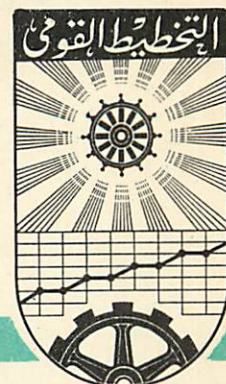


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An Introduction to the Problems
of Decision-Making in
Enterprises

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1. Introduction

The following paper might be useful if it were decided to introduce a greater degree of decentralization in the operations of public enterprises, and provided that viable cost-price relationships could be created, and used as the major indicators for policy decisions. The paper confines itself to the problems of current operations (i.e. ignores investment decisions), and assumes that the enterprise operates with a fixed quantity of capital equipment. There is therefore only one constraint but the argument could be extended if there were more by resort to linear programming. The paper concentrates on relating some well known ideas familiar to economists to the problems of enterprise decision-making and is really an exercise in the application of opportunity costs to decision-making. Some attempt is made to show the relevancy of management accounting to this process.

2. Once it is recognized that deciders possess a degree of discretionary power and that their success however partial is conditioned by the quality of their decision-making which is the means for exercising this discretionary power, a host of interesting questions arise; which may be examined in various ways. It is possible to classify the major issues into 3 types:-

1. In the first category we may include those problems about decision-making which have to do with decision itself, divorced that is from the context in which the decision is made. That is under this category we are interested in the rationale of a decision, in its premises in assumptions, the process of argument which is based on these assumptions and the conclusion reached. Here we are interested in the number and kind of assumptions made, their realism or otherwise; is the process of argument valid and is the conclusion valid? A discussion of decision-making in these terms is in the main a logical exercise.

2. The second issues have to do with what may be termed the environment of the decision making process. Individuals and groups which take part in the decision-making process are part of a wider society from which

they draw ideas which tend to condition the decision-making process particularly as regards the premisses processes or assumptions which underline that process.

3. Finally we may point to issues which have to do with process of decision-making i.e. how the decision is made. Here we are referring to the organizational structure within which the process takes place, and we are therefore interested in the formal and informal mechanisms within the organization which may influence the type of decision made. Again, the question as to whether the decision is made by an individual, group, or committee, would be relevant to an investigation under this head.

Here we will concentrate upon the formal attributes of the decision-making process as comprehended within the first of the three categories. The advantage of this approach is that it does lay bare the main logical foundations of the decision making process, and the approach can be made in sufficiently general terms as to be applicable to a greater or lesser extent to most decision-making problems. Thus is not to argue that the issues outlined under the second and third heads are unimportant, and the fact that we exclude them from the main discussion will undoubtedly lend an air of unreality to the discussion.

In proceeding to the first problem, it is first necessary to achieve a working definition of what is meant by the term decision. Tentatively we may say that a decision is a conclusion drawn from certain premises. From this it should not be inferred that a decision has a completely logical standing; often a decision may be, and very often is, based upon demonstrably wrong premises, an incomplete number of premises, or again may be based on a selection of premises among those which are possible. However a decision making process need not be undertaken on the basis of a logical process of thought because the process of decision making connotes nothing as to the system of argument. (if any) which is used in connecting up the assumptions which underlie it and in reaching a conclusion. Again decision making need not be linked up with action. Possibly most decisions remain suspended from this standpoint.

Some writers have emphasized this point by distinguishing between what they call an idea decision, and i.e. a decision which does not prelude action based on it, and an active decision which prefaces action. The significance of the distinction is of course that very often idea decisions and active decisions are linked together after any elapse of time.

Now for our purposes there are three assumptions about the decision-making process which have to be kept under observation continuously, not because they are necessarily very realistic, but because they offer a basis for analysis where the assumptions, as is usually the case, remain unfulfilled. The first assumption may be called that of complete knowledge i.e. we shall assume the deciders to be completely informed in the sense that not only will they know the specifications of all possible courses of action which they may undertake but also that they know what the outcome of any particular course of action will be. Now this assumption really involves three further assumptions. (1) The first assumption relates to the knowledge which is deemed relevant to the choices facing the businessman in the situation requiring decision. Probably only a tentative line of division may be laid down to divide relevant knowledge from non-relevant knowledge, but it certainly excludes knowledge not bearing closely upon the choice (s) to be made. More important perhaps is the fact that the assumption of complete knowledge carries the implication that the decider can predicate the outcome from adopting and not adopting a particular choice, from which arises the important consideration as to whether the knowledge assumed is confined to the more proximate or the ultimate consequences of choosing. But whether we adopt either or both of these views the assumption carries with it the implication that the decision maker is certain about the future. Though highly unrealistic this aspect of the assumption carries with it the theoretical advantage that it is a starting point from which we may introduce the complications of the existence of uncertainty both as to kind and extent.

Secondly it is usual to assume, again as a starting point, that the decider is infinitely sensitive; translated into business parlance, this

analogy would imply that the decider can change from one choice to another at the slightest change in the surrounding conditions and that he can adapt his facilities smoothly to the change, by small marginal changes in prices, costs or some other variable. This implies two things. First that the changes in the surrounding conditions are smooth and marginal and not in any sense catastrophic or a shock and secondly that he is capable of adapting the facilities of his organisation smoothly to meet such small changes. Clearly this adaptation is an important problem because if we presume the decision is an active and not an idea decision there may be lags in the adaptation. Now where these conditions are fulfilled the characteristics of the choices and decisions can be translated into continuous differentiable functions expressible in terms of the calculus.

Thirdly, we may add another critical assumption, which is that we take it that the decider has the quality of rationality. This term, like sanity, is very difficult to define, but at a minimum it would incorporate two leading ideas. The first idea is that the decider is capable, somewhat weakly perhaps, of stating an order of preference as among the choices or alternatives among which he has to decide. That is he can state his choices in terms of the more preferred and the less preferred, so that if the enterprise decider were offered two choices say as between X and Y, he is able to state that he prefers X to Y or vice versa, or that he is indifferent as between them. A further aspect of this is that the preferences of the decider must be transitive which means, in our case that if the individual prefers X to Y, and he also prefers Y to Z, then he prefers X to Z. Similarly, if the decider is indifferent as between X and Y and between Y and Z, then he may be taken to be indifferent as between X and Z. This appears to be a going obvious condition, but there appears no clear reason why it should always hold.

The second aspect of the term rationality that is of significance is that the decider is assumed to be able to order the alternatives or choices before him with some particular object in view. That is to say he may prefer X to Y, but we wish to know that the object of the preference of X over Y is. Usually we assume that the choices or alternatives may be ranked in such a way that the decider may maximize something i.e. we take it that the motive

of the decider is to maximize something, bearing in mind that the motive is related to the immediate choice before the decider. In some ways this assumption may be regarded as the most important aspect of the idea of rationality; because in most theories of decision making this appears as a central principle. Mathematically the concept of maximization is a very useful idea since it is possible to use it in conjunction with the idea of infinite sensitivity so as to specify a unique point which is the goal of the decider. It is of course possible that a set of functions may not be in a form which allows for predicating one unique point and so lead to determinate solutions, but generally if we use this criterion it is possible to predicate the goal. From this we can state the direction of movement given the stimulus, and hence, given this assumption prognosticate the end result.

But again, the trouble with this assumption is that if it is stated in the very general form in which it has just been stated, the proposition is unexceptionable. The problems begin when we come to specify what is to be maximized, Unfortunately this is precisely what we have to do when we wish to adapt the concept of maximization for operational purposes. For an enterprise we may be tempted to say that profits are what deciders wish to maximize. But this phrase is itself vague, and poses questions of meaning such as whether long or short term profit maximization is the objective, and what occurs when there may be an apparent conflict between them. But more important perhaps is the fact that if one admits, as has been suggested earlier that current industrial structures allow for a larger area of managerial discretion, that is, if one credits management with a capacity to affect, or control markets, then the possibility arises that a degree of discretion exists as to objectives. Maximization might be a sinequa non of the capacity to survive in market dominant situations; in cases where managerial discretion exists, we should at least admit of the possibility of a range of choice as to objectives. Even so, it is perhaps unnecessary to take an extreme position, and argue as some have done that the typical business is a unit of accommodation i.e. serving as it were

as an honest broker as between various interest groups such as trade unions, shareholders, customers, and management, implying that profits are not the expression of a particular motivation but only an uncontrollable residual, remaining after the claims of these interest groups have been fully accommodated for. It is also of course possible to argue that profit maximization may set up such intolerable strains within the managerial group itself that its attainment may become a subsidiary issue. This reminds us that any maximizing process is in itself onerous, and costly, and managers may wish to avoid, or not pursue with full vigour a particular choice among preferences which may bring about such frictions. In this way the institutional environment may influence the process of decision making.

Summarizing these assumptions we may say that a useful starting point is to take the case of perfectly rational deciders who are cognizant with the future effects of their decisions, who are capable (together with what the organizations (they control) of unlimited adaptation both of their own organizational structure and the physical resources they command, and whose objective is the simple minded pursuit of maximum profits. It can be argued that a theory of decision making based on such assumptions is devoid of relevance because it has no application to real business circumstances. Indeed it may be suggested that it is the very absence of these conditions which makes the study of economic administration so complex and so interesting and so necessary. That is, it is the very existence of constraints in some shape or form that makes the problem what it is. But in offering a premium to logical adequacy at the cost of discounting realism, it ought to be borne in mind that our task is to dissect the decision making function, and to accept a framework of ideas which makes this possible. In this way it may be possible to assess the relevance of the constraints upon the decision making process which exist in real life and analyse then consequences for the assumptions we have already made. The approach which we propose to adopt will also, as we have already indicated, divorce the decision making process from its business context by saying little about the institutional framework within which it operates. One is on stronger grounds in omitting this aspect of the problem if only because no valid general

statement about the effects of the operation of these institutions upon decision making has as yet been made.

In this part we have to undertake a deeper analysis of the theory of decision-making, with the object of putting forward a series of classifications which will be of value in later expositions.

Now it is obvious that when we are called upon to make a decision there is the implication that the decision is about alternative choices which we have before us. That is, we can not decide anything unless we have a choice, or choices to consider. Clearly also such choices emerge from the fact that we have some scarce thing about which we have to choose. In sum therefore, if there were no scarcity, there would be no need to choose, and if we did not have to choose, there would be no need for decisions. Scarcities, choices and decisions are inter connected in the sense that the ideas follow in a given sequence.

It follows then that one of the concomitants of choice and a decision is that in order to fulfill one end or ends, another choice or choices have to be relinquished altogether, or remain in abeyance for a period of time. That is to say if we implement one choice by a decision, it means relinquishing another choice which must remain unfulfilled either for a period of time or for ever. Not only is this the case, but also, the fulfilment of a given end often commits resources in a particular form, or in a particular way. That is, implementing a particular choice usually (though not always) implies some special, and possibly unique way of bringing about the desired result, and so over a short period of time at least, it is very difficult to undo the consequences of the original decision. That is, one can make a new decision but one is precluded from actively implementing it by the fact that the original decision has meant that our resources have been used up in a particular way. Hence for the time being, the consequences of a decision imply an irrevocable act, which we find very difficult to undo.

The upshot of this is that every choice, and therefore every decision involves a sense of something foregone. Something has to be relinquished altogether, or for a period of time. Now we can say therefore, that an implemented choice implies something left undone, or something has been done without, or forgone. So we can say that what remains the unimplemented, or

what has been foregone is, in the fullest sense a cost, for the foregoing is the cost. We may say then that every decision involves a cost because something is foregone, or an opportunity has been given up as a consequence of the choice, and what is forgone, or the opportunity given up can be said to be the cost of the decision.

This use of the term cost to refer to the major characteristic of a decision may appear to imply that every decision involves a money cost, because we usually associate the term cost with the outlay of money. It is of course true that many decision, particularly on the field of business administration are quantified in money terms, which usually, lends precision and definiteness to the idea because money is a unit of measurement. But it is also valid to remark that both in business and outside it, costs need not be so quantified in money terms. Usually there are very good reasons for this, two of which are worthy of some comment. First, it is very difficult to measure in money terms many costs; for example, certain costs may be imposed upon my neighbour by my addition to excessive noise in my home and these species of costs might be called social costs. Indeed it has almost become a characteristic of social costs to infer that they are not measurable. Situations of a similar kind can arise within an enterprise. Secondly, it may not be worth while measuring the cost, even though it is quantifiable in money terms; in this case costs are for trivial, and the effort of measuring them is, or may be, greater than the value of the answer from an operational stand point. In business this sort of situation can arise even in cases where the costs are relatively large because competition is insufficiently keen to force a narrower, precise, calculation. But a cost is no less a cost if it is not measured in money terms. Essentially it is the foregone, unimplemented opportunity which is the cost.

At the same time it has to be admitted that our conception of costs would be of little operational value unless it could be quantified; and the next issue which arises is, how do we measure costs in the sense we now use the term. If, as we say, a cost is involved when resources are devoted to a particular use, and therefore withdrawn or not used for alternative or other possible use, we have to investigate what is foregone before we can

estimate the cost of devoting the resources to current use or uses. We have to attempt to do this on money terms not only because it adds precision to our ideas about decision-making, but also because in business we are either faced to do so because of competition and or because we are accountable to the shareholders or government etc.

The matter would be put thus wise. Suppose I devote a certain given quantity of resources in the form of manpower to a specific use which I can measure in physical terms say man-hours, or money terms, and I wish to find the cost of the decision in the above sense of that term. I should have to consider what alternative uses the man hours could be devoted to, which will allow me to compare up the contribution made by the man-hours in their prevailing use, with the contribution made in the alternative contemplated use. Suppose further that there is only one alternative use for the sake of simplicity. Now, I may know quite well what contribution is made in the present use because I have calculated expenses. But in order to find out the cost of continuing to devote the resources to their current use the question which arises is, what contribution would they make in the alternative use? Until I know this, I cannot answer the question - what is the cost of continuing to devote the resources to the present current use?

There appear to be two possible lines of attack to obtain an answer. One view is that what we ought to do, is to compare the expenses paid for the manhours in question in the present use with the gross value obtained from the labour in this use. In this way, I obtain the net value contribution in the present use. This difference has now to be compared with the expenses which would be paid for the labour if used in the alternative occupation and the gross value from the labour if devoted to the alternative use. Now the difference obtained here which would be the net value contribution in the alternative use constitutes, in money terms, what is foregone by devoting the man-hours to the existing use. As is obvious, the approach meets two difficulties; 1st, how to assess the expenses of the labour if it was devoted to the alternative use, for the expenses might be

different to those involved in the existing use; and secondly how to assess the gross value contribution in the alternative untried occupation. Possibly we can get over the first of these from our knowledge of the situation, but the second estimate is difficult.

Now the second line of attack, to this question of measurement strongly objects to the procedure just adopted chiefly on the grounds that it is difficult, if not impossible to measure the gross value forgone (say in output) because it assumes that there is practical difficulty in estimating this quantity. Proponents of this latter procedure argue that it is impossible to do this and to wish to undertake a short cut, which is, instead of attempting to measure the gross value (of output) forgone, we should take the expenses (wages) paid for the man-hours in their existing occupation as a measure or index of what the man-hours would contribute in the alternative occupation. This means that the known figure of expenses (in the form of wages), is taken as the value contribution of the man-hour resources in the alternative, contemplated occupation.

Now obviously, to the extent that the wages paid for the man-hours in the existing occupation approximate or equal the net value condition in the alternative occupation the difference between the two approaches is small or nil. And the difference would be nil if two conditions were fulfilled. First, if the wages outlay in the present and contemplated outlet for the man-hours were the same; and secondly that businessmen were so sensitive to differences between wages and net value obtainable in two outlets, so that if any differences arose between net value and wages they would be competed away immediately. If we assume that the situation is so competitive as to erode differences the two methods, effectively, give the same result. So that the second method meets the practical difficulties at the cost of a possibly unrealistic assumption about competition. The first approach is formally adequate but its conditions are difficult to fulfill in practical terms. But this should not affect its value as a mental tool.

We may leave for the moment the question of measurement of cost in our sense in order to point to another major characteristic of the cost concept. If the cost idea has to do with the sense of foregoing, then it must be also insisted, as a consequence, that a cost is a reflection of a current, immediate, experience. That if to say choices, with their consequent costs made in the past give rise to a sense of foregoing at the time they were made, but there were past implemented foregoings. Clearly, these do not reflect currently foregoing which are the subject of current costs experience. Now this is a critical issue, for we can say then that in deciding about choices, costs in our sense are closely relevant to them, that is, decision-making and cost in our sense are linked together intimately. When we make decisions we are dealing with the present and the future, but not the past, for we cannot decide about the past in any meaningful way. The past is past such as we may reflect it, and whatever we have inherited from it. It is over and above with, or spoilt milk. In a famous phrase "bygones are forever bygones". Now if decisions are about the present and the future, then our cost concept must be about the present and future too, so that if we define cost in terms of alternatives given up, or in terms of foregoing, and think of cost purely in terms of the present and ~~future~~ and never in terms of the past, then, decision making and costing, properly understood, are about the same thing.

Now if we agree on this issue particularly as to the true meaning of cost, then it must also be admitted that when we plan in business the cost aspect of each plan must be about the present and the future only. If the content of a plan, and therefore decisions about plans is in the future and only in the future, the administrations of a business must be extremely careful to ensure that the relevant factors entering into a plan (which is a choice really closed up) relate only to the future. Hence one of the most important, if not the decisive element in planning and decision-making is to isolate expenses and which attach to a plan (a choice) so that they ensure that they do in fact relate to the future. Hence and for these reasons, we may say that all past, historical expenses, and all past historical revenues are strictly irrelevant to decision making, and if we exclude them, we can be really certain that our decisions are in fact

decisions (i.e. to do with the future). The fact is we cannot decide about the past, only the future, hence we must be certain that the mental tools we use in considering the future do not carry the rust of the past. This is not to say that data about the past may not be used as a guide to the future. But data collected in the past if used at all must be incorporated into mental furniture that this to do with the future and the future alone.

If these general ideas about the meaning of the term 'cost' are accepted it is important that the significant differences between the meaning we have give to the term, and the meanings attributed to the term in business should be appreciated. From this, it is not meant to imply that there is something unwarranted in the meanings ordinarily attributed to the term in business practice. Provided the term is precisely defined, its usage can cause no confusion. But in our case it is essential to avoid confusions because of the special view we have if our subject matter.

It is not uncommon in business to state or imply that all outgo, or expenses whatever their source are costs of different kinds; but it will be accepted that this procedure cannot be squared when the view point have taken up. This view point can be then expressed by saying that only those expenditures or expenses which are a reflection of choice can be regarded as 'costs' in our terminology. This involves a re-examination of all expenditures that may masquerade (from our new point) as costs in order to discover whether they are costs in our sense, and the purist, accepting this attitude, would not apply the term costs to the situations where expenditures are undertaken which do not reflect choice.

However, what we have done is take up a point somewhere midway between the views of the purist and the expediencies of ordinary business usage, in order to make our view-point more palatable and less foreign to those who wish to retain the ordinary terminology. The matter can be put as follows. As indicated before when we are making decision or choosing as between alternatives, or alternative plans, our considerations have to do with the future. Now when we are considering plans, which usually have consequences as far as expenditure is concerned, we can say that those

expenses or expenditures which need not be undertaken if the plan is not undertaken are 'costs'. These are expenditures which we can either undertake, or not undertake i.e. we can choose a plan in respect of them. We can avoid undertaking them if we so wish. We may call expenditures which fall into the category avoidable costs, because we may define such costs as those which we need not incur in the project is not undertaken. If therefore an executive has before him a list of expenditures which relate to a project and he wants to ensure that any item of expenditure is truly an avoidable cost, all he has to ask is; is such and such an item one which need not be incurred if the plan were not undertaken. If the expense is one which need not be undertaken if the plan is not undertaken, then we have what we have defined as an avoidable cost. The word avoidable is intended to illustrate the concept, and the word escapable, alternative or opportunity may be used instead of it provided to some meaning is implied.

We come now to a more difficult consideration. Now there will be some expenses which will be the same whether the plan or not the project is undertaken. Since such expenses will remain the same, it will not be possible to choose in respect of them. Such expenditures are obviously unavoidable, or inescapable, and we can conveniently call them unavoidable costs. These are expenses which will be incurred, whether or not the plan or project will be undertaken. Now it will be clear that in calling such expenditures unavoidable costs we have in fact contradicted the whole principle on which our concept of costs has been erected. That is, we have called an expenditure an unavoidable cost, whereas in reality it is not a cost in any sense. Since we cannot choose in respect of an unavoidable cost, or forgo anything; it is not, on our principle a cost at all. But we shall call it a cost for purposes of convenience to accord more with business usage.

The same terminology can also be applied to revenues. Thus, an avoidable revenue is one which need not accrue to the decision maker if the project is not undertaken. On the other hand, an unavoidable revenue is one which would accrue whether or not the project is undertaken.

But it should be accepted that the price of accepting this terminology is considerable. The true economic cost of a plan is the net revenue (i.e. the difference between the avoidable costs and avoidable revenue) in the next best alternative which is rejected by the decision-maker. We confine the term cost to the former of these quantities, but use the term in a prospective and not retrospective sense. The difference between avoidable cost and avoidable revenues of the accepted plan or 'opportunity' is taken as an index of the value of the next-best, but rejected opportunity. This appears to be the only condition in which prospective cost and revenue data may be used to approximate to the economist's view of costs as forgone opportunities.

4. It is now possible to make a sub-division by type of various kinds of avoidable costs. This is the distinction between those avoidable costs which are allocable and those which are unallocable. By allocable avoidable costs we mean that class of avoidable costs which may be directly and unequivocally attributed to the administrative point of reference implied in the planning procedure which may be individual units of output, departments of plants, or plants themselves. On the other hand unallocable avoidable costs cannot be so attributed to the same point of reference which is subject to the decision to be made. Therefore, it is of some interest to note that it is quite possible that unavoidable costs which may be allocable when considered from the standpoint of one point of reference, may be allocable if considered from a different point of reference, so that costs may be unallocable from the standpoint of a department but allocable from the standpoint of a plant. Again flexibility of interpretation is called for depending upon the character of the enterprise plan, and no costs may be regarded as permanently allocable or unallocable respectively.

The idea of allocability may, with equal validity be applied to revenues as well as costs. Again though it has to be noted that only avoidable revenues have significance from the decision making point of view, so that we can speak of unallocable and allocable avoidable revenues, which will depend on turn the interpretation of the administrative point of reference we have in mind.

So much for classification. The question which now arises is what significance has the distinction between allocable and unallocable avoidable costs? In order to illustrate this perhaps we could concentrate upon allocable avoidable costs and by reference to fairly specific cases.

If we take the normal case of multi-product enterprise, which we assume produces two products, in two distinct departments or plants, and consider the problems of the allocation of avoidable costs from its standpoint. This is of course a highly simplified situation, where department X produces all the a and department Y produces all the b. This is of course seldom the case in reality because enterprises could be producing in several

ways. i.e. could be producing various combinations of a and b in different departments. In the first of these cases, where an enterprise were producing the same product in two departments, then perhaps only a departmental allocation of avoidable costs would be of significance from the administrative standpoint: in the second case alluded to, the reference point might be both the product and the department.

Given that we accept the simple case the next question to ask is why two different products are produced, because this affects the analytical procedure we adopt. One reason for simultaneous production of the two products might be because that mode of production was technically imperative, as is often the case in the chemical industry or in the oil industry where the catalyst cracks oil in given proportions which tend to be invariant within fairly narrow limits. This gives rise to the phenomenon of joint costs and is discussed below.

But there are other cases of multi-product production where technical considerations are not an imperative matter, where, that is, it is a matter of choice as to what products to produce and in what proportions i.e. it is a matter of administrative choice entirely. In this purely commercial matter, we may apply our distinction between allocable and unallocable costs of the avoidable type.

Now in this case there are usually costs which are avoidable, but provided the decision maker is prepared to cease to produce the two commodities a and b i.e. to cease two and hence under our assumptions all activities. These costs which fall under this definition we may term common costs. It is seldom the case that all avoidable costs involved in the production of a and b can be unequivocally allocated to either one product or another. There are, that is certain costs that will have to be incurred so long as a or b are being produced. Moreover these costs will remain the same whether a alone is produced, or whether b alone is produced. They are avoidable costs therefore, but only on the essential condition that neither a or b are produced. In the terminology being used therefore, these costs are unallocable as between a and b, so they may be termed

common costs. Also as already indicated such costs are avoidable, but only on the condition that neither a or b are produced, so they are avoidable unallocable costs.

In addition to these costs there will be what have been termed avoidable costs, that is those costs which can be avoided if product a alone were discontinued, or if product b alone were discontinued.

Now in order to reach a sensible decision about the unallocable avoidable costs and the unallocable avoidable costs, we have to deal with the problems in two stages. First, if we apply the maximising criterion as earlier assumed, we take the maximum avoidable revenue, obtainable from the production of a, which we will assume can be calculate. These may be taken at this stage, only those avoidable costs which may be unequivocally allocated to a. Similarly, the maximum avoidable revenues attaching to b is assumed calculatted, and related only to those avoidable costs imputable or allocable to b.

The second step is to summate the total avoidable revenues for both a and b, and assume that this is positive. From this sum we may subtract the total avoidable allocable revenue, and so derive the residual net avoidable revenue for both a and b. This residual or net avoidable revenue has then to be compared with those avoidable costs which are unallocable as between a and b., as given in example I below.

Example I

	in £ E	
	<u>Department or</u>	<u>Department or</u>
	<u>Product</u>	<u>Product</u>
	(a)	(b)
Allocable Avoidable Costs	£1,500	£ 800
Avoidable Revenues	£1,600	£1,000
Individual Net Revenues	£ ,100	£ ,200
Summated Net Revenue	£ 300	
Assumed Total Unallocable Avoidable Costs = £ 250		
Contribution to Unavoidable Costs = £ 50		

Alternatively, there are four possible courses of action from a decision making standpoint to which may be assigned the respective avoidable costs and revenues.

<u>Course of Action</u>	<u>Avoidable Costs</u>	<u>Avoidable Revenue</u>	<u>Contribution to Unavoidable costs</u>
(i) Production of (a) alone	£1,500 allocable £ 250 unallocable	£1,600	£ -150
(ii) Production of (b) alone	£ 800 allocable £ 250 unallocable	£1,000	£ -50
(iii) Neither (a) nor (b)	0	0	0
(iv) Both (a) and (b)	£1,500 + £ 800 allocable + £250 unallocable = £2,550	£1,600 + £1,000 = £2,600	£ +50

Another aspect of the same argument is given in example II below, where the complication of a split up of the common costs is discussed.

Example II

The case of a storeman whose services were used in Departments A and B. Suppose on a basis of a technique of splitting the contribution made to each Department, Department A 'bears' £300 of his services and Department B 'bears' £100.

Assume other data as follows:

	<u>Department A</u>	<u>Department B</u>
Allocable Avoidable Costs	£1,000	£1,800
Avoidable Revenues	£1,200	£2,000
Individual Net Revenues	£ +200	£ +200
Summated Net Revenues =	£400	
Unallocable Avoidable Costs =	£400	
Contribution to Unavoidable Costs =	£0	

All allocable and unallocable avoidable costs are met and it is worthwhile keeping both Departments going despite nil contribution to Unavoidable Costs, about which nothing can be done anyway in the time period concerned.

The result would be different if the technique alluded to above were used, e.g.

	<u>Department A</u>	<u>Department B</u>
Allocable Avoidable Costs	£1,000	£1,800
Avoidable Revenues	£1,200	£2,000
'Allocation' of Storeman's Wages	£ 300	£ 100
Total 'Allocable' Costs	£1,300	£1,900
Net Revenue	£ -100	£ +100

The decision now is very different from the above; Department 'A' should be closed down. This is possible in case of common costs. The essential difference between this case and one involving joint costs (and joint production) is that technical circumstances would prevent the closure of Department A if it were desired to continue production in Department B.

It ought to be said that the magnitude of the unallocable avoidable costs depends upon the objective of the decision making exercise i.e it is a purely relative matter depending upon the standpoint from which the problem is considered. So that the distinction between the choice of a departmental or a product or process viewpoint is very significant. For this reason, the overall decision-maker may view matters differently from say a subsidiary decision maker, and unless the latter is given very clear terms of reference as to the administrative or operational standpoint which he is asked to adopt error and conflict is bound to arise, which need not be resolved by making organisational divisions and distinctions of a permanent character. Indeed it is often in the nature of the decision-making process that organisational inflexibility conflicts with its efficient conduct.

For example, if we are involved in providing a 'service' or a product, then depending upon the manner in which we define a product or service and use it as the administrative reference point, some resources may be dispensed with altogether, if the service is discontinued, and some may not, because some of the resources will be used in the provision of other 'services'. That is, the more we particularise, in the sense that we make finer distinctions, the smaller the proportion of the resources used that may be dispensed with, if the service or product or department

is discontinued. The broader or less fine the distinctions, the greater the proportion of resources which may be dispensed with. Or again, the finer the distinction (greater particularisation) the larger the element of unallocable avoidable costs, and the smaller the element of allocable avoidable costs, and vice versa; so that the proportion of allocable to unallocable avoidable costs alters with the scope of the universe of discourse.

This point may be illustrated by reference to an example which is often too familiar in modern railway operation in developed countries, which requires the closing of branch lines because they are unused or very under utilised because of switches of passengers and freight to the roads from the railways. Here the distinction between allocable and unallocable avoidable costs is a major consideration, but one which requires clear understanding of the reference point at issue, and the definition of the service which it is required to discontinue. In this case the discontinuance of the service might be interpreted to mean the discontinuance of such frequent running of trains as between points A and B. Thus, it might be argued that it is worthwhile financially to discontinue the morning service, and retain the evening run, thus say having the frequency. Now if we mean by the 'service', the morning run, little more than the cost of the fuel used by the engine may be saved. If however, we mean by the 'service' both the morning and the evening journeys, we may be able to save, if the capacity of an engine plus crew is two trains per day, in addition to the fuel, the cost of maintaining and replacing the engine, the pay of the crew plus the accompanying rolling stock. Again, if we mean by the 'service' any train journeys whatsoever between A and B, we can close down the two stations A and B as well as make additional savings. Further if we mean by the 'service' any train going over the A to B Track, we can take up the track. Similar considerations would apply with equal force inside enterprises.

At this point it is worth mentioning a second problem in cost allocation which is somewhat different in character to the one just outlined, because it derives from the existence of different production conditions, to those we have been examining. In the last example of the

distinction between allocability and unallocability of costs attention was directed to the question: is it worthwhile on our assumptions to continue or discontinue the production of a particular commodity or service, or of a department or process. The case we now have to consider in effect assumes that this problem has been solved, so that attention can be directed to an ancilliary and often subsidiary issue which is: how much of the product should be produced or to what extent should capacity be used?

Very often it is not possible to impute or allocate in practice because of the basic characteristics of the output. It is too often assumed that mass, flow production of small similar units are characteristic of production processes: rather, by far the commoner cases are those where single unit output or output by 'batches' is the case. In these situations unallocability exists, in the sense that costs may not be allocated to undividual units of output, but only to single units, or batches of output. This means that we cannot consider to exist a continuous differentiable function, and we cannot examine problem of costing in terms of a marginal avoidable cost function.

In addition to this, we have to consider case where some avoidable costs have to be incurred not simply to produce single additional units of output, but outputs beyond that. That is to say the inputs are indivisible, which is very often the case with many types of overhead expenses. Some overheads are incurred as soon as the enterprise starts off in business, and their size remains the same regardless of the output of the enterprise. But in addition to these there are those other types of expenses that increase not gradually as output increases, but in discontinuous jumps. This implies that a certain quantity of some types of resources have to be employed, even though the output may vary within wide limits, say to 100 units a week: out if weekly output exceeds 100 units even by one additional unit, a relatively large lump of additional resources is required. But no more of that type of resource will then be required until output increases say to 200 units a week.

As indicated these considerations arise usually either because cannot produce gradually in small units, or because inputs are obtainable in large indivisible lumps. This means that we cannot allocate avoidable costs to particular units of production but only to ranges or often batches of output. The two cases being alluded to are conceptually quite different, and may exist together or apart in an enterprise. In the absence of these, and given that avoidable revenues may also be regarded as a smooth differentiable function, the avoidable cost approach to decision making would proceed in the hallowed text book manner. But the facts of the industrial sence are very different to this and it is no use proceeding as if the text book assumptions were reproduced on the ground. If they were the assumption made earlier as to infinite sensitivity of the decider would be fully justified. This means however that the act of decision making must become far less precise where these awkward conditions exist, but it is to be noted that to the extent this argument is accepted, this does not involve as a consequence the rejection of the avoidable and allocable categories by which decision making may be elated to the problems of enterprises on the ground. In fact this is one of the advantages of relating the decision making function both to real problems and at the same time accepting what is fundamentally the economists view of costs

5. A cost which remains the same whether or not we undertake a project has no relevance to the decision whether or not to undertake the project. Such a cost we shall call an unavoidable cost—a cost we cannot avoid whichever way the particular decision under review goes.

It is extremely important to realise that it is not possible to classify particular kinds of outlays as always being avoidable costs and other kinds as always unavoidable. What is an avoidable cost will depend upon the problem under consideration. We should, strictly speaking, talk not of avoidable costs but of the avoidable costs of doing something—for example the avoidable costs of undertaking a particular contract, the avoidable costs of buying a new machine, the avoidable costs of producing 10,000 units of output in a year. It is not the avoidable costs of the thing but the avoidable costs of undertaking, or buying, or producing. In deciding whether or not to rent a new factory building, the rent and rates will be avoidable costs but once we have committed ourselves to renting the building, the rent and rates are unavoidable costs in relation to decisions whether or not to undertake a contract or to produce a certain output in the forthcoming period. Avoidable costs must always be related to a particular decision. It is not possible to go through a Profit and Loss Account and tick off avoidable costs.

In our decision-making, it is the avoidable costs and the avoidable revenue which we must estimate. If the avoidable revenue of a project is in excess of the avoidable costs, it will be better to undertake the project than to do nothing, when this is our only alternative. Where projects are competing with each other, and the management has to choose from among them, it will naturally choose to undertake that one which is expected to show the greatest excess of extra revenue over extra costs—that is the greatest excess of avoidable revenue over avoidable costs.

This, then, in outline is the avoidable costs approach or if you like the "what's the difference" approach, since we are estimating what difference there will be in costs and revenue if the project (whatever it may be).

The first example relates to a departmental store. Frequently the Profit and Loss Account, whether it records past transactions or whether it is a

budget of expected transactions, is prepared in an analysed form. The revenue, stocks, purchases and expenses are allocated to departments, or apportioned among them. A number of expenses can only be apportioned on some more or less arbitrary basis and the accounting textbooks recommend us to choose some "reasonable" basis, having regard to the nature of the expense to be apportioned. A long list of possible bases are given us including: area of floor-space, cubic capacity, departmental sales, departmental gross margins, number of employees and so on. There are a very large number of possibilities. In many instances there is little to choose between them, but if we were to choose one basis a department might show a profit, whereas if we were to choose another apparently equally appropriate basis the department might show a loss. One wonders, of course, what such a profit or loss can mean.

On table I, we have shown, in outline, a departmental budget drawn up in this way. Rent and Rates have been apportioned on the basis of the floor space occupied by the departments (A occupies two-thirds of the total floor space and B the other one-third). General Management Salaries and Expenses have been apportioned on the basis of the departmental sales (i.e. in the ratio 6,000 to 4,000). The other expenses relate specifically to the departments to which they are charged and need no arbitrary apportionment. On this basis, Department A shows a profit of £6000 whereas Department B shows a loss of £200.

If results similar to those shown are likely to recur, should Department B be closed down? We will assume, since we are not dealing here with control but with decision-making, that there is no inefficiency within Department B. In order to decide whether to close down the department, we must adopt our "what's the difference?" approach. We must estimate what the effect of the closure would be upon the total net profit of the undertaking. What sales would be lost and what costs would no longer be incurred if Department B were closed down? The rent and rates on the whole premises would still have to be paid and it might not be possible to reduce the £1,000 general management salaries and expenses. Let us, then assume that these costs would remain the same whether or not Department B were shut

down and that they are therefore unavoidable costs of the department in relation to this decision. The other costs would be saved and are therefore avoidable costs of the department in relation to this decision.

If instead of making arbitrary apportionments of expenses, we had only charged avoidable costs to departments as has been done in Table II, we should have seen that Department A is contributing £1,400 and Department B £300 towards the unavoidable costs and towards the net profit. If Department B were closed down, the net profit of the undertaking would fall from £400 to £100. Clearly, then, it would be better to allow Department B to continue in existence, if the only alternative were to do nothing with the floor space, the equipment, the managerial facilities and the working capital which would become available if the department ceased to trade.

However, we may not be faced with the simple alternative of using the resources for Department B or doing nothing with them. There may be some further choice open to us: to use the floor-space for a new department, or perhaps to sub-let the space and equipment occupied by the department. If more than £300 p.a. could be obtained from any alternative use of the resources, then, of course, that alternative will be preferred to their use for Department B.

Table III shows a comparison of alternative uses of the resources. If sub-letting were the best alternative use (supposing, for example, that the available floor-space was the whole of the top floor and could be let off without disturbing the arrangement of the remainder of the building), then department B would be retained at a net gain of £20 p.a. In the avoidable revenue of the sub-letting there should be included not only rent receivable but any income which would arise from the freeing of resources no longer required. (E.G. Working capital might be freed and equipment no longer required. This could be sold and the cash invested to produce income).

If we have chosen the use of resources, in each instance, which showed the greatest excess of avoidable revenue over avoidable costs, then we cannot do better than that. It is useless to consider whether each department has made a "fair" contribution, if it has made the maximum possible contribution.

So far we have only considered shutting down departments and substituting new departments for old ones. A further possibility is to increase the floor-space occupied by one department by reducing that occupied by another. Table IV relates to this kind of problem.

The problem is this: we have a fixed area of floor space and over the period for which we are budgeting we cannot increase this area. The floor-space can be used for department X or department Y or partly for one and partly for the other. The area of the floor-space is 4 units: one unit being the area required for one counter and its surrounding gangway. What is the most profitable way of allocating the floor-space between the competing uses?

(The units of floor-space we must be concerned with are those which are just large enough for the addition of one unit to a department, or the subtraction of one unit from a department to make a significant difference to the costs and/or revenue of that department). There are five possible allocations of floor-space between X and Y: 4 to X+0 to Y; 3 to X+1 to Y; 2:2; 1:3; 0:4.

The table first sets out estimates of the avoidable revenue and avoidable costs of department X on the basis that all the floor-space is allocated to it. Estimates are then made of the avoidable revenue and avoidable costs of each department under each of the other possible allocations of floor-space. Once more apportionments of overheads will not help in the solution of the problem and might in fact be misleading. Any costs which would not be altered by the changes in the allocation of floor-space (for example, rent, rates and apportionments of general administration expenses) should not be included in the calculations. Col. VI shows the combined avoidable revenue minus the combined avoidable costs and represents the combined contribution which is being made towards unavoidable costs and net profit with each space allocation. If we were to deduct from Col. VI any costs which relate to the floorspace as a whole, since these will be the same for each of the five situations, the most profitable positions will still be either row 3 or row 4. These are equally profitable and are preferable to allocations shown in rows 1, 2 and 5.

As floor-space is taken from one department that department's contribution is reduced and as floorspace is added to the other department the second department's contribution is increased. If the contribution of the department which is given added floor-space is increased by a greater amount than the contribution of the other department is reduced, then that shift of floor-space is worthwhile.

A similar problem to this is that of allocating machine time between competing uses. If products have to undergo more than one process, this may involve a number of complications.

A final illustration is from manufacturing industry. Not infrequently a decision has to be made whether to make or to buy a component. We want to consider what information about costs and revenue is required by those who are faced with such a choice.

If it were possible to make the component but it is decided not to do so, then manufacturing capacity would be come available. We have to consider whether this capacity is likely to remain idle or not. First let us assume that the facilities freed by not making the component would remain idle. Under these circumstances, the effect of making the component will be that costs will be incurred that would not be incurred if it were not manufactured and the effect of buying the component ready made will merely be that a sum of money has to be expended on its purchase. We should then compare the avoidable costs of making the component with the purchase price of a ready-made component and the choice will go to the cheaper of the alternatives. In practice there may be non-cost factors to take into consideration (e.g. quality differences) but I am ignoring these.

Now let us assume that the facilities freed by not making the component would not remain idle but would be put to some other use. There will no be two effects of buying the component ready made: (1) a sum of money has to be expended on its purchase and (2) a contribution towards the unavoidable costs can be obtained by using the spare manufacturing capacity. (This contribution

is the excess of avoidable revenue over avoidable costs arising from this alternative use of the freed facilities). It is the net result of these two which has to be compared with the avoidable costs of making the component. We can set out these figures in two ways as shown in table V.

(1) Avoidable costs of making	Purchase Price <u>minus</u> net revenue from alternative use of resources
(2) Economic sacrifice of making	Purchase Price
- (a) avoidable expenses	
+ (b) net revenue forgone	

The net revenue which will be forgone as a result of making and thus using up capacity which otherwise would have been available, is just as much a sacrifice incurred and therefore a cost as what I have now called avoidable expenses. Both (a) and (b) are strictly part of the avoidable cost of making the component.

I

DEPARTMENTAL ACCOUNTS

(with arbitrary apportionment of unavoidable costs)

	Dept. A £	Dept. B £	Total £
Cost of Goods Sold	3,600	2,800	6,400
Assistants' Wages	900	700	1,600
Rent and Rates	100	200	300
General Managment	200	100	300
Salaries and Expenses	600	400	1,000
Total Expenses	5,400	4,200	9,600
Net Profit or <u>Loss</u>	600	<u>200</u>	400
Sales	6,000	4,000	10,000

DEPARTMENTAL ACCOUNTS

(avoidable costs approach)

II

	Dept. A £	Dept. B £	£	Total £
Sales	6,000	4,000		10,000
Less Avoidable Costs:				
Cost of Goods Sold	3,600	2,800		6,400
Assistants' Wages	900	700		1,600
Sundry Expenses	100	200		300
Departmental Contributions	1,400	300		1,700
Less expenses of business as a whole:				
Rent and Rates			300	
Management			1,000	1,300
Net Profit				400

III

THE USE OF FLOOR-SPACE, ETC.

	Use as Dept. B £	Use for sub-letting £
Revenue	4,000	300
Less Avoidable Costs	3,700	20
Contribution (towards unavoidable costs and Profit)	300	280

IV

Allocation of Floor-Space Between
Departments X and Y.

	I <u>Allocation of</u> <u>Floor-Space</u>		II <u>Avoidable</u> <u>Revenue X</u>	III <u>Avoidable</u> <u>Revenue Y</u>	IV <u>Avoidable</u> <u>Costs X</u>	V <u>Avoidable</u> <u>Costs Y</u>	VI <u>Combined</u> <u>Net Revenue</u> <u>X plus Y</u>
	X	Y	£	£	£	£	£
(1)	4	0	100	-	80	-	20
(2)	3	1	88	53	70	41	30
(3)	2	1	68	99	53	79	35
(4)	1	3	39	133	28	109	35
(5)	0	4	-	154	-	129	25

THE MAKE OR BUY PROBLEMMAKE

(1) Avoidable Costs of Making

(2) Economic Sacrifice of Making
 = (a) Avoidable expenses
 plus (b) net revenue forgone

BUY

Purchase Price

Minus net revenue from
 alternative use of resources.

Purchase Price

Note: The only essential difference between (1) and (2) is the switch of the net revenue from being a deduction under the heading of 'BUY' to being an addition under the heading of 'MAKE'. A resultant change in wording is necessary.

6. We can carry the analysis of costs for decision-making to a further stage. It is still with expected future costs what we are concerned. We are dealing with special purpose budgets, rather than with the profit and loss account or with the costing system.

We can deal with a problem of allocating avoidable costs to types of product, when a number of types of product are being manufactured in the plant. The particular aspect of this problem considered is that relating to joint products and bye-products.

The first point which can be made is that the distinction between joint-products and bye-products is arbitrary. When two or more products, arising out of a single process or set of processes, are regarded by the firm as being, in some way, of equal importance, they are termed joint products. If, however, a product is regarded as of less importance than others, then it is called a bye-product. Presumably the criterion of importance will be normally the market value of the output of each type of product. But if the market values do not coincide, it must be difficult to decide how big the difference should be before a product is relegated from the first division (of joint products) into the second division (of bye-products). In spite of this somewhat arbitrary distinction between joint products and bye-products, cost accountants normally adopt different procedures in computing their cost. This is unfortunate since, particularly in the Chemical Industry, the dividing line between them is continually moving. For example, the Leblanc Soda Company started off with soda ash as its sole marketable product, while salt cake and hydrobromic acid were waste products. The hydrochloric acid emitted fumes which blighted the countryside around. The introduction of government regulations compelled the company to do something about these fumes, and in dealing with this problem, the company converted both hydrochloric acid and salt cake into saleable products. In the second stage, then, what had been waste products were now treated as bye-products. The third stage arose when the introduction of the ammonia process for producing soda caused a fall in the price of soda ash, which now was treated as a bye-

product, hydrochloric acid being the main product. Thus hydrochloric acid started as waste, became next a bye-product and then the main product. The story has a sad ending. The hydrochloric acid was sold mainly to the bleaching industry but the demand for it fell catastrophically as a result of the introduction of cheaply produced chlorine as a substitute in that industry. And that, ~~we~~ regret to say, was the end of the story and of the company.

There is no advantage whatsoever in attempting to make this distinction between joint and bye-products. As ~~we~~ shall try to show, precisely the same considerations apply to each in decision-making.

The usual costing procedure is to record the bye-product at its selling price less any separate costs incurred after the split-off point (e.g. refining and packaging) and to treat this as a deduction from the joint cost. The result is that the bye-product shows no profit or loss--all the profit or loss being attributed to the main product.

Whereas in arriving at the cost of joint products, it is usual to apportion the joint cost to the joint products in some arbitrary way, frequently in the ratio of their relative weights or their selling prices. Textbooks often recommend a points system as a basis for apportionment, on the grounds that it is more "scientific". So many points are given to each product to measure selling price differences, so many for differences in weight and so on. The joint cost is apportioned in the ratio of the total points given to each product. To call an arbitrary mixture of arbitrary methods "scientific" is to use words in rather an odd way.

Two illustrations from the chemical industry may demonstrate the absurdities which may arise from these arbitrary apportionments.

A survey was made in 1926 in America of firms producing caustic soda and chlorine as joint products. In firms using similar processes, the joint cost was found to be apportioned in five different ratios: 50 : 50; 40 : 60;

60: 40: 39.008: 35.46 (in the ratio of the atomic weights) and 56.76 : 43.27. The last ratio was worked out so that, when the joint cost was apportioned in this way, caustic soda and chlorine showed an equal book profit. The firm adopting this ratio had previously made the apportionment on a 50:50 basis, which resulted in the chlorine department showing a loss. The bankers, who controlled the company, wanted the chlorine foreman sacked. The works manager wanted to retain him and was able to satisfy the bankers by altering the ratio in which the joint cost was apportioned. This kind of thing can only bring costing into disrepute.

Another instance of the misuse of costing had rather more serious results. Methanol was produced in America, with acetate of lime and charcoal as joint products. The joint cost was apportioned over the three products in the ratio of their selling prices. In Germany a new method was discovered of producing methanol by a cheaper process which did not result in the production of the other products, and half a million gallons of methanol were imported into the U.S.A. as a result there was a large drop in the selling price of methanol in the U.S.A. without any major change in the selling prices of acetate of lime and of charcoal. Since the apportionment of the joint cost was in the ratio of selling prices, a smaller part of it was charged to methanol and a correspondingly larger part to the two other joint products. It appeared, therefore, that methanol had been produced more cheaply in the U.S.A. than it had been in previous years. The American producers of methanol sought a higher rate of import duty on the product, and were able to satisfy the Tariff Commission that costs of production at home had fallen. This indicated, it was claimed, that the American Industry was not less efficient than the foreign industry, and a 50% increase in import duty was authorised by the President. Costing was, in this instance, an admirable guide to inefficiency.

The important point is that whenever joint costs are apportioned on a selling price basis and a new method is discovered of producing one product by itself more efficiently than under the old method, the costing

system will discourage the businessman from switching to the new more efficient process.

If, then, the apportionment of joint costs is only misleading, what cost information about joint products do we need to accumulate and what budgets do we need to prepare? Briefly the answer is: if apportionments are useless, then don't make any apportionments. We can prepare a budget on the same sort of lines as we did for a departmental store.

Table 1 shows in summarized form the kind of apportionment which we have criticized. Table 2 shows a re-arrangement of the information on the avoidable costs approach.

What we should do is to show the contribution which each joint product is making towards the joint cost. This will give an indication of whether it is worth while to continue the separate processing and sale of each joint product or whether it would be preferable to dispose of it as waste. We must deduct from the avoidable revenue of each product those costs which would be saved if we ceased to separate processing and sale of that particular product while continuing the processing and sale of the other joint products. Those costs are avoidable costs which can be allocated to the products and we shall call them allocable avoidable costs. Some costs will be saved if none of the joint products are produced but will not be saved if any one of the products is not produced. These are unallocable avoidable costs.

The excess of avoidable revenue over allocable avoidable costs is the product contribution. The excess of the total product contributions over the unallocable avoidable costs is the total contribution. Unless the total contribution is positive it will not be worthwhile producing at all.

For price and output decisions, it is necessary to distinguish between cases where the proportions in which the joint products can be produced are fixed and cases in which they can be varied.

When the proportions are fixed, price and output decisions can only be made by taking the whole bunch of products together. The products in the

aggregate are responsible for the costs in the aggregate. The revenue in the aggregate arises from the products in the aggregate. The considerations involved will be similar to those involved in price and output decisions for a single product. We shall be dealing with this problem of choice of output at a future session.

A more interesting situation arises where it is possible to vary the proportion in which the joint products are produced. This is so common in the chemical industry as to be almost the typical instance. The situation is that it is impossible to produce Product A without also producing Product B but that within certain technical limits it is possible to expand or contract the output of Product A relative to that of Product B. Frequently, by the application of greater heat within a process we may drive off a greater volume of a gas while reducing the quality or the quantity of residual solids. This is the situation we understand in the production of cokes and coal gas. The greater the quantity of gas extracted from coking coal, the lower the quality of the residual coke. The problem is to achieve the mixture which will give us the greatest profit. In order to achieve this we must be able to estimate how total costs are likely to change as, say, the temperature is changed at which the process is carried out. We must also estimate the effect upon total revenue of increasing the output of the gas and reducing the quality (or the output) of the other product.

This procedure is illustrated on the third slide. The first column does not show the total cost of applying heat, but the extra cost of applying a further 10° of heat. We are, then, recording the increase in avoidable costs of applying heat as a result of raising the temperature of the process in increments of 10° . This is called the marginal cost of applying heat in the process. We have assumed that the cost of raising the temperature by a further 10° becomes greater as the total temperature rises. The next two columns show the increase in the revenue from the gas and the decrease in the revenue from the solid resulting from the application of greater heat. The increase in revenue is called the marginal revenue. The declining figures reflect the fact that the application of additional heat is likely to become progressively less effective. The fourth column shows

the effect upon total revenue. We should apply an additional 10^0 of heat provided that the marginal total revenue arising from such an application is greater than its marginal cost. In the illustration we should then apply the third additional 10^0 but not the fourth additional 10^0 .

JOINT PRODUCTS

(with arbitrary apportionments)

	Product A	Product B	Total
Separate Costs: Avoidable	£ 4,000	£ 2,000	£ 6,000
Unavoidable	1,000	500	1,500
Joint Costs ^x	20,000	24,000	44,000
Administrative Costs etc.	11,000	13,500	24,500
Total Costs	36,000	40,000	76,000
Sales Proceeds	35,000	51,000	86,000
	£ 1,000	£ 11,000	£ 10,000

x Includes £ 4,000 unavoidable costs.

JOINT PRODUCTS

(Avoidable Costs Approach)

2.

	Product A	Product B	Total
Revenue	£ 35,000	£ 51,000	£ 86,000
Less Allocable Avoidable costs	4,000	2,000	6,000
Product Contributions	31,000	49,000	80,000
Less Unallocable Avoidable Costs			40,000
Net Contribution			40,000
Less Unavoidable Costs			30,000
PROFIT			£ 10,000

3.

JOINT COSTS: VARIABLE PROPORTIONS

(Variation dependent upon application of heat)

			Extra Cost	Extra Rev. A (Gas)	Extra Rev. B(Solid)	Total Extra Revenue	Additional Profit
1st	additional	10°	£ 20	+£ 50	-£5	+£45	+£25
2nd	"	"	21	48	4	44	23
3rd	"	"	28	+ 40	- 3	+ 37	+ 9
<hr/>							
4th	"	"	34	+ 34	-£2	+£28	-£ 6