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# PRODUCTION ECONOMICS, AVERAGES AND STANDARDS IN RESEARCH AND EXTENSION

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**Though theoretically desirable, production functions are difficult both to obtain and to use. Farm standards have generally been the main vehicle for giving farm management advice, despite their defects. This article puts an argument for standards but concludes that more effort can be made to use standards derived from mathematically defined production functions.**

In many countries of the world there is, and has been, disagreement about measures used in giving farm business management advice. The controversy centres around the use of "optimal" values for inputs and outputs as opposed to non-optimal or "average" values. Thus, for the production function represented by one farm, there is an optimal combination of inputs and outputs on the one hand, and, on the other, there is a non-optimal but profitable combination which one might expect to find being used on the average. This is the essence of the argument but it is further complicated because no two farms operate on exactly the same production function, i.e. with the same types of resources, technology and management. In consequence, the best that can be done is to find the average combinations of inputs and outputs for farms which are operating on slightly different production functions. The figures finally obtained are average and not necessarily optimal figures for the average of several individual farm production functions.

The farm standards used in the United Kingdom are based on average values of inputs and outputs for a group of farms. They are thus non-optimum and average, as described in the first paragraph. The words "farm standard" are also used in other places to describe values which are not necessarily the exact average of many farms. The definition of a farm standard for the purpose of this paper is a set of values which indicate the average properties of a group of similar farms.

A discussion between Candler and Sargent[1] on the one hand, and

* The author wishes to acknowledge the great assistance of R. Jardine in critically examining most parts of this paper. Thanks are also due to T. R. Morgan and others for their interest and aid. Needless to say, none of those who assisted agree unreservedly with the contents of the paper.

[1] W. Candler and D. Sargent, "Farm Standards and the Theory of Production", *J. Agric. Econ.* Vol. 15 No. 2, Dec. 1962.

Blagburn[2] on the other, has highlighted what what might be called the two extreme views on the subject. The arguments or modifications of the arguments used by both parties would, no doubt, be endorsed by economists in many other countries, including Australia. The proposition put forward by Candler and Sargent is as follows:[3] "It is suggested that the calculation and use of farm standards for different types of farming in different areas is unlikely to be the most profitable way of solving many farm management problems." This proposition merits some consideration because farm standards, or something very like them, are used in many places. Candler and Sargent also suggest there is a difference between the "Australian-American school of farm management" and the "farm standard school". The former, they say, "is concerned with the structure of production relationships" and, therefore, presumably is likely to be a more profitable way of solving farm management problems. Blagburn,[4] however, sees standards as a "means of attempting to diagnose the economic weaknesses of a farm as a preliminary to working out an improved system of management". His philosophy is that, with their limited resources, farm economists "have to choose between giving optimum advice to the isolated few and providing something rather more rough and ready for a larger number".

The object of this paper is, first, to examine the extent to which farm economists should concentrate on establishing and using optimal values obtained from production functions (rather than average or standard values obtained by other means) and second, to examine the value of production economics in using average or standard values.

### *Optimal Requirements and Standards*

Under the name of production economics, economic value theory has formed the basis of *teaching* in farm business management since the early 1950's. The teaching of production economics has been based on the well known input-output curve shown in Figure 1. Heady[5] states that constant or increasing returns are seldom found in agriculture, suggesting that most production economists are concerned with the diminishing returns part of the curve between A and B in Figure 1. Between A and B, the marginal product falls as each additional unit of input is added. Figure 2 shows the marginal product and the average product curve rising and then falling. Optimal production occurs when the output is such that, for each type of input, marginal cost equals marginal return. Figures 1 and 2 show the relationship between output and a single input. In maximizing income, two other relationships need to be considered. When expanding output, inputs need to be combined in such proportions as to produce any given output at least cost (factor-factor relationships). When there are several outputs, they need to be produced in such proportions as to yield the highest return for any given cost (product-product relationships).

[2] C. H. Blagburn, "Farm Standards and the Theory of Production—a Rejoinder", *J. Agric. Econ.* Vol. 15 No. 2, Dec. 1962.

[3] Candler and Sargent, *op. cit.*, p. 282.

[4] C. H. Blagburn, *op. cit.*, p. 295.

[5] Earl O. Heady, *Economics of Agricultural Production and Resource Use,* Prentice Hall, New York, 1952, p. 34.

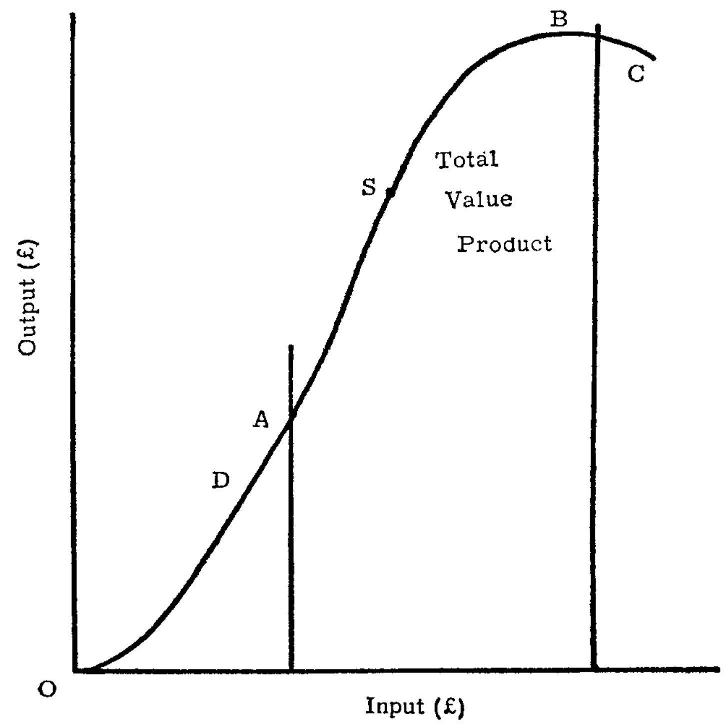


FIG. 1

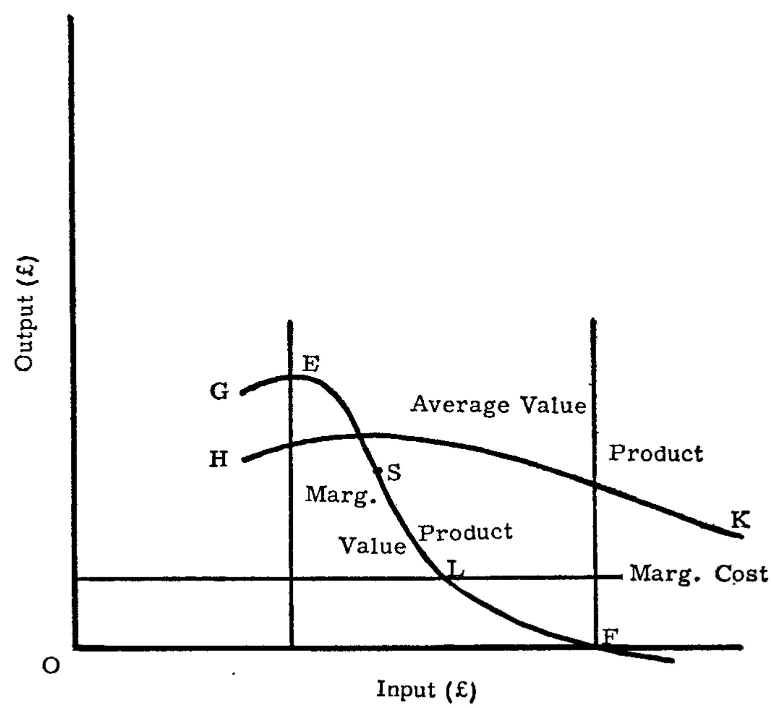


FIG. 2

Farm standards are not usually defined in terms of such relationships as are shown in Figures 1 and 2. In calculating a standard for net income per acre for example, unprofitable farms could be excluded and the rest averaged. It is a reasonable assumption that profitable farms have, in the course of time, come to use resources in an approximately optimal way but, since a range of net incomes per acre is observed, this can only be approximately true and the farmer with the highest net income per acre will be nearer the optimum than the rest if area is the limiting factor and capital investment is much the same on every farm. Given these circumstances, a "standard" farm will probably be between A and B in Figure 1, and between E and F on the marginal value product curve in Figure 2.

### *Availability of Production Function Analyses*

All economists would surely agree that marginal analysis provides a complete theoretical answer to farm economics problems. However, for various reasons, very few practical problems, superficially at least, appear to have been answered by an appeal to marginal analysis. It is only on rare occasions that a production function is established well enough to permit the point of optimal output to be calculated, and the difficulties involved give rise to doubts as to the wisdom of spending a great deal of time in determining the precise shape of such functions.

A convenient point to begin a discussion of this question is to examine the success of farm economists in establishing production functions. According to Lloyd,[6] Pearse in an unpublished M.Sc.Agr. thesis stated that he found only two experiments of use, from a farm management point of view, in all the work that the Department of Agriculture of Western Australia had carried out. No such research effort has been directed at the Victorian Department of Agriculture. What can be said about the Victorian Department, however, is that, in some cases, the equivalent of production functions have been obtained and have been correctly used by agricultural officers for years, without the aid of agricultural economists. For example, the Mallee Research Station *Guide Book* shows the equivalent of marginal products and marginal value products obtained from the application of several levels of superphosphate, and the appropriate recommendation is based on this.[7]

Where relatively simple fertilizer trials are carried out on cash crops, the shape of the production function can be readily established and, in the case of the Victorian Department of Agriculture, has been so established. Where more complicated fertilizer treatments are necessary or where animals are concerned, production functions are difficult (and expensive) to define and thus do not appear so frequently, if at all. A case in point is the alleged complementary relationship between beef cattle and sheep. It has been supposed for many years that beef cattle and sheep grazed on the same property, use pastures more effectively than either one would alone. This has been a much quoted relationship but the only published work on it by agricultural economists in Australia is by Campbell and Musgrave.[8] These workers noted the absence of

[6] A. G. Lloyd, "Agricultural Experiments and their Economic Significance", *Rev. Mark. Agric. Econ.* Vol. 26 No. 3, Sept. 1958, p. 192.

[7] Victorian Dept. of Agric., *Mallee Research Station, Walpeup: Guide Book 1962*, Melbourne, 1962.

[8] K. O. Campbell and W. F. Musgrave, *Economic Aspects of the Association of Beef Cattle with Sheep Production in South-Eastern Australia*, Dept. of Agric. Econ., Univ. of Sydney, Res. Bull. No. 3, 1958.

experimental work and were thus forced to rely on a farm survey for their information. The lack of experimental evidence in this case is not due to ignorance of the suspected relationship or to poor experimental technique but, simply, to inadequate resources for the experimental work.

Even in such a highly developed agricultural country as the United States, there are some significant omissions in the list of established production functions. For example, it is surprising to find that the relationship between feed input and milk output for dairy cows is still open to a great deal of doubt, although there are areas where dairy cows are kept in barns for a great part of the year. Even in this situation, the difficulties may be insuperable as Reid[9] points out. A more specific illustration of the lack of experimental data in Europe is contained in an O.E.C.D. bulletin, showing that the data given in European Farm Management Handbooks is insufficient for economic decision-making, in the sense that it does not provide marginal response rates.[10]

Farm surveys are also a source of information from which farm management economists can obtain production functions. Neither in Australia, nor indeed anywhere in the world, is there a great deal of survey information which can provide functions from which marginal productivities can be calculated. Australia is not short of farm management economists who are capable of deriving production functions from survey data, if they thought it worthwhile to collect such data. The fact is, however, that, to the writer's knowledge, only eight such analyses have been carried out since 1957. The latest of these is a study of irrigation farms in Victoria by G. F. Hickey.[11]

Clearly, insufficient experimental or survey data is available in Australia for the estimation of production functions. If such data were available from experiments, or if farm management economists had collected suitable survey data, then many more production function analyses would have been performed. A similar situation exists overseas, though not to the same extent in all countries. Heady and Dillon review production function analyses from farm studies in many countries of the world.[12] In the number of studies attempted, the United States leads the field, followed by Japan. Three studies only are quoted for the United Kingdom, despite the highly developed agriculture of this region. Evidently, not as much work has been done in this field as might have been done.

### *The Scarcity of Production Function Studies*

Data for production function analyses become available as more suitable experiments and more farm surveys are made. It has already been noted that not many experiments in certain parts of Australia, at least, provide material suitable for marginal analysis. This situation is

[9] J. T. Reid, "Problems of Feed Evaluation related to Feeding of Dairy Cows", *J. Dairy Sci.* Vol. 44 No. 12, Dec. 1961.

[10] O.E.C.D., "Inter-Disciplinary Co-operation in Technical and Economic Agricultural Research", *O.E.C.D. Documentation in Food and Agriculture* No. 50, Paris, 1962, pp. 22-30.

[11] G. F. Hickey, "The Economics of Irrigated Dairyfarming in the Central Gippsland Irrigation District", unpublished M.Agr.Sc. thesis, Univ. of Melbourne, 1964.

[12] E. O. Heady and J. L. Dillon, *Agricultural Production Functions*, Iowa State Univ. Press, Ames, 1961, Ch. 17.

not peculiar to Australia and one of the reasons for it is that scientists and economists have different outlooks. Dorfman *et al.*[13] rightly suggest that scientists are interested primarily in "different ways of doing things, each of which implies its own characteristic pattern of input and output rates". Economists, on the other hand, want to establish the optimal pattern of inputs and outputs for each production process. Both sets of information are descriptions of the technological conditions of production but, while scientists regard the former as their function, they do not so regard the latter. Thus, to quote Dorfman *et al.* again:[14]

> "The production function is a description of the technological conditions of production and the economist takes no direct responsibility for ascertaining it. Instead, he regards it as falling within the purview of the technologist or engineer. But there seems to have been a misunderstanding somewhere, because technologists do not take responsibility for production functions either. They regard the production functions as an economist's concept and, as a matter of history, nearly all production functions that have actually been derived are the work of economists rather than of engineers."

The attitude of scientists to experimentation undoubtedly has some validity where untested new production techniques are waiting to be examined, and it may be more important to know average input and output data for them than to calculate optimal solutions for accepted processes. This proposition is more likely to be correct in underdeveloped countries, where superior production methods may be able to change the face of agriculture. Nevertheless, even in highly developed agricultural countries, new production methods are continually being discovered, many of them by farmers themselves, and all have some claim on the time of economists. Williams[15] sums up the argument as follows: "the aim should be to get on the right production function and not to worry too much about the location on that surface especially when this is subject to uncertainty anyway".

A second general reason for the scarcity of production function analyses is the recognition that individual farm functions are required for solving individual farm problems. Since it is not feasible to establish these, economists have to use what is available—experimental production functions or average production functions from survey data. In both cases, but particularly with production functions from farm surveys, economists are divided in their opinions about the value of this type of evidence as a basis for advising individual farmers. To put it another way, if economists were satisfied that production functions derived from experiments or farm surveys could be applied to individual farm situations, then, no doubt, there would be a great many more production functions available. In the same vein, it is recognized that uncertainty in predicting future prices and production levels limits the value of even the most refined production functions. Williams[16] has suggested "that we are worshipping a false and transient image, in the

[13] R. Dorfman, P. A. Samuelson and R. M. Solow, *Linear Programming and Economic Analysis*, McGraw-Hill, Englewood Cliffs, 1958, p. 131.

[14] *Ibid.*

[15] D. B. Williams, "Economics in Australian Agricultural Extension Services", *Aust. J. Agric. Econ.* Vol. 3 No. 1, July 1959, p. 32.

[16] *Ibid.*

present state of our knowledge, if we try to base extension programmes on changes in input levels, up and down, in accord with changes in cost-price ratios". The fact that such attempts are confined largely to the lecture room is perhaps a reflection rather of lack of data than of conviction.

The number of experiments and farm surveys made also depends upon the resources available and the passage of time. Resources are limited both in terms of the quality and quantity of labour and capital required. Experiments and surveys comprehensive enough to give several points on the same production function (or what is hoped is the same production function) unquestionably require more time and capital than those designed to give only two points. While this may not be the only reason why more data suitable for production function analysis is not available, it is certainly a major one. Schapper, Parker and Treloar appreciate this point in discussing experimental design and supplementary feeding for sheep.[17] However, they suggest, as a solution, that the capital might well be voluntarily provided by farmers themselves. This indeed, is one avenue not fully explored, which could remove one of the limitations at present restricting the number of experiments that are adequate for economic analysis.

Though better ways of finding capital for farm management research may be found, the technical difficulties are still very great. Gilson[18] sums this up very well, not only for Canada but for all countries, as follows:

> "If the farm management specialist is to deal effectively with the many questions which are raised by farmers and agricultural administrators in Canada, he will have to be supported by a continuing programme of sound research. For some inexplicable reason, it is believed by many (economists included), that solutions for the important economic problems associated with the farm business are readily available or, if not available, may be quickly obtained through farm accounts or farm management surveys. For those who have engaged in serious research, nothing could be further from the truth. The farm management specialist must depend on a programme of research every bit as tedious and complicated as that of the plant breeder or animal nutritionist and, like the fields of plant or animal science, farm management research may range from the Baconian methods of 'getting the facts' to the highly deductive methods of mathematical economics."

Nothing so far said is meant to suggest that farm economists have not a useful part to play in assisting research workers to plan experiments which give better results on which to base economic decisions. However, while this is a laudable activity, it cannot be regarded as a full-time occupation.

It might be supposed that a search through the literature would

[17] H. P. Schapper, M. L. Parker and D. W. G. Treloar, "Supplementary Feeding of Sheep and Experimental Design", *J. Aust. Instit. Agric. Sci.* Vol. 24 No. 4, Dec. 1958, p. 335.

[18] J. C. Gilson, "The Role of Farm Management in Relation to the Technological Development of the Agriculture Industry", *United Nations Conference on the Application of Science and Technology for the Benefit of the Less Developed Areas*, U.N. E/Conf. 39/C/405, Oct. 1962, p. 3.

indicate the extent to which the quest for production functions is continuing. To some extent this is so, and it has already been shown that the number of completed production function studies in Australia is small. What is also indicated, however, is that linear programming has taken a great hold on the profession in recent years. This, in itself, is an indication that production function analysis has, to a greater or lesser extent, been abandoned.

### *Alternatives to Production Function Analysis*

The establishment of non-linear production functions is, as already stated, difficult and, when established, they have not always, in the opinion of some, Johnson[19] for example, been used very effectively. The establishment of linear production functions is just as difficult but, occasionally, their existence is assumed though not rigorously proved. A case in point is the assumption that pasture is being wasted and that additional animals can be grazed without affecting production per head of any of the flock.

The main alternative to production function analysis involves the assumption of constant returns to scale, i.e. a linear relationship between a specific set of inputs and a known output. Thus, in haymaking, it is usually assumed, probably correctly, that the same unit of combined inputs of land, labour, machinery and fuel will continue to produce successive units of hay. A similar assumption is made in linear programming. In each enterprise or activity, the combined variable inputs are assumed to produce the same output. The situation described both for the case of haymaking and for linear programming is the result of constant returns to scale.

Fortunately, there is some evidence that constant returns to scale do exist in agriculture in Australia. In most of the production function studies made in Australia from farm survey data, approximately constant returns to scale have been found.[20] These studies have all used the Cobb-Douglas type production function.

Both in linear programming and in all budgeting studies, except those few which incorporate data from production functions, no attempt is usually made to combine inputs for any one production process in the optimal proportions. There is no reason why this should not be done, except those given in the earlier part of this paper. Generally, the inputs for each enterprise, combined on the farm as they are at the moment, optimal or not, are, with their appropriate outputs, expanded or contracted. This situation is shown in Figure 3 where a Cobb-Douglas production function is assumed. Line OABC represents the optimal combination of cows and acres on a given farm at different levels of total production. Point E represents the present combination of cows and acres on the farm where the output is 10,000 lb. butterfat. If the dairying operation is called upon for expansion from 10,000 to 20,000 lb. in a linear programming exercise, the expansion would occur from E to F. In fact, B would be the optimal point.

Though it does not usually attempt to combine inputs for a single production process at their optimal level, linear programming is,

[19] G. L. Johnson, "Stress on Production Economics", *Aust. J. Agric. Econ.* Vol. 7 No. 1, June 1963, p. 16.
[20] G. F. Hickey, *op. cit.*, p. 28.

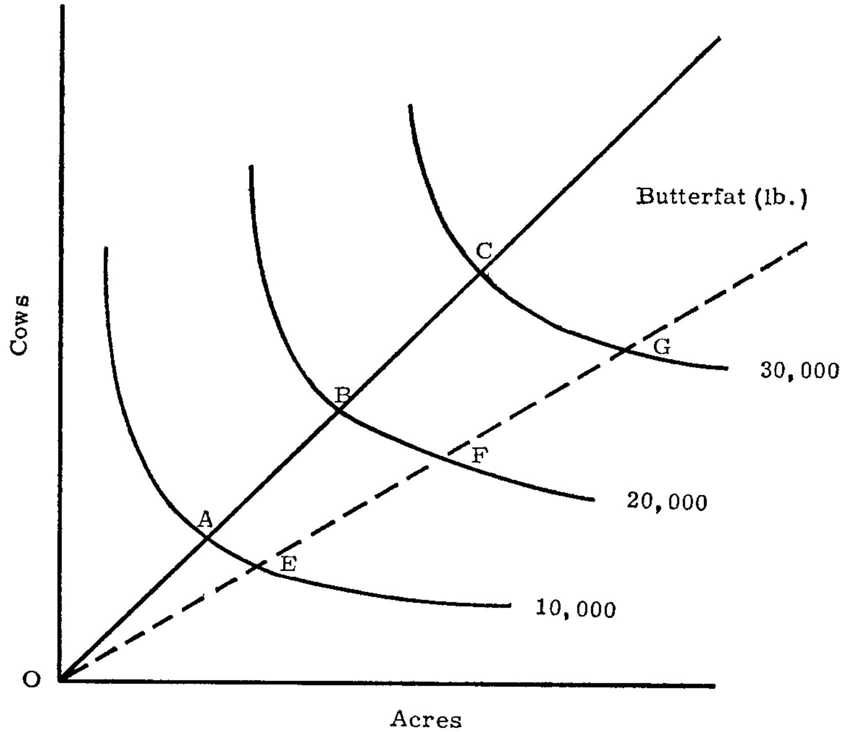


FIG. 3

nevertheless, a logical method of farm planning. At the very least, it provides a logical approach to the problem of combining enterprises in the very practical situation of limited resources. Nevertheless, since many farms in Australia, perhaps most, are single enterprise businesses, linear programming is not always a helpful alternative to production function analysis.

One other aspect of linear programming and its derivatives is of some consequence in this discussion. Where a new enterprise or activity is to be introduced to the farm, an estimate of the output and the combination of inputs necessary to produce it must be made. In the absence of known optimum, average or individual inputs and outputs from other farms or experiments, all that is left is a guess. Thus, there is a case for the preparation of a series of average inputs and outputs for production processes which can be used for budgeting or programming purposes. This is a major problem (perhaps the major problem) in farm management research and extension in Australia today. It is a problem as great as, if not greater than, establishing the best technique to use on largely non-existent data. It is a problem of establishing average figures.

Where there is no opportunity to recombine enterprises already operating on the farm, other ways of providing farm management advice are required. One method (the most common) is to use the experience from other farms and experimental data to estimate the direction in which a profitable change in resource use might be made. The individual input-output data from another farm, or the average from a group of farms, is used to calculate a point on the production surface. If the net income at this point is higher than that of the problem farm, the direction of a profitable change in resource use has been suggested. The words "direction of a profitable change" are highly significant. Since the production functions of no two farms are the same, the profitability of a proposed change can only be established with certainty after that change has been made. This is exemplified in Figure 4. Point B is where a farmer is currently operating, using one series of inputs represented by $X_2$, but none of $X_1$. Farm production is 20,000 lb. butterfat at B. It is suggested, suppose, by a published study that if OF of input $X_1$ were used, total costs would be raised by an amount equal to 1,000 lb. butterfat but 23,000 lb. butterfat would be produced. This position is represented by M in Figure 4.

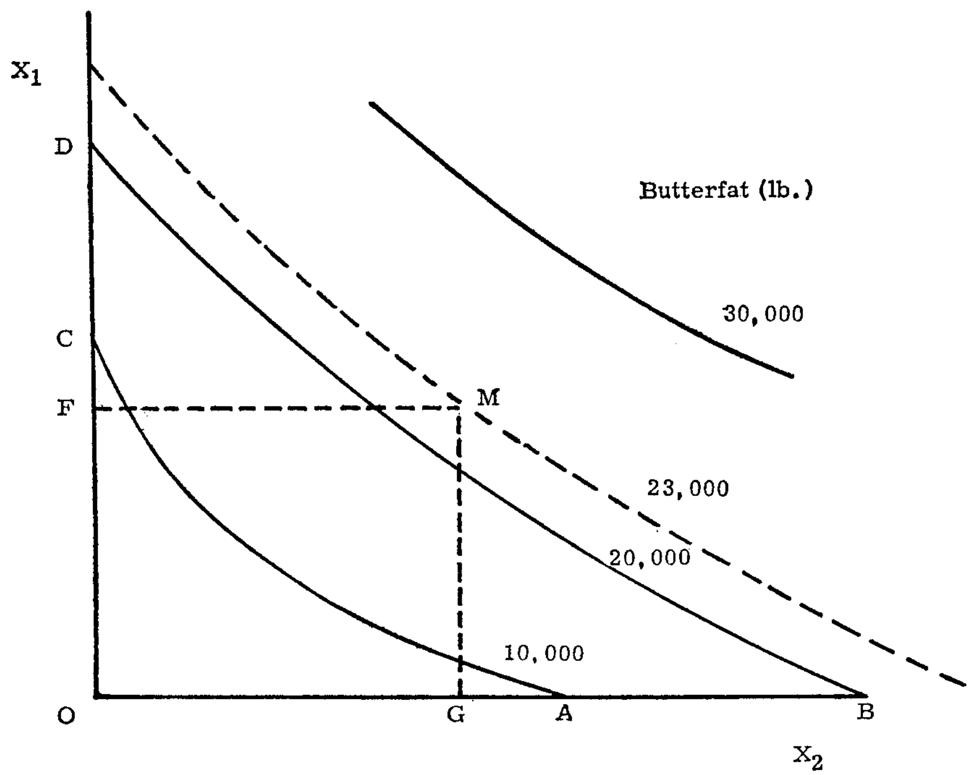


FIG. 4

One case that Figure 4 could represent is the result of a published budget study. The study might show that the introduction of a fodder crop ($X_1$) in place of pasture ($X_2$) only, is likely to increase income with an increase in costs equal to 1,000 lb. butterfat. A second case illustrated by Figure 4 could be the result of a published standard farm. The standard farm could be shown as having a series of inputs including $X_1$ (which might be concentrates) and an output of 23,000 lb. butterfat. The conclusion of a farmer at B who does not use concentrates might be that it would be worth trying some to see what happens. The question still remains whether the calculation of point M is likely to provide a reasonable combination of resources and level of output leading to a net income which would be higher than many farmers already have.

The argument for a series of standard inputs and outputs is that one point on the production function or production surface is given, which is in the optimal range though not at the optimal point. In Figure 2, the "optimal" range is given by EL and the average, or standard, is in the middle of this range at S. In Figure 4, this same point could be represented by point M. All farms are operating on their own production functions. If each farm adopted a "standard" level of input then, for some farms, this might be point E and for others, point F, in Figure 2. It might be expected, however, that most farms would range between E and L. Thus, on the average, the group of farms will be operating somewhere near the middle of the average input-output curve.

The various inputs and the volume of output which give rise to the average or standard farm can be divided by one another to give several ratios. The process of comparing the ratios of individual farms with the average ratios has become known as comparative analysis. Comparative analysis is a term which seems to have been coined in the United Kingdom to describe the process of deducing what might be done on one farm by comparing it with what is done on others. The main vehicle for comparison is a series of ratios, which are described in *The Farm as a Business*.[21] A standard ratio would be 100. Hence the adoption of the term "standard" to describe this method of analysis. Comparative analysis and the use of standards have been highly developed in the United Kingdom but are by no means confined to that country. They are used, for example, in the United States at Cornell University[22] and were used by the early workers of that country in the farm economics field.[23]

Standards must be used in conjunction with trial and error modications. The modification may involve a reallocation of resources in the present production process, or it may involve a new method of producing the product. Unlike a budget, comparative analysis does not show the specific costs involved in moving from one income level to another. It merely suggests the kind of budgets which it might be profitable to make. Comparative analysis is, therefore, a precursor of budgets and does not take the place of them. In this connection, an international seminar of farm management experts came to the conclusion that standards have "often proved effective in making them [farmers] reconsider their management methods and has led directly to improvements in profit".[24] It has also been said of standards that they do little more than "erect monuments to past folly" since they are based on past performance of actual farms.[25] This is true in the sense that they can do no more than make below-average farmers average. If the scatter of farmers about the average is wide, then it may be a considerable achievement to bring those below average to somewhere near the average.

It is not suggsted that the calculation of standards from farm surveys can be anything else but a first step in providing farm management

[21] *The Farm as a Business*, H.M.S.O., London, 1958.

[22] G. Casler, *Farm Business Management: Ontario County 1961*, Cornell Univ., Dept. of Agric. Econ., A.E. Ext. 173, Feb. 1962.

[23] H. C. M. Case and D. B. Williams, *Fifty Years of Farm Management*, Univ. of Illinois Press, Urbana, 1957, p. 360.

[24] O.E.C.D., *op. cit.*, p. 151.

[25] O.E.E.C., *Farm Management in the United States: Report by a Group of Experts*, O.E.E.C., Project No. 395/B, Paris, March 1958, p. 45.

advice. There is always the danger that surveys to calculate standards will be repeated in the same repetitive form, year after year, without adding anything new. Johnson points out that this was a danger which finally overtook the early workers in farm management.[26] He also points out, however, that this danger can also overtake workers using more sophisticated techniques. Standards will be able to indicate fewer weaknesses in farmers' businesses, as farms become more uniform, and they will thus help to solve fewer problems. Likewise, once standards have been calculated and have shown the need for specific budgeting studies to answer specific problems, the problems can then best be solved by doing the budgeting studies, not by calculating more of the same sort of standards.

A serious drawback of the standards approach is that, by itself, it does not use all the information which was collected to produce the standard. This suggests that all the data collected should be published even if it is not analysed beyond calculating standards, so that the complete farm picture is given. Just as average figures may suggest profitable changes in organization to below-average farmers, so may individual above-average figures suggest profitable alterations to other above-average farmers. There is, therefore, every reason to publish all figures.

The difficulties of using standards, or any survey material for that matter are formidable. Schapper has dwelt on this at some length.[27] Candler and Sargent have demonstrated the errors that an adviser untrained in production economics may commit.[28] The positive value of production economics is unfortunately small, but this same statement is true of most advisory information, because of its fragmentary nature. Production economics has its greatest value in preventing standards (and other information) from being used in the wrong way. Every efficiency ratio or standard which is used in some general context can theoretically be wrong for every individual farm to which it might apply. Production economics can demonstrate that this is so. At the same time, a budget for the individual farm could demonstrate it equally well. Given that a farmer or adviser recognizes the need for a budget and knows the range of alternatives open to him, no efficiency ratio or standard is likely to lead him astray even though he has no great understanding of production economics theory. Nevertheless, if it is believed that advisers do lead farmers into error by accepting efficiency ratios blindly and refusing to use budgets, then production economics theory has the value noted above.

In the State of Victoria, advisory officers are sometimes sent to districts where there has never been an advisory officer before. In these circumstances, it is hard to imagine a more suitable beginning than to attempt to estimate the profitable range on the production functions where farmers are currently operating. Whether or not all advisory officers, stationed for some time in an area, are capable of doing this without a formal survey, is open to some doubt. For example, Cozens and White found that some farm management practices which were

[26] G. L. Johnson, *op. cit.*, p. 12.

[27] H. P. Schapper, "Uses and Limitations of Farm Surveys", *Aust. J. Agric. Econ.* Vol. 1 No. 1, June 1957.

[28] Candler and Sargent, *op. cit.*

being recommended in 1958 added little to incomes in a dairying district.[29] At the same time, the reallocation of other resources which were likely to increase income considerably had been neglected. In a recent sociological survey in the same area, some five years later, Brien, Wrigley and Jardine, among other things, confirmed that particular finding of the earlier work.[30]

### *Example of the Use of Standards from Survey Data*

Examples of the use of standards exist in abundance and it might seem unnecessary to produce yet another one. However, one point does not seem to have been sufficiently recognized, viz. that the aim of the standards approach is not to maximize efficiency ratios but to maximize net income. The system of comparative analysis advocated by Blagburn is described in *The Farm as a Business* and another good example of the use of the system is given by Clarke.[31]

Farm 18 in Table 1 is below average in net farm income per acre. The problem is to suggest a way to increase net farm income per acre and hence raise net farm income. The stocking rate is low, 4·36 acres per cow and, therefore, well below average. This suggests that an increase in stocking rate could increase income. Suppose it is proposed to add 10 more cows, raising the stocking rate to 3·5 acres per cow. Suppose at the same time the farmer is only willing to do this if additional hay is made or purchased, so that all cows have 3,500 lb. per cow. He is already above average in hay consumption and this will, of course, make him worse still. Will this matter? It will not matter if, in making the change, his net income is higher than it was before. In more academic terms, if the marginal return from adding 10 more cows is greater than the marginal cost of the added hay and other associated cow costs, then it will pay to make the change. Suppose the variable costs of adding one more cow are £10 and for 10 cows £100, and that 20 tons of hay has to be purchased at £7 per ton. The total cost of the proposed change would be £240. Total return per cow is £81·7 and the added total returns for the ten cows £817 if production per cow remains the same. On this simple budget, it would clearly pay to add more cows.

Suppose the change is made and is successful or unsuccessful, as the case may be. Is a further profitable change suggested by the data of Table 1? Concentrate per cow is low and so is production per cow. This suggests an increase in concentrate feeding, with the hope of raising production per cow by more than the cost of the feed.

It is clear that the content of production economics in the above exercise is rather small. The idea of marginal product and marginal cost is present. It is likely that the concept of opportunity cost would arise because extra labour would be required for the additional cows. The difference between fixed and variable costs is evident. What is also clear is that a farm adviser could begin to offer sound advice to Farm 18

[29] L. E. Cozens and H. A. White, *A Survey of Dairy and Pig Farms in Woorayl Shire, South Gippsland, Victoria*, Dept. of Agric., Melbourne, 1959, p. 43.

[30] J. P. Brien, J. F. Wrigley and R. Jardine, *A Study of Some Personal and Social Factors in Relation to Farmer Performance*, Dept. of Agric., Melbourne, 1963, unpublished.

[31] *The Farm as a Business, op. cit.*; G. B. Clarke, *Making the Farm Pay*, Dept. of Agric., Univ. of Leeds, Feb. 1956.

TABLE 1

*Comparative Data from 19 Dairy Farms—Upper Yarra Valley, Victoria*

| Farm no. | Hay per cow | Super. per acre | Concentrate per cow | Milk prodn. per cow | Stocking rate (acres/cow) | Milk prodn. per acre | Milk prodn. per acre | Net milk prodn./acre* |
|---|---|---|---|---|---|---|---|---|
| | lb. | lb. | £ | galls. | acres | galls. | £ | £ |
| 1 | 1680 | 320 | 9·2 | 746 | 1·48 | 504 | 72·3 | 66·1 |
| 2 | 2428 | 350 | 14·8 | 684 | 2·27 | 301 | 45·8 | 89·3 |
| 3 | 1670 | 182 | 12·7 | 598 | 2·29 | 261 | 36·7 | 30·9 |
| 4 | 1102 | 170 | 10·4 | 598 | 3·66 | 163 | 28·4 | 25·0 |
| 5 | 723 | 200 | 12·6 | 619 | 2·83 | 218 | 37·6 | 33·2 |
| 6 | 1467 | 228 | 17·7 | 794 | 2·75 | 289 | 38·5 | 32·0 |
| 7 | 1975 | 237 | 10·4 | 576 | 3·00 | 189 | 26·8 | 23·8 |
| 8 | 3294 | 235 | 12·1 | 697 | 3·33 | 209 | 32·9 | 29·3 |
| 9 | 1400 | 150 | 12·7 | 588 | 2·97 | 198 | 32·8 | 28·5 |
| 10 | 1064 | 112 | 15·4 | 496 | 2·24 | 221 | 30·3 | 23·4 |
| 11 | 2211 | 246 | 7·6 | 510 | 2·17 | 235 | 35·9 | 32·1 |
| 12 | 1921 | 100 | 5·1 | 481 | 3·52 | 137 | 21·5 | 20·0 |
| 13 | 3731 | 186 | 2·2 | 478 | 3·10 | 155 | 25·9 | 25·1 |
| 14 | 3102 | 301 | 12·0 | 562 | 3·06 | 184 | 28·8 | 25·0 |
| 15 | 1288 | 240 | 9·6 | 625 | 3·65 | 171 | 25·1 | 22·4 |
| 16 | 1892 | 120 | 9·6 | 611 | 2·86 | 213 | 33·5 | 30·2 |
| 17 | 6000 | 112 | 9·6 | 523 | 3·94 | 133 | 21·4 | 18·9 |
| 18 | 3233 | 0 | 0·0 | 484 | 4·36 | 111 | 17·7 | 18·4 |
| 19 | 3445 | 280 | 16·7 | 771 | 4·20 | 183 | 25·2 | 21·2 |
| Average | 2296 | 199 | 10·5 | 602 | 3·04 | 214 | 32·5 | 31·3 |

* Net of concentrates.

with the information in Table 1, together with a knowledge of the farm itself. It may be objected that an adviser could offer the same advice without the aid of such a set of data because he would know the figures intuitively. He may—but, when farm economists can produce something which works, however simple, it may be best to make sure of it and not trust to intuition.

### *Modified Standards from Survey Data*

In Australia, while certain information is available to advisers from experiments, most of the economic information on which they rely has to come from the farms they see. Advisers use a formal or, more usually, an informal survey to decide what courses of action they will advise. Farm survey data, no matter how it is analysed, is valueless for predictive purposes unless it is accepted that the effect on output of different combinations of inputs on different farms can show what is likely to happen on any one farm. The same thing could be said about the personal observations of advisers. While all this might be the case, it is not generally supposed that it is. Both farmers and advisers act on the proposition that what they see on one farm may be of use on another, with or without modification. A great deal of information from farms is used in this way. Since it is so used, production economics—if it is to play a realistic part in helping the adviser—must make some contribution. The problem is to make the most out of what information there is, not to work out an ideal solution from a manufactured set of figures.

One solution is to get information from a sufficient number of farms, so that a mathematical function can be applied to it. Using a Cobb-Douglas function, for example, the effect on output of a number of inputs can be calculated. To obtain what is usually regarded as a sufficient degree of accuracy, data from at least 50 farms are required. Since this is rarely done, the advisory officer is left with details of many farms in his head and perhaps 20 or so on paper.

An illustration of the kind of information an adviser may have as the result of a survey of fairly homogeneous farms is shown in Table 1. One problem becomes clear immediately. There are not enough farms to construct curves to show the textbook factor-factor relationships for two variables, all else being held constant. It is, therefore, impossible to begin to advise farmers what levels of inputs to use to equate marginal cost and marginal return. There is no evidence of any relation (i.e. a production function) between hay fed per cow and either production per cow, stocking rate, or production per acre. The textbook production function is absent. It would appear that 180 to 220 gallons of milk, worth £23 to £33 per acre net of concentrate costs, can be obtained with anything from 700 to 6,000 lb. of hay per cow. Deleting the two extremes, the same statement can be made for 1,000 to 3,500 lb. of hay. At the lower extremity of hay fed per cow, one would expect production per acre to fall. It might not, but this is what one would expect. The production function might reasonably be expected to appear as in Figure 5, with a band of possibilities instead of one line. If a production function of the type in Figure 5 were accepted, the marginal equivalent would appear as in Figure 6. The average figure for hay per cow is 2,296 lb. Bearing in mind that farms are not homogeneous, to accept

1,000 lb. of hay per cow as the point where diminishing returns begin might be dangerous. It would appear safe enough for an adviser to suggest to farmers to slowly reduce hay fed per cow to 1,500 lb., keep

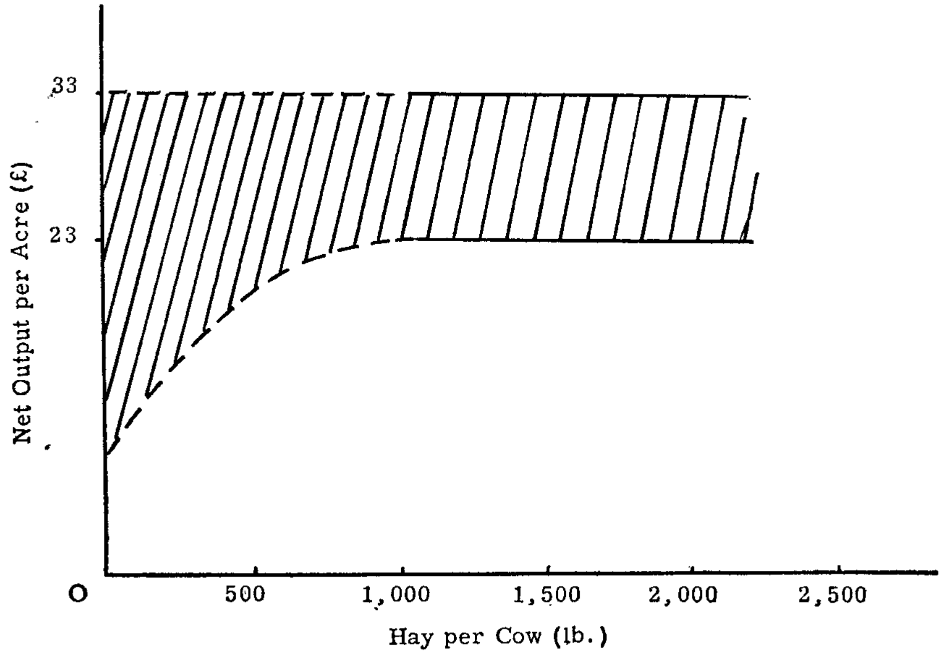


FIG. 5

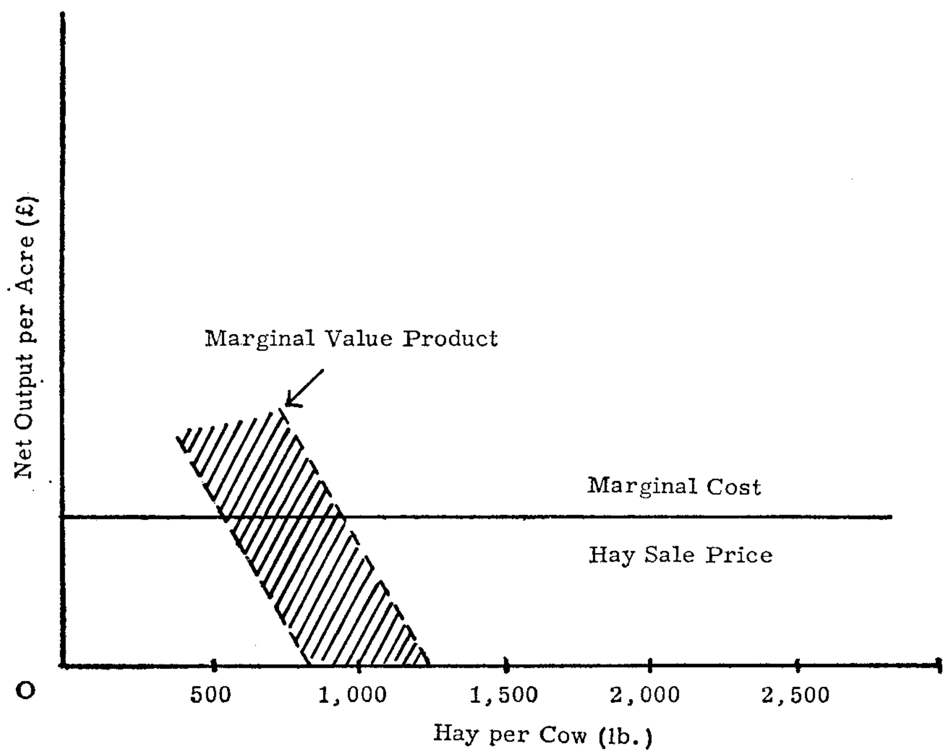


FIG. 6

the rest and see what happens. Thus may a modified standard begin. In this case, it could be said that a standard has been defined as the result of a rudimentary attempt to define a production function.

In the absence of well documented production function data, it is reasonable that advisory officers should attempt to define modified standards of their own, or have this attempted for them by farm economists. It is clear that there is a limit to the number of variable factors which can be defined in this way without a great deal of detailed study. Nevertheless, there are sufficient variable factors (hay, concentrates, silage, cows, labour, acres) to provide a start, and it is sensible to begin on the easier factors which, as it happens, seem to have the most effect.[32] The unprofitable parts of rudimentary production functions are, in some cases at least, discernible from the data which are necessary to define standards.

The preceding argument suggests that there is a further logical step which should be taken when establishing modified standards. It is this: if there is a trend in survey data which can be seen by tabular and graphic analysis, then it can be more clearly seen by using mathematical analysis. A Cobb-Douglas production function was therefore fitted to eighteen of the farms in Table 1. Six variables were used and the analysis showed that three of these were significant, viz. cow numbers, superphosphate, and concentrates. The six variables accounted for 96 per cent of the variation in milk production. The amount of hay fed was not significantly related to production, confirming the subjective diagnosis an adviser may have made from the data in Table 1. By contrast, an adviser would have been unlikely to suspect from the information available that superphosphate usage was significantly related to production. Thus, in this case, the regression analysis confirms the modified standard and provides marginal productivities for three other variables from which other modified standards may be derived. The success of this one analysis suggests that economists can usefully fit production functions to fragmentary data in Australia at least, and provide modified standards for advisers and farmers.

## *Conclusion*

Production economics and its concomitant marginal analysis is really only useful when appropriate production functions have been established. In agriculture in Australia, such functions are nearly all of the cross-sectional farm survey type, analysed by regression analysis. It has been noted in this paper that these studies are comparatively rare.

Production function studies which have as their objective the optimal allocation of resources are not likely to be the most useful form of employment for farm management economists. The resources required are too large and the optimal levels so calculated too doubtful for use on individual farms, without serious modification. The direction in which resources should be changed is the most important thing, because the optimum can never be known on an individual farm. Some consideration should therefore be given to calculating marginal productivities by regression analysis for small farm surveys. The object of this analysis would be to suggest the direction of resource allocation for average

[32] Cozens and White, *op. cit.*

farmers. Above-average farmers can only be assisted by experiments and case studies.

The method of thinking involved in marginal analysis is not being questioned. Undoubtedly, research farm economists need a thorough grounding in marginal analysis so they can recognize data from which marginal products can be calculated—in case they should ever unearth it. Beyond this, however, marginal analysis remains a method of thinking, rather than a practical tool to find an optimum answer. The real test of production economics theory is its value in interpreting the economic implications of inadequate data, for data will always be inadequate for any one farm, and probably, for any one district. How well it has succeeded is an enigma. A course in higher mathematics would be a better preparation for a farm economist faced with this situation, than a course in higher production economics.

Most attempts to solve farm problems have to be made with average figures. The lack of average figures for use in research and extension in Australia is a greater problem than the question of which technique to use with them. The budget is the practical method of providing solutions to farm management problems, because it uses whatever information is available. Alternative solutions can usefully be given by using averages for different ranges of input. The economic concepts involved in using budgets are few, but they can be shown to be useful and are as follows, an understanding of:—

(i) the difference between fixed and variable costs;
(ii) opportunity costs; and
(iii) the meaning of a marginal cost or return.

There is one added requirement derived from common sense rather than economics—an awareness of the range of alternatives. This latter requirement is more fully met in the formal approach to resource allocation that linear programming supplies than it is in simple budgeting. For this reason alone, the method of setting out the problem used in linear programming is to be commended.

The calculation of standards serves a useful purpose by suggesting changes in farm organization which enable below-average farmers to become average farmers. Standards are most useful where there is a wide spread about the mean, as appears to be the case in Australia. The change in farm organization suggested by standards must be followed by a budget. The standard only suggests the kind of budget which should be made. It does not, in itself, provide the added costs and returns involved in making the change. Thus it differs from a budget study designed to solve a specific problem.

Standards need only be calculated for one or two years to achieve their object. All the figures from the farms in the survey should be shown. The calculation of standards should be followed by studies designed to solve specific problems. It is certain that some of these problems will have been suggested during the calculation of the standards. The budget studies themselves will, in most cases, be establishing an average or standard input-output situation.