if this figure forced the company to make a loss, then it would be discounted in order that a profit could be retained. In other words, this inter company transaction ultimately becomes an internal political decision.

It would seem that in situations where joint costs

were apportioned to joint products, the resulting data only had a very minimal use in decision-making and only then in certain specific circumstances. One company perhaps summed up the general consensus of opinion when it stated:-

"The cost accounts just show where the company has been and bears no relation to decision-making. Different accounts are needed for different people according to the purpose for which they are required".

CHAPTER 7. CONCLUSIONS

At this point it may prove useful to refer once again to the objectives of the research specified in Chapter I. The objectives were to:-

(1) Establish the nature of the current methods used by industry to apportion joint costs to joint and by-products with particular reference to the chemical and food sectors.

(2) To determine whether there is any particular apportionment method related to a particular industry or section of the industries concerned and to establish the reasons for the particular choice of technique.

(3) To clarify the extent to which the various 'generally accepted' textbook apportionment methods are employed in the industries concerned and to reveal any alternatives used in practice.

(4) To assess the importance that the companies involved, place on individual joint product cost data in aiding management in decision-making. The possible reasons considered for cost assignment were:-

    (a) To provide stock valuations for income determination.

    (b) To aid in pricing decisions.

    (c) To aid management in determining output quantities and product mix.

    (d) To determine whether a product should be processed further.

(5) To consider the extent to which the view that, 'no attempt should be made to determine the cost of individual products up to the split-off point, but that it is more important to calculate the profit margin in terms of total combined units', is upheld in practice with reference to the chemical and food processing sectors of industry.

For the purpose of analysing the empirical data, the manufacturing process was used as a statistical base, the categorization of the processes being based on the Standard Industrial Classification for the United Kingdom. Both the chemical and the food industry were subdivided into three major sections for study, namely;

(a)	The organic sector	Chemicals
(b)	The inorganic sector	
(c)	Miscellaneous chemicals	
(d)	Organic oils and fats	Food
(e)	Meat and meat products	
(f)	Milk and milk products	

In relation to the first three objectives, not all companies considered a joint cost apportionment of any kind to be at all necessary or even useful. This view was particularly prominent in the crude oil refining area. It was considered by the majority of refineries that the complex nature of the process involved and the vast number of joint product outputs, made it impossible to establish any meaningful cost apportionment between products. Comments made, tended to uphold the views of various authors, who

stressed the relevance of a shift in costing emphasis from the output unit to the input unit. Therefore, the majority of opinion saw each joint product as representing a percentage of the initial barrel input, the 'aim' being to maximize the benefits from the refining cycle. The 'cost' of each joint product played no part in assisting in the achievement of that purpose.

The majority of other companies represented in the organic sector of the chemical industry, tended to favour some kind of joint cost apportionment. In general, the method used, represented a variation on the sales value or the physical units/chemical formula bases. The sales value method predominated in the petrochemicals area, whereas coal processing companies generally favoured a physical units based system of apportionment. The actual nature of theprocesses concerned influenced the costing system adopted, each one being tailored to the specific needs of the company in question.

The concentration of physical unit or chemical formula based apportionment methods was more pronounced in the heavy or bulk chemical areas. Further down the chemical line, companies operated a variety of costing systems, ranging from no apportionment, through several types of generally accepted apportionment bases to a main product/ by product approach.

There are no hard and fast rules regarding which products should be treated as joint products and which should be deemed by-products. While a distinction between by-products and joint products may be made in theory, the

final classification must be made by each business for its own purposes. The relationship between products if often not a static one. A number of factors may affect the relative importance of products, resulting in a need to consider re-classification and a subsequent modification of costing methods in order to reflect the changing situation. The overall policy and manufacturing objectives of the company influence the original classification of a product. Some instances requiring consideration for a possible re-classification are changes in market price, competition, the increase in demand for a minor product and developments in technology. The companies presently operating a main product/by-product costing system were generally operating in situations of 'changes in product status'. Two cases prevailed:- The company which had modified its procedures from a 'generally accepted' joint cost apportionment method to a main product/by-product approach; Secondly, the company which was presently considering a change in product status and hence costing treatment from main and by-products to joint products.

Several companies, particularly in the food sectors, recognised the 'theoretical' joint product status of outputs, but chose to stipulate one main product stream for costing purposes. However, the organic oils and fats section bore some relationship with the chemical industry, both in the nature of its processes and in the costing procedures applied. Costing complications very evident in relation to chemical processes, such as recycling of products and alternative manufacturing routes, were also

apparent in this food sector.

It would seem that in the areas where joint cost apportionment was undertaken, variations on the sales value and weight methods were predominant. However, this must be qualified by saying that each individual company operated its own unique system in order to satisfy its own needs.

For the costing of by-products, all the companies interviewed employed a market value approach, where the recoverable value of the by-product was credited to the total cost, leaving a remaining balance which was considered to be the cost of producing the main product(s). The establishment of an assigned value was the principal problem in accounting for the by-product. Numerous variations in procedure existed, depending on factors such as; the market in which the by-products were sold and if not sold externally, the conditions under which they were internally used.

Having established the type of costing system applied in various joint product situations, the reasons for making any kind of apportionment at all might be considered. Most accounting textbooks and accounting literature recognize only a limited role for joint cost apportionment, generally specified in the area of stock valuation. The need for individual product cost figures for financial reporting purposes has continually been emphasized. However, in the other areas of decision making such as product mix, further processing, and pricing, the use of alternative, more relevant information is stressed.

The refinery section of the oil industry avoids the

issue of apportioning joint costs and bases all decisions on alternative and more meaningful information. The calculation of arbitrary individual product cost figures simply for stock valuation purposes was considered to be a meaningless exercise. Hence, stock was valued at "some figure lower than current value".

In general, companies making a joint cost apportionment could find no apparent use for the data other than stock valuation. Two situations were specified, where individual product cost data might have some influence:- In cases where special orders or contracts were concerned; In plant closure decisions it was suggested that the overall cost trend might have some influence. Except for these individual circumstances, the reasons given by the accountants interviewed for the computation of seemingly irrelevant cost figures were:-

(i) The provision of a stock figure.

(ii) The costing system has always been in operation. Why change?

(iii) Psychological reasons - there appeared to be some feeling of security in "knowing the cost of a product".

In conclusion, the only tangible reason for apportioning joint costs to joint products would appear to be for financial reporting purposes. It is generally recognised that the calculated individual product cost is a purely arbitrary figure and therefore it can be debated whether it is even necessary for stock valuation. It would seem

that many companies are producing individual joint product cost data unnecessarily and perhaps a re-education regarding the 'costing of joint products' is required.

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Burton Street
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Our Reference CW/AS.

Your Reference

APPENDIX A

February 1980.

Dear Colleague,

Branch Research Project in Co-operation with Trent Polytechnic.

An Empirical Study into Joint and By-Product Costing in the U.K.

The purpose of this study is to investigate the methods used in apportioning joint costs to joint products (or by-products). For the purpose of this investigation, joint products will be regarded as individual products of significant value, produced simultaneously as a result of a common manufacturing process. The study will further reveal the uses to which the resulting cost information is put and its relevance in the decision-making processes of the company, particularly regarding stock valuation, pricing decisions, further processing decisions, reporting of profit margins and determination of product mix.

The research team would like to interview members with experience of this particular problem area. If you can spare an hour of your time, please contact one of the undersigned at Trent Polytechnic, Telephone No. 48248, or complete the attached form and return to us.

Yours sincerely,

C. Wootton

CYRIL WOOTTON (Branch Research Officer)

H. Morris

HARRY MORRIS (Associate Member)

K. Slater

KAREN SLATER.

Director R Hedley MA
Chief Administrative Officer
D B Davies DPA

DEPARTMENT OF BUSINESS AND PROFESSIONAL STUDIES
Head of Department G S Hardern BA(Econ) LLB ACMA

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POLYTECHNIC

Burton Street
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Our Reference

Your Reference

APPENDIX A (contd.)

To: C. Wootton,
Principal Lecturer in Accounting,
Dept. of Accounting and Finance,
Trent Polytechnic,
Nottingham.

AN EMPIRICAL STUDY INTO JOINT & BY-PRODUCT COSTING IN THE U.K.

NAME .....

POSITION .....

COMPANY NAME .....

ADDRESS .....

.....

.....

.....

TELEPHONE NO. .....

TRENT
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Telephone 0602 48248
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Our Reference KS/LJL.

Your Reference

APPENDIX B

Dear

A group of the accounting staff at Trent Polytechnic, in conjunction with the Nottingham Derby and District Branch of the ICMA, are conducting a research project into process costing. Enclosed is a brief outline of the nature of the investigation.

The general aim of the study is to establish the nature of current methods used by industry to apportion joint costs to joint products, with particular reference to the chemical and food processing industries.

Although we have contacted numerous firms engaged in process-type industries, gaining helpful information from eighteen firms, we have been surprised at the small number that have joint or by-products resulting from their manufacturing processes. We are therefore particularly concerned that we establish contact with as many firms as possible that have this problem.

In this respect we would be grateful if you could assist us in this project by discussing the costing procedures undertaken by your particular company, on a mutually convenient date. From past experience we have found the discussions to take no more than one hour. All information will be treated as completely confidential.

In the hope that you will be able to assist, we will contact you by telephone in the near future.

Yours sincerely,

KAREN SLATER

Enc

Director R Hedley MA
Assistant Director and Chief Administrative Officer
D B Davies DPA

TRENT BUSINESS SCHOOL

Dean of the School G S Hardern BA(Econ) LLB ACMA

An Empirical Study into Joint and By-Product Costing in the U.K.

For the purposes of this study, joint products (and/or by-products)are defined as individual products produced simultaneously as a result of a common manufacturing process or series of processes. Joint product costs are those which arise in the course of such common processes involving common raw material inputs.

The project will attempt to determine the various techniques used in allocating the joint process costs to the subsequent joint products and the extent to which the joint product cost information is used in the determination of product mix, in pricing decisions and further processing decisions. It will also consider the effect on inventory valuations and profit reporting.

The intent of the project is not to argue the theoretical justification of the various allocation procedures, but to determine whether there is any particular allocation method related to a particular industry, to study the techniques related to the various sizes of firm and to analyse the extent to which such cost figures are used for decision-making purposes.

APPENDIX C

Interview Framework

Is there a joint product costing system in operation?
If not, what are the reasons. How is the problem overcome?

The nature of the joint product process:-
What are:-
(a) The common raw materials?
(b) The resulting joint products?
(c) The resulting by - products?
Is the resulting output in fixed or variable proportions?
What are the proportions?
Are the outputs graded or individual products?
Include a short description of the production process.

What factors influence the manufacture of joint products?
e.g. technological characteristics, markets available.

On what basis is the distinction between joint and by - products made?

What type of allocation basis is used for joint product costing?
(a) According to physical measurement,
(b) According to market values,
(c) Some kind of survey method,
(d) Some other method.

How are by - products accounted for?

What are the reasons for the chosen methods?

Include a description of the methods in operation.

How has the joint product costing system developed?
(a) What is the extent of computerisation?
(b) How long has the current system been in operation?
(c) Is the present system considered satisfactory?

If product mix can be varied, what factors affect the establishment of the particular product mix chosen?

Is further processing required on any joint product to put it in a saleable form?
(a) If so, what role does the joint product cost before the split - off point play in the further processing decision?
(b) If not, is it purely incremental cost and revenue that is considered?
If a market value method is used are joint costs assigned on:-
(a) Market value at split - off point
(b) Ultimate market sales value

What are the marketing problems associated with the individual joint products?

APPENDIX C (contd.)

How are the prices for each product set?
Are the joint cost figures important in this decision?

In general, what is the importance of the allocated costs in aiding management in decision - making?

What do you consider to be the main reasons for allocating joint costs?
(a) To provide stock valuations for income determination,
(b) To aid in pricing decisions,
(c) To aid management in determining output quantities,
(d) To determine whether a product should be processed further.

It has been suggested that no attempt should be made to determine the cost of the individual products up to the split - off point, but that it is more important to calculate the profit margin in terms of total combined units.
Is this view supported?

If joint costs are not allocated to individual joint products, then:-
(a) How is stock valued
(b) What information is used to aid in the various decision - making areas.

APPENDIX D ADVANCED STUDIES UNDERTAKEN

The following post graduate courses of study were attended by the researcher:-

1) Polytechnic Library courses on retrieval methods.
2) Personal tutorials, arranged when required with the Polytechnic Statistics Department.
3) Trent Business School staff seminars, one of which was conducted by the researcher. The seminar topic was related to the research, a copy of the discussion document being contained in Appendix E.

APPENDIX E

Are Accountants Worth Their Weight in Oil?

by Karen Slater

The question raised in the title was prompted by the results of empirical research undertaken in the chemical and food processing sectors of industry. The content of the paper is limited to some of the findings specifically related to oil and petrochemicals.

A brief outline of the nature and purposes of the investigation is given before any attempt is made to answer the question.

The refining of crude oil is a typical example of a process from which joint and by-products emerge.

Definition of a Joint and By-Product

The ICMA definitions of joint and by-products are as follows:-

Joint Products represent "two or more products separated in the course of processing, each having a sufficiently high saleable value to merit recognition as a main product".

A By Product is one "which is recovered incidentally from the material used in the manufacture of recognised main products, such by-products having either a net realisable value or a useable value, such value being relatively unimportant in comparison with the saleable value of the main products".

It is also noted that a clear distinction between terms such as joint product, by product, waste or scrap is not always possible or even necessary. An item regarded as a by-product in one factory may be termed a joint product in another. Joint product costs are defined as those which arise in the course of such common processes involving common raw material inputs.

Aims of the Research

The aims of the study were to establish the nature of the current methods used by industry to apportion joint costs to joint products with particular reference to the chemical and food sectors. The intent of the research was not to argue the theoretical justification of the various allocation procedures, but to determine whether there is any particular allocation method related to a particular industry, and to determine the extent to which the joint product cost information is used for stock valuation purposes, in the determination of product mix, pricing decisions and further processing decisions etc.

In What Areas Are Joint and By-Products Found?

The following are a few examples of joint and by-products produced in the chemical and food industries:

continued.

INPUT	JOINT AND BY-PRODUCTS
Crude Oil	Naphtha, Gas Oil, Fuel Oil, Kerosene Etc.
Naphtha	Ethylene, propylene, methane, ethane, butane etc.
Coal	Coke, gas, suphate of ammonia, benzol, coal tar
Salt	Hydrogen, chlorine, caustic soda
Milk	Cream, skim, buttermilk, buttergrains, whey, etc.
Vegetable & Animal Oils	Glycerine, fatty acids, olene, stearine, etc.

Although these areas (and several others) were covered in the research, for simplicity, the paper is restricted to the findings related to oil and petrochemicals.

Usual Textbook Accounting [illegible]ment of Joint and By-Products

1. Physical Measure

- Allocation of cost according to the proportion of weight of each joint product to total units produced.

2. Market Value

- Joint costs are apportioned in proportion to the relative sales value of the products.

The above two methods are perhaps the most commonly used in textbooks but are by no means the only ones. There are several variations on these alone. Another method sometimes cited is the Survey Method.

3. Survey Method

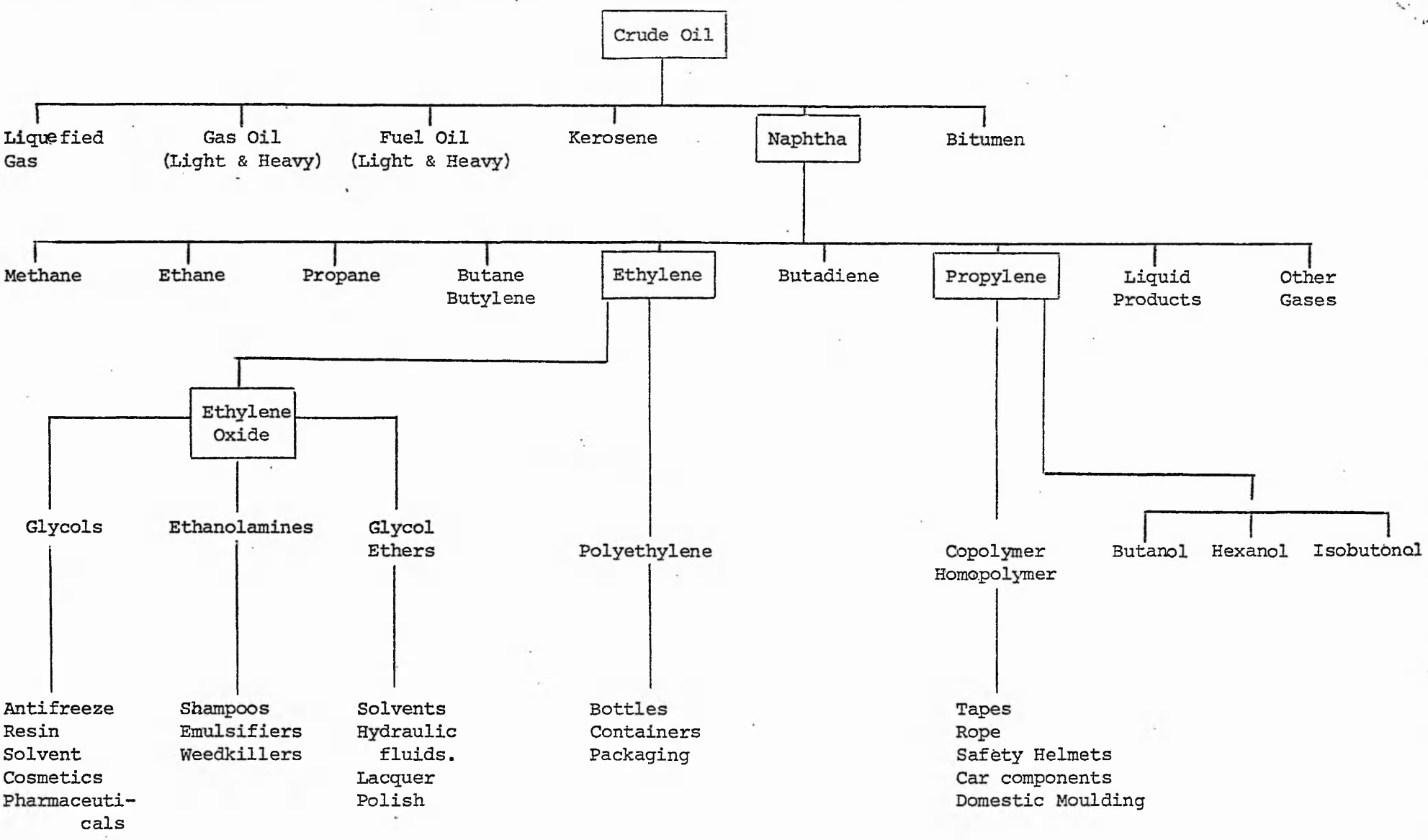
- This is an arbitrary plan of apportionment, based upon consideration of all the important factors involved in producing and marketing the various products. A schedule of percentages or weights is then prepared showing management's appraisal of the proportionate amount of the total joint costs that should be borne by each product.

The most common textbook method of dealing with by-products is for the by-product net realisable value to be credited back to the main product(s)

Summary of Findings Related to Crude Oil and Petrochemicals

Diagram I shows a very simplified version of the crude oil refining, and naphtha cracking processes, also giving some indication of the final outputs from the various product streams

continued.


Crude Oil
Liquefied Gas
Gas Oil (Light & Heavy)
Fuel Oil (Light & Heavy)
Kerosene
Naphtha
Bitumen
Methane
Ethane
Propane
Butane
Butylene
Ethylene
Butadiene
Propylene
Liquid Products
Other Gases
Ethylene Oxide
Glycols
Ethanolamines
Glycol Ethers
Polyethylene
Copolymer
Homopolymer
Butanol
Hexanol
Isobutonol
Antifreeze
Resin
Solvent
Cosmetics
Pharmaceuti-cals
Shampoos
Emulsifiers
Weedkillers
Solvents
Hydraulic fluids.
Lacquer
Polish
Bottles
Containers
Packaging
Tapes
Rope
Safety Helmets
Car components
Domestic Moulding

3.

OIL REFINERY OPERATION

1. The majority of oil companies visited do not make any attempt to allocate joint costs to joint products. Several companies indicated that they had experimented with various joint costing methods in the past, but as the complex nature of the process makes it impossible to establish any meaningful cost apportionment between the products, other information has been preferred for making decisions on product mix, pricing, inventory valuations etc.

2. Stock Valuation

"After comparing prices of products from a barrel of crude with the original cost of crude, the stock is then costed at some figure lower than current value". This was the general view of the majority of companies.

3. Decision Making

Contrary to popular belief, the input of crude oil to the refinery yields a fairly standard product structure and the ability to produce a physically different yield is very limited. Therefore, the product mix problem does not really arise.

In line with the current literature relating to accounting in the oil industry, the companies concerned emphasised that the aim was to increase the value of a barrel of input ie., maximise the benefits from the refining cycle. Therefore, for decision-making purposes, economic studies are undertaken to find the additional revenue expected if the company runs one more barrel of crude.

Pricing

No company admitted to being a price leader, only a price taker, whether it be from another company, the European Market or the World Market!

Transfer pricing seemed to be essentially a political decision, although companies were loath to pursue this subject. No cost information was used in any decision involving price.

An Example of the Costing System of one oil company who did allocate Joint Costs to Joint Products:-

Diagram 2 shows the specific outputs of the refinery operation for the particular company in question and also indicates the status of these outputs as defined by the accountant.

Diagram 2

INPUT	PROCESS	OUTPUTS
Crude Oil →	Refine →	Gas. By Product Kerosene. By Product Stabilised Naphtha. Joint Product. Gas Oil. Joint Product. Atmospheric Residue. Joint Product.
Atmospheric Residue	Refine →	Gas Oil. By Product. Residue. By Product. Lubricating Oils. By Product

4.

Note the change in status of Gas Oil within the same operation.

System

1. Atmosphere Residue and Gas

Costed in relation to calorific fuel value even though atmospheric residue is termed a joint product and gas a by-product.

Problem - Gas oil is obtained from the first process and further processing of atmospheric residue.

Solution - If the atmospheric residue is further processed it is considered to be worth more than the calorific value because gas oil is obtained.

New Costing of atmospheric residue in this case - The figure represents a weighted average calculated as follows:

1/3 fuel value + 2/3 market value of the amount of residue to be recycled in the further process.

Having established the cost of the atmospheric residue and gas, this is subtracted from the total cost and the remainder allocated to gas oil, naphtha and kerosene on a tonnage basis.

The gas oil in the further process is costed on the strength of the process 1 cost.

The calorific value of the residue is credited back to the process.

The Lubricating Oil takes the remainder of the cost.

The costing system represents one of a variety of "unique" ways of allocating costs within the chemical industry

NAPHTHA CRACKING OPERATION

In this area, unlike the refinery operation, the majority of companies used some basis for allocating joint costs to the product outputs.

The concensus of opinion amongst the accountants interviewed was the treatment of ethylene and propylene as the 2 joint products from the cracking process. The remaining products were generally classed as by products and their value credited back to the joint products.

Methods used to value By-Products

1. By products used as fuel were valued at calorific value.
2. By products further processed and sold were credited back at market value less further processing cost.

5.

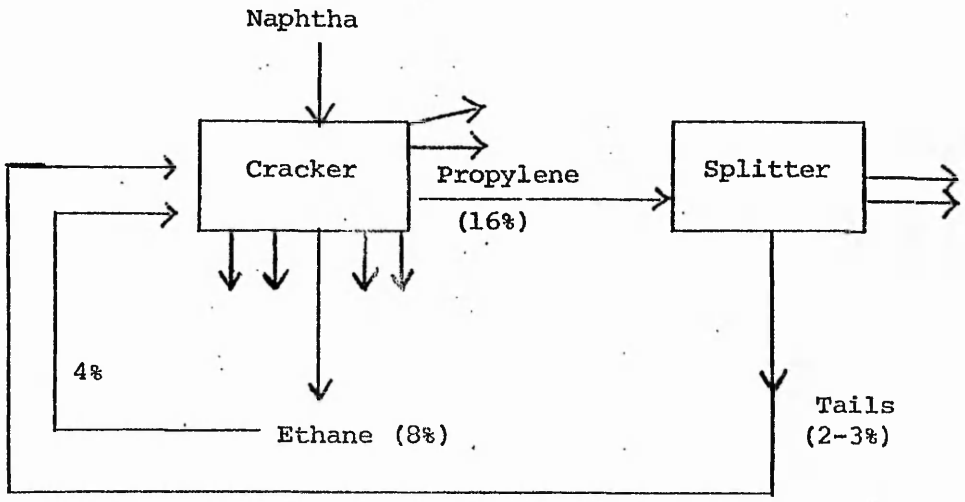
Methods for allocating Joint Products

1. Tonnage basis weighted by North West European Commercial value.

2. Chemical Formulae.

Costing of Re-Cycled Products.

This represents an additional costing problem which is common in the chemical industry. An example of the treatment of re-cycled products is shown below:-



Of the 8% ethane obtained from the cracking process, 4% is recycled into cracker and 4% sold. Tails represent residues from the splitter process representing 2-3% of the propylene input and are also recycled into the cracker.

Valuations

1. 4% Ethane recycled is not valued on the grounds that it is recycled through the same process.

2. 4% Ethane sold is credited back to the joint products.

3. Tails are valued - at a cost derived through discussion - this generally represents the commercial value which is on par with that of naphtha.

Stock Valuation

Where joint costs were allocated, stock was valued according to cost.

Those few who did not allocate costs valued stock at market price less an element of profit (calculated as the average profit for the division.

continued.....

6.

Decision-Making

Short-Term

No company admitted to basing any decision on the costing information obtained.

Linear programmes were generally used as the basis for decisions regarding further processing and product mix (where slight variations in output were possible). The marginal costs and revenues for each alternative production combination were studied on a "rolled through basis" i.e. the computer facility to isolate profits and losses and fixed cost absorption at each production split off point.

Long Term

Plant closure decisions were influenced by cost data but the actual numbers were not considered to be relevant, more the trend. This type of problem along with decisions to invest in new plant made use of incremental analysis.

At this point it might be useful to consider the role of the marketing department in the decision making area. If the linear programme as used in the short term situations above showed a loss on the variable cost, then the option would normally be rejected. However, the marketing department generally had a prerogative to sell at less than variable cost in order to retain the market - the information for these decisions was collected independently by the marketing department.

In one major oil and petrochemical company, the marketing department even re-classified the products treating ethylene as a main product and all the remainder as by products. They then used their own valuations of by products and credited these back to ethylene tofind the cost, and then based their decisions on this information using the marginal cost of ethylene as a basis for negotiation. The accounting department, well aware of the situation, still produced cost figures for the marketing department, figures which were continually ignored due to their "irrelevance".

The question could then be asked - why are accountants producting endless cost figures which apparently are irrelevant to all decisions?.

Pricing

No company admitted to being a price leader and everyone suggested that prices were determined by market forces. No cost information was used for any decision involving prices.

Conclusions

The refinery section of the oil industry avoids the issue of allocating joint costs and bases all decisions on alternative, more relevant information. This view is in line with current literature on the subject.

The petrochemical sections of the industry do, however, allocate joint costs to joint and by products by various methods taking a great deal of time and money. The reasons given by the accountants interviewed for the computation of seemingly irrelevant cost figures were:-

1. The costing system has always been in operation. Why change?
2. It provides a stock valuation figure.
3. It is comforting that the 'cost' of a product is known!

If, the only tangible reason for allocating joint costs is for stock valuation, (resulting in an arbitrary figure anyway) then what is the answer to the question raised in the title?