Farm management

UNIVERSITY OF NOTTINGHAM

The Economic Arithmetic of Agriculture

Inaugural Lecture by

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Not long ago a leading newspaper reported the case of a farm manager, responsible for 14,000 acres, who "believes that instinct is out and exact daily figures are essential. Over his farms he has weigh bridges installed at strategic points to weigh the fertiliser, the produce and livestock in and out of every field. Used to the careful interpretation of the results of research, he reads a great deal and guesses nothing".

Another farmer in this East Midlands region of ours recently described his ambitions as follows: "To iron out the spasms to which all farming activity is subject and to make the work graph run level throughout the year".

This seems to be a new kind of language for farmers to talk. I suppose it is the inevitable accompaniment of the scientific and statistical age in which we live. "Instinct is out . . . . . he guesses nothing . . . . . to make the work graph run level throughout the year . . . . ." Is mathematical precision taking the place of the wisdom of experience which has for so long been held in reverence as the hard-won and close-kept secret of success in farming?

What did Virgil's husbandman, for instance, care for "the work graph of the year" ? Obedience to the rules of good husbandry in those days does not appear to have called for even a rudimentary knowledge of the three R's. I have searched in vain in the Georgics for any precepts expressed in quantitative terms. If he could but count the days of the month as they passed, the swain would have arithmetic enough.

I shall quote from Dryden's translation of Virgil (for who today would expect an economist — or his audience — to be conversant with the original?).

> "The lucky days in each revolving moon
> For labour choose: the fifth be sure to shun ;

That gave the Furies and pale Pluto birth,
And arm'd, against the skies, the sons of earth.
.....
The seventh is, next the tenth, the best to join
Young oxen to the yoke, and plant the vine.
Then, weavers, stretch your stays upon the weft.
The ninth is good for travel, bad for theft.
Some works in dead of night are better done,
Or when the morning dew prevents the sun."

True, the peasant's marking-off of the passage of time was not expected to be confined to the lunar month. He was expected to

"Observe what stars arise or disappear ;
And the four quarters of the rolling year".

But in over three thousand lines of exhortatory and pragmatic verse, the only hint of any necessity to budget, to plan the work graph of the year or to instal any kind of inventory control system occurs in the following passage:

"But, when cold weather and continued rain
The lab'ring husband and his house refrain,
Let him forecast his work with timely care,
Which else is huddled, when the skies are fair:
Then let him mark the sheep, or whet the shining share,
Or hollow trees for boats, or number o'er
His sacks, or measure his increasing store".

Thousands, probably millions, of farmers in the world today do not attain even that modicum of measurement. The yeoman stock of this country were for centuries distrustful of book-learning and of precise calculation. One of our own poets of more recent times, Victoria Sackville-West, observed with keen insight this resistance when, in 1926, she wrote of the Kentish yeoman

"His way is still the obstinate old way
. . . Still is his heart not given
To such encroachments on a natural creed ;
Not wholly given, though he bows to need
By urgency and competition driven,
And vanity, to follow with the tide
. . . and in his calling takes a stubborn pride
That nature still defeats
The frowsty science of the cloistered men,
Their theory, their conceits.
The faith within him still derides the pen,
Experience his textbook".

One is reminded of Edmund Burke's outburst — though it was provoked in a rather different context —

> "The age of chivalry is gone. That of sophisters, economists and calculators, has succeeded ; and the glory of Europe is extinguished for ever".

This resistance to sophisters, economists and calculators has by no means disappeared from the twentieth-century farmer's way of thinking, but there are many signs that it is crumbling. The two instances to which I referred at the beginning are not particularly eccentric ; they are of a type which is providing the kind of leadership which attracts a big following. The progressive young farmer of today knows that instinct and guesswork are out.

Their place is being taken by the analysis of detailed farm records, by budgeting, by comparison of individual attainments in production and expenditure with standards based on observation of many farms and by controlled experiments. There is a new flexibility in systems of farming, which springs from recognition of the fact that higher productivity and higher profit come not only from more effective deployment of resources in their present uses but also from transfer of resources from less productive to more productive enterprises.

Mathematical devices and techniques first applied elsewhere are now rapidly being adapted to agriculture's needs. One example is the slide rule. Some farm management experts are convinced that there now exists a sufficiently well-established body of empirical data about certain input-output relationships in certain types of farming that it is worthwhile for day-to-day advisory purposes to have at hand a slide rule on which the scales are appropriately laid out. I have in my possession a German "farm slide rule", developed by Blechstein. It embraces seven distinct groups of scales and is designed to deal with such diverse questions as: the feeding rations required for cows at various levels of yield ; the acreage to be planted with certain crops in order to provide a given feed supply ; the receipts from sale of milk at a given price, at a given level of yield per cow and with a herd of a given size ; the optimum rate of substitution of tractors for horses in various working conditions ; and the amount of labour which the farm should require, taking account of its size and land utilisation.

Of course such a slide rule has its limitations. Because of physical or organisational differences between the individual farm

and the hypothetical model farm built up from present knowledge, the indications obtained by using the various scales may be misleading. The instrument has to be used intelligently and with a full appreciation of its inherent assumptions. But so used, it may often be able to indicate weaknesses in a farm's organisation and modifications which are likely to prove profitable, and to do this in a fraction of the time which reiterated trial-and-error arithmetic would demand, and with less risk of mistakes in calculation. Many farmers get into difficulties not because they have the *wrong* enterprises (cows, hay, roots, cereals), still less the *wrong* resources (labour, tractors, fertilisers, land), but because they have them in the wrong proportions — they do not fit together properly. It is claimed that the slide rule will assist in carrying out the calculations necessary to indicate more desirable, yet still practicable, combinations ; but it does not, and never will, provide all the answers. Farming is too heterogeneous for that.

A second example of the application of a modern mechanical device to farm management problems is to be found in the use of electronic computers for linear programming. This is another approach to the problem of finding the best solution from among an almost infinite number of possible combinations, the criterion being that the best solution shall be that which maximises the final profit but does not conflict with certain restraints which are imposed on the solution to make it realistic and practicable. For example, it may be decided to instruct the machine, when seeking the "best" use of land on a farm of 100 acres, not to produce a solution which postulates more than, say, 20 acres of sugar beet (because of an acreage quota restriction imposed by a public authority), nor one which "bunches" the labour requirements too much at one season of the year and leaves labour idle at another. To carry out in their entirety the calculations necessary to produce the unique, optimum solution would be inconceivable without the help of an electronic computer or a comparable machine.

Here once again, the instrument has to be used with intelligence and with an awareness of the assumptions. Perhaps one of the greatest potential dangers which could result from the widespread adoption of linear programming for advisory purposes lies in the fact that the calculations usually assume that the present or recent levels of prices of farm products and of resources used in farming will persist. If, in the event, large numbers of farmers changed their enterprise combinations in a common direction, following the indications of the optimum

solution in each case — let us say, towards beef and away from milk — market price relationships would be almost certain to change very appreciably and the optimum solutions would no longer hold good.

There can be no questioning, however, that farm budgeting on the basis of systematic calculations following an approved pattern has paid handsome dividends on very many farms, and we may confidently suppose that it has come to stay. The conspiracy between agricultural economists, statisticians, accountants and rural sociologists to obtain all possible observations of the farming scene in quantitative terms is rapidly becoming an open conspiracy, as the multiple benefits of measurement become apparent. The accumulation and reconciliation of a body of "irreducible and stubborn facts" without which, as A. N. Whitehead warned us, no study can claim to be scientific, is now seen to be fundamental not only to the claims of agricultural economics to be a respectable university subject but also to the achievement of prosperity for the individual farmer and — as I hope to show later — of a sound policy for the whole agricultural economy.

I must not give the impression that a high degree of precision and tidiness has already been reached in our field. Agricultural economics belongs with the social sciences, not with the biological. The facts which we analyse in order first to trace and later to confirm significant patterns and relationships are facts of human behaviour. They reflect the decisions of men, their preferences, their social ambitions, their adaptability, their dogged conservatism, their infinite capacity for innovation or for muddling along. Man and his institutions are at the centre of our stage, not irritating intrusions which the laboratory is designed expressly to exclude.

We therefore have to accept with a good grace and an indulgent smile the idiosyncrasies of our subjects, and our theories must try to embrace their eccentric as well as their normal behaviour. Yet we are obliged to make simplifying assumptions and to abstract from the wealth of detail. Thus we may decide to concentrate on those activities which are concerned with the earning of profits, assuming that most of the decisions taken on the farm will fall more or less into place around this central motif. It is a perilous assumption. We know that we cannot dismiss as eccentrics all those farmers who get more satisfaction from the contemplation of a fine herd of cattle than from accumulating a healthy and mounting bank balance. We have to agree with those masters of classical economics who have insisted that

income consists in the last analysis of satisfactions, not of shekels. Yet without a more tangible definition of income than this, we cannot begin to measure its determinants, which is one of our major tasks. Our economic arithmetic cannot get to work.

Even when we decide that we must leave to others the exploration of the non-material motives of man and that the only kind of income with which we can come to grips is that which takes the form of cash or of goods and services received in kind, we still confront a host of measurement problems. It is not only that farmers' incomes show extreme variation from year to year and are gained in an astonishing variety of ways. They are not even determinate except by first gaining the consent of the farmers to the laying-open of their private account books and afterwards submitting the entries in those books to intricate processes of addition, subtraction, estimation and adjustment of numerous elements.

For millions of employed persons in this country, their annual income can be fairly accurately estimated without having to put any questions to them as individuals, but simply by multiplying their weekly wage by 52 and adding an allowance for the average amount of overtime worked per week and another for any special bonuses. With the aid of a ready reckoner this calculation may be achieved in a matter of seconds, and many workers in the same grades will have very much the same annual incomes.

The net incomes of each of a group of farmers in a certain 12-month period cannot be so easily determined. We have to add up the total receipts from sales of the various kinds of produce leaving the farm, making a further allowance for the value of food taken directly from the farm into the farmer's own household ; then subtract the total of all the items of expenditure incurred in producing that year's output (including a depreciation allowance for the using up of capital and its obsolescence) ; and finally adjust the result up or down to take account of any changes in stocks between the beginning and end of the year. Even this somewhat lengthy description is a greatly simplified version of the catalogue of steps which are necessary, and of the accounting conventions which have to be observed if a fair statement of the year's net income is to be reached from the scanty, and often scrappy, information made available to us.

The important point here is that the farmer's net income is a residual, not a contractual, amount. It can be accurately known only if the items on the two sides of the account are *all* present

and correct. Sometimes the farm accountant finds, to his great satisfaction, that all the necessary records are available and the amount of estimation (I spurn the use of that detestable word "guess-timation") involved is negligible. This ideal, happily, is not so rare as it used to be. Often, however, even when a respectable set of accounts is kept, particular items of income and expenditure will be found to have been overlooked. In the absence of written records, memory will nearly always discreetly exaggerate some items and belittle others, and it will be entirely fortuitous and contrary to human nature if these errors cancel out.

If there is any uncertainty about the measurement of any of the elements comprising the major aggregates in the calculation, this uncertainty is liable to be greatly magnified in the residual. Relatively small errors in large magnitudes become critical as soon as we begin to subtract these magnitudes one from another and concentrate attention on the margin between them.

One consequence of this is that it enormously increases the difficulty of tracing the economic effects of any action which a farmer may take. To identify the causes contributing to an effect and to assess the relative importance of each is difficult enough where their combined effect is capable of accurate measurement, but when even this condition is absent, the scientific attitude burns with a very unsteady flame and is liable to be extinguished altogether.

If the study of farm management has been able to retain any grip on this slippery surface of fact, it has been because of the patient efforts of more than one generation of fieldworkers to establish the true situation of a farm in detail and to repeat this operation in hundreds of cases, so that statistical analysis becomes not only practicable but valid.

If I have dwelt rather long on this question of the statistical determination of individual farm incomes it is because the explanation of these incomes — their level relative to the incomes of other members of the community and their fluctuations from year to year and from decade to decade — occupies such a central position in the whole range of our studies, from land use and labour mobility at one end to marketing and international trade in farm products at the other.

The simple arithmetical process of *enumeration,* without further adjustment, has important applications in farm economics. It is now almost one hundred years since the series of annual

censuses of British agriculture was begun, a series which has continued unbroken to the present time. Beginning with a short enumeration of the principal crops and classes of livestock, the census form now extends to well over a hundred items including a very wide range of crops, a detailed classification of animals by age, sex and purpose, various categories of labour and many items of machinery and equipment. This form has to be completed by every occupier of over one acre of agricultural land, at least once a year. In this way there has been built up a fund of statistical data, for every county and parish in the kingdom, which must surely be unequalled in any other field of industry.

Here again the application of modern electronic sorting and tabulating devices is bringing us to the threshold of quite exciting new possibilities. Census data are of value not only for the aggregates which are derived from them — the total acreage of wheat, the number of tractors and so on — but even more for the insight which they can give into the way in which those aggregates are composed — in a word, into the *structure* of agriculture.

We hear a great deal nowadays, and especially in the European context, about the importance of structural reform and structural adjustment in agriculture. Without reliable census data, however, it would be impossible to describe what that structure is, and without frequent repetition of the census it would be impossible to discern the important structural shifts, to identify the growing points and to trace the locus of significant change. It is generally acknowledged, for instance, that agricultural production in this country is becoming concentrated into fewer and fewer hands. But where and how rapidly is this change taking place ?

By means of mechanical coding and sorting of census material it is possible to submit all this information to a great variety of cross-classifications, and by repeating this at intervals of time to throw into relief these structural features and movements. The implications of any proposed change in policy, for example relating to commodity prices, can be much more clearly envisaged when such material is to hand.

From time to time one is encouraged to pursue the quantitative approach in new directions by the writings of scholars who are preoccupied with problems quite remote from one's own day-to-day work. Philosophers in particular have a happy way of formulating generalisations which fit one's own particular situation surprisingly well — but I suppose that is their job. Recently, in trying to read that difficult book by Pierre Teilhard

de Chardin, "The Phenomenon of Man", I came across his assertion that, viewed in the perspective of history, "man has only just begun to take a scientific view of his own significance in the physical world". He goes on to list a whole series of "senses" which have to be developed if, as he says, man is to discover man and take his measure. Without these senses (most of which seem to consist of a quickening of imagination in one way or another) man will remain "an erratic object in a disjointed world". In the list he places "a sense of movement, capable of perceiving the irresistible developments hidden in extreme slowness — extreme agitation concealed beneath a veil of immobility — the entirely new insinuating itself into the heart of the monotonous repetition of the same things".

I believe that it is a sense of movement closely akin to this which inspires the best work in economic analysis generally and which particularly illuminates those types of structural analysis which can be performed for a steadily-evolving industry like agriculture.

The census provides a convenient bridge by which I should now like to lead you from the economic arithmetic of the individual farm to that of the national farm — this term being a useful abstraction coined to represent the whole agricultural activity of the nation regardless of boundaries separating individual farms and ignoring transactions between them.

During the war of 1939 to 1945 agricultural policy in this country was administered largely through the elaboration of a system of guaranteed prices and assured markets which put farmers in a position of economic security and stability which was in sharp contrast with their inter-war exposure to the cruel and unpredictable forces of the market.

To operate the new administrative devices efficiently and fairly, the government found itself in need of reliable statistical estimates of a kind not previously put together. In particular, it was urgently necessary to know what was happening to the total income of the national farm — whether, for example, it was increasing at an excessive rate as a result of the generous new guarantees, whether it afforded farmers a standard of living commensurate with their contribution to the war effort, whether it left them sufficient funds to invest in more intensive systems of production, and so on. Out of this need was born the Departmental Net Income Calculation, which ever since the mid-40's has figured so prominently in the annual price review negotiations between the farmers and the government.

Before the war, virtually the only means available to estimate the total income of British agriculture was to refer to a sample of farm accounts collected annually for the Ministry of Agriculture and Fisheries by provincial agricultural economics departments (some of which were attached to universities) and to inflate this sample by appropriate multiplying factors so as to arrive at a national aggregate.

This procedure was shaky, not only because of the blurred edges to the concept of income to which I have already referred, but also because the sample could not be relied upon to be representative — indeed it was known not to be so. In the first place it consisted of volunteer farmers ; and farmers who both keep accounts and are willing to divulge them are hardly typical specimens today, and certainly were not typical thirty years ago. In the second place, the very practice of keeping these accounts and discussing them with an economist could be expected to influence management, generally for the better, thereby rendering the sample more biased than it was when first selected. Finally, it was known that certain types of farm were under-represented in the sample, but there was no satisfactory framework of reference by which to judge the extent of this under-representation.

The government statisticians were therefore driven by necessity to find another route to their objectives. They found that by working from the outset with certain national aggregates (known or estimated) they could proceed without reference to the farm accounts sample, using it only at a later stage to check the validity of their estimates, and for various other purposes connected with the price review. Thus, farmers' receipts from the sale of wheat would be estimated not from a limited number of individual accounts, but from statistics of total deliveries (which were compulsorily recorded at that time) multiplied by an ascertained average price. Similarly, the estimate of expenditure on fertilisers depended not on farmers' own statements but on aggregate deliveries by manufacturers, again multiplied by an average price.

In this way, piece by piece, a consolidated national account of farm income and expenditure was built up, and the method, now much refined, persists today.

It is, of course, all too easy to be lulled into a false sense of precision when using these results. Trends and tendencies are delineated in figures which are too insubstantial to bear the weight of a great superstructure of inference on which policy decisions

can then safely be based. Estimates multiplied by estimates and subtracted from yet other estimates are unlikely to give a final result which is correct even to three significant digits ; so that if we say that the net income of British agriculture "fell" from £337 million in one year to £334 million in the next, we are making a statement of probability, not of fact. We have to add under our breath that it is not at all impossible that in reality the movement was the other way, because in the first year total receipts (at say £1500 million) were overestimated by a half of one per cent. Once again, you see, we are dealing with a relatively narrow residual derived as the difference between two much larger aggregates. We may reflect, with Browning: "Oh! the little more, and how much it is! And the little less, and what worlds away!" I salute the French agricultural statistician Klatzmann who, though personally responsible for the calculation of the annual net income of French agriculture (again using the "national farm" concept), always attached to his figures an explicit reference to the wide margin of error.

It must also never be forgotten that the broad tendencies revealed in the aggregate will often conceal quite diverse movements in constituent parts of the total (such as regions or types of farming).

At the same time that the principles of the agricultural net income calculation were being worked out and put into practice in Whitehall, a much more far-reaching statistical revolution was taking place in other government offices nearby. Round about 1941, economics in this country took a new direction. In that year the Central Statistics Office was set up, within the Cabinet Office.

It was given the task of constructing as accurate as possible a picture of the income and expenditure of the country. National accounting — or, as it is sometimes called with a wider connotation, social accounting — had arrived ; for by that time, and largely under the influence of Keynes, it had been realised that an effective economic policy could only be based upon the knowledge of certain vital aggregates (such as consumer expenditure, capital investment, overseas payments and so on) and their relationship one to another.

As we have seen, the agricultural net income calculation was not designed as a part of the national income and expenditure estimates for which the Central Statistics Office was responsible, but it furnished almost ready-made an important element in that structure.

It was also in 1941 that Professor Leontief, of Harvard University, published his study entitled "The Structure of the American Economy, 1919-1929". He appears to have been the first economist to conceive the idea of constructing a complete table of inter-industry relations, with the aim of arriving at a better understanding of the way in which the whole economic system works. All economic activity may be divided up into a number of sectors, each of which draws upon other sectors for the materials and services which it needs and each of which delivers goods and services destined ultimately for final consumption. When a major change takes place in some sector of the economy — let us say, an increase in purchasing power in private households — the effects of this can be seen to reverberate throughout the rest of the economy, sometimes penetrating to points remote from the part where the initial impetus occurred. The statistical table which is constructed to show these interrelations is now usually called an input-output table, and no self-respecting central statistics office is without one.

Now agriculture is one of these sectors of the economy — or at least a sub-sector of that part which is labelled "industry". Agriculture buys fertilisers, fuel, machinery and many other items from the rest of the domestic economy, or from abroad, and in turn delivers farm products for use as food (with or without intermediate processing) and as raw materials of industry, such as wool and tobacco. The identification and measurement of the flows in these two directions is therefore an essential part of the construction of national input-output tables.

It will be obvious that the elements of the agricultural net income calculation which I have already described coincide very closely with these flows into and away from the agricultural sector, and in one country after another it is becoming a permanent part of the statistical system that annual accounts for the agricultural sector should be established. In the interests of true international comparability — which, if established, can be most illuminating for a better understanding of the way in which agriculture develops — the United Nations Organisation and its agency the Food and Agriculture Organisation (F.A.O.) have prepared a handbook of definitions and methods which is being generally adopted.

Much can be learnt about the probable course of agricultural development in the less advanced countries in the immediate future by discovering what point they have reached on a path already traversed by others. Thus, the substitution of tractors for

animal power and of machinery for manpower follows a certain tempo and pattern which repeats itself with remarkable similarity in country after country. Agricultural sector accounts reveal this same imitative behaviour. For example, the proportion of expenditure to income in the agricultural sector rises as income rises ; higher productivity in farming is associated with closer integration with the non-agricultural sectors. Our country is already well advanced along this path, and others are following in rapid succession.

We are, it seems, only at the beginning of a phase of rapid development of the input-output approach into a very powerful tool for economic analysis and policy. It opens up the prospect of having at our disposal nothing less than "A Computable Model of Economic Growth," and this is the title of a recent publication from the Department of Applied Economics at Cambridge. Starting from the proposition that "the main reason why we do not have a more successful economic policy is that we do not understand the economic system sufficiently well", the authors, Stone and Brown, give priority to a study of the anatomy of the system (the social accounting matrix) and its physiology (the relationships describing the organic functions of the economic body). They have now built up a model of the British economy as it was in 1960, and with the help of an electronic computer they are able to change any chosen variables and relationships in that model and study their manifold effects. They are now engaged upon the projection of the model to 1970, on various but specific assumptions.

The predictive power of this apparatus may well prove quite revolutionary in its impact on economic planning, as well as on short-term decision-making. Instead of having to guess the probable consequences of certain government actions or of certain developments such as the rate of population growth, it will be possible to *measure* those consequences within certain margins of error which have yet to be empirically determined. As the Cambridge pioneers say, the fact that a modern computer can produce a new version of the social accounts within a few hours "means that we can explore alternative policies in detail without suffering their unwanted consequences in real life ; it means that we can trace difficulties to the weak points of our economic system ; and it means that we can begin to think seriously about keeping the economy close to a chosen path".

If the situation in 1970 turns out to be different from that which the model describes — as it certainly will — this will not

prove the model to be at fault in its manner of construction, but will only show that some of the assumptions built into it have been changed in the event, whether deliberately or by force of circumstance.

The implications of this new economic arithmetic for agriculture are not easily predictable, but they must be immense. Whether we are concerned to maintain the living standards of our farmers, to strengthen our resources of skilled manpower, to ensure cheaper food for the whole population or to help poorer countries to break out of their poverty, we must seek a closer understanding of the springs of economic growth. Never again will the prosperity of agriculture, and the policies needed to promote it, be considered in isolation from the rest of the economy. The consequences of the expansion or contraction of farm production, of the raising or lowering of farm prices, of the movement of people out of agriculture into other industries, and of changes in the productivity of resources used in the agricultural sector will be much more clearly seen, and this should lead to more rational and far-seeing policy decisions. In the broadest terms, the welfare potentialities of this new tool should be very great, as it points the way to the elimination of waste and the more rapid and painless adjustment of the economy to the changing situation. The agricultural community should benefit fully from this increase in the general welfare. It is therefore important that the basic data for the agricultural sector in the model should be the best we can make them.

Statistical projections into the future are not confined to national studies. Some work of the greatest importance has been going on, and will certainly develop further, in the international field. I will refer only to studies made by F.A.O., with the help of other international agencies, of the prospects for the world food and agricultural situation in 1970.

Here the economic arithmetic is concerned with such simple but all-important concepts as the rate of population growth, the development of productivity per head, the proportion of their incomes which people spend on food, the part of food expenditure which finds its way back to the farmer (sometimes called "the demand for food at the farm gate"), the rate of transfer of farm population into other occupations, and so on.

For illustration I will select just one or two figures which seem to contain the essence of the world's food problem today.

Population growth is *much* more rapid in the less developed regions than in the more developed regions of the world. If this fact is not familiar to us all by now, it certainly will be by the end of the 1960's. F.A.O.'s projected rates of population increase are 1.2 per cent per annum in high income countries taken as a group, but 2.4 per cent per annum in low income countries, with Mexico heading the list at 3.0 per cent. In the group described as high income countries, the demand for food as delivered from farms is projected (on the basis of population and income estimates) to increase in the 1960's at the rate of 2.0 per cent per annum (I am using the average of two projections, labelled "high" and "low"). In recent years, food production in those countries has been increasing at a rate of 2.3 per cent per annum. First conclusion: If production continues to expand at recent rates it will run ahead of demand in these high income countries ; result, surpluses. The United States already has accumulated stocks valued at an amount roughly equal to the annual national income of the United Kingdom.

In the low income countries, on the other hand (that is, most of Asia and the Far East, the Near East, Africa and part of Latin America), the demand for food delivered from farms is projected to increase at 3.8 per cent per annum whereas food production has recently been expanding at only 2.9 per cent per annum. Second conclusion: Unless production can be stepped up to a considerably faster rate, these countries will suffer increasing food shortages.

World food supplies have been gaining, with intermittent setbacks, on world population increase, so that world food production per head is rising ; but almost all of the improvement over the pre-war level has been in the more developed regions.

These projections are not targets, in the sense of plans of campaign which are deemed to be desirable and feasible — though they will contribute to the eventual formulation of these plans. Nor are they forecasts. The assumptions used are not necessarily the most likely ones — for example, the assumption that prices will remain at their present level. But they serve the purpose of demonstrating the economic implications for the world economy and for its several members if certain trends which are now apparent persist or develop in certain ways. They say, in effect, this is where we shall arrive if this and this trend, now emerging, prevail in the future. They focus attention upon incompatibilities in national policies, upon emerging *imbalances* between supply and demand, and upon the strains and stresses

which must be expected if current trends are not changed by policy. They also serve to restrain both the over-enthusiastic and the excessively pessimistic by indicating the range within which realistic possibilities seem to lie.

In this lecture I have used the phrase "economic arithmetic" rather than mathematical economics or econometrics. This is not because I think higher mathematics has no place in relation to the measurement of the food and agricultural situation — far from it. Mathematical training is going to be more and more essential as the value of model-building and of projections is confirmed. I have spoken of arithmetic only because many of the stubborn facts which we confront can be revealed by simple processes of addition and subtraction, multiplication and division, ratio and proportion.

For example, if the people employed in agriculture are not all full-time farmers or regular workers, but operate part-time, seasonally or casually, the only way to arrive at a sensible estimate of the total agricultural labour force is to convert the various types according to some unitary scale and then add them all together.

If Europe's food production runs ahead of her food requirements, subtraction indicates to us the extent of the surplus which must be disposed of elsewhere.

The total food requirements of a nation may be estimated approximately by multiplying the population by the average food requirements per head.

If a limited total amount of farm income has to be shared between a very great number of families, simple division demonstrates that income per head in agriculture must remain low.

The proportion of agricultural population to total population may be compared with the proportion of agricultural income to national income. National diets may be compared by studying the proportion of the calories and of the protein which comes from vegetable sources and animal sources respectively. The Swedish agricultural economist Dovring has spoken of "the proportions that distinguish a sound society from a suffering one".

Admittedly, the simplicity of some of these key numerical indicators can be deceptive. If we say that there are more food calories available per head of population in country A than in

country B, there may nevertheless be more hunger in country A because of its unequal distribution, geographically and between the classes of society.

If France produces wheat in excess of her own requirements and sells considerable quantities abroad, she may still not be self-sufficient in wheat in a complete sense, because her millers may have to import certain kinds of hard wheat to make a satisfactory grist.

If we say that the average size of farm in this country is 68 acres, basing this on a number of agricultural census forms returned and the total area of agricultural land, we are certainly stretching the word "farm" beyond reasonable limits.

There are many statistical pit-falls of this kind. Even so, to the extent that they introduce into public debate a better sense of proportion than can possibly be derived from personal observtion alone, these statistical distillations perform an essential function.

In conclusion may I say that all these calculations, which I have reviewed with such undisguised approval for the most part, should not be regarded as entirely cold-blooded, inhuman exercises. I have tried to indicate how substantially they can contribute to farmers' individual incomes, to the more rational matching of national resources to needs, to structural adjustments which can take place according to plan instead of under dire necessity and, on the international scale, to greater welfare of all peoples through the achievement of balanced growth.

Whether these beneficiaries will ever be chivalrous enough to acknowledge a debt to sophisters, economists and calculators is quite another question.

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