An Economic Survey of the New Zealand Sheep Industry

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INTRODUCTION:

I should like to preface this paper with a remark of Lord Kelvin's: "When you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot measure it, when you cannot express it in numbers, then your knowledge is of a meagre and unsatisfactory kind."

The Meat and Wool Boards' Economic Service was set up in 1950 by a Joint Committee of the two Boards for the purpose of "collecting data relevant to the sheep farming industry of New Zealand so that the Boards might be in a position to keep themselves informed on the economic aspects of the industry." The accent was thus placed on the economics of sheep farming, and it is as an investigator into the economic aspects of the sheep industry that I am speaking to you to-day, not as a theoretician on mathematical statistics. The information derived from the Service's operations is primarily for the use of the Boards themselves; we hope to make it available ultimately to bodies other than the Boards, to whom the information may be of use and interest. I propose in this paper to discuss our sheep farm survey under three main headings:

I. The principles of sample surveys.
II. The application of the principles to practical problems.
III. The analysis of the data.

I. THE PRINCIPLES OF SAMPLE SURVEYS.

To collect the data required for our work demands either a complete census or a sample survey. For reasons of time and cost the taking of a complete census is out of the question; we therefore rely on a sample survey. Sampling is a statistical device for learning about large masses of data by studying a small proportion of them. But it must not be thought that a sample is a cheap and somewhat inferior substitute for a complete census: provided the statistical requirements are met, sampling may ensure greater completeness and accuracy in the returns because of the economy of effort involved; more detailed information may be obtained and more easily handled; and a very considerable increase in the speed of execution and analysis is made possible.

What then are the statistical requirements of a good sample?

The two important features are:—

(1) the selection must be made at random, so that each and every unit of the population has an equal chance of being selected; and
(2) the sample must be large enough to avoid the undue influence of abnormal items. It has been shown that the reliability of a sample is, in fact, proportional to the square root of the number of units it contains.

Errors arising from faulty selection methods are known as errors due to bias: and errors due to chance differences are known as random sampling errors.

The simplest and the only certain way to avoid bias is for the sample to be drawn entirely at random; or at random subject to rigorously observed restrictions which, while improving the accuracy, are of such a nature that they do not introduce bias into the results.

The simplest way of reducing the random sampling error (i.e. of increasing the accuracy of the sample) is to increase its size. There are definite limits to this, however, as accuracy increases only in proportion to the square root of the number of units included in the sample; so that if you have a sample of 200 units and wish to double the accuracy of the results, you must increase the sample, not to 400, but to 800 units. Other methods of increasing the accuracy of the sample are by stratification and by the use of variable sampling fractions. Stratification means that the population is divided into groups of units in such a manner that the units in each group are more or less homogeneous. Each of the groups (or strata) is then sampled at random. This ensures that subdivisions of the population which are of interest in themselves are adequately represented.

The use of variable sampling fractions for different strata may lead to considerable gains in accuracy in cases where the material is known to have wide deviations from the mean, and especially if the sampling fractions can be made proportional to the within-strata standard deviations of the units.

The structure of the various types of sample could be discussed here at some length, but as time does not permit I shall merely mention that Chapter 3 of Yates' "Sampling Methods for Censuses and Surveys" gives a clear description of some 15 to 20 methods which may be used in various circumstances.

II. PRACTICAL PROBLEMS.

In the application of the foregoing principles to the practical problems which arose in the planning and execution of our survey, **cost** was a factor which had to be given consideration at every stage. Decisions were the resultant of balancing cost against time and then reconsidering the decisions in the light of their effect on the accuracy of the sample. It was accepted that the survey would be of a long term nature, that is a continuing and expanding survey in which the original farms plus additional new cases would be included year after year.

The earliest questions to be decided were the administrative organisation of the survey, the definition of the sampling unit, the method of selection of farms, the method of collection of data, the setting out of questionnaires and forms for the recording of data, the treatment of non-response, and what steps could be taken to increase the accuracy of the sample.

The form of administrative organisation was determined largely by the fact that the data, owing to its complexity and volume, could only be satisfactorily collected through personal interview by a highly trained field staff. We required therefore a small number of field officers, located at strategic points throughout the country, and a head office staff to analyse the results of the field officers' work. At the present time there are four field officers, each with a typiste; and seven persons in the head office including the Executive Officer, so that the staff of the Service numbers only fifteen in all.

The method of collection having been settled, the sampling unit was then defined as a bona fide sheep farm; that is, one which wintered not less than 500 sheep and derived not less than 80% of its total revenue from the sheep flock. By choosing these "cut-off points" it was possible to discard a tremendous number of farms from the population of sheep farms and thus narrow the field without losing sight of any important segment of the sheep farming industry. There are, for example, 35,000 flocks in New Zealand, but of these, 14,000 or 40% have less than 500 sheep. These 14,000 flocks contain 3 million sheep, so that if we drop these flocks entirely and thus cut down the labour of selection by 40% we are dropping only 8% of the total **sheep numbers.** Thus we still cover 92% of the sheep

population, and after all it is the sheep which is the unit of production, not the farm.

To carry out random selection a suitable "frame" must be available, that is a list of names or a map of holdings which embodies a means of identifying and locating every unit of the population from which the random selection is to be made. The Return of Sheepowners was the best frame available, and while not as up-to-date as one could wish, it has served our purpose reasonably well. Incidentally, the defects in the frame have been responsible for some degree of non-response. The treatment of non-response from selected units is quite important in a survey such as this, because unless non-response is confined to a small proportion of the whole sample, the results cannot claim any general validity. Every effort is therefore made by our field officers to reduce non-response to negligible proportions, and by dint of vigorously following up each case they have succeeded in doing so. Only about one farm in every fifty is rejected through unco-operativeness, and about one in thirty because of incomplete or inadequate records; but the main reason for rejection from the random selection lists is that the farm is not a "sheep farm" within the definition adopted. Substitution of another farm for the rejected farm must only be made from a random list and for reasons previously mentioned, cannot be left to deliberate choice.

In order to reduce the random sampling error, the method of multiple stratification with variable sampling fractions was used. The two-way stratification consisted of grouping farms by size, and grouping by geographical regions. Ideally, stratification by class of farm is desirable (e.g. fat lamb, store sheep, high country), but as the national distribution of sheep farms by class is not known we were obliged to use stratification by flock sizes, which are known for every county in New Zealand. There is, of course, a very rough correlation between size of flock and type of farming, and classification by type of farm is made after the farm has come into the survey. Correspondingly, while the county is not an ideal regional unit (consider counties like Rangitikei and Ashburton, which run from the mountains to the sea) it is the most convenient unit administratively and has therefore been used as the basis for geographical stratification. The frame, the Return of Sheepowners, is arranged by counties.

The determination of the absolute size of the sample, i.e. the number of farms to be included in the survey, required some thought. Obviously, the more farms the better, but the limitations of time and costs on the one hand, and the need to comply with the geographical and size group distribution on the other hand, imposed a compromise solution; and the initial objective for the first few years of the survey has been set at 500 farms. Since the absolute size of the sample is more important than the sampling fraction, it appears that this number will give us a reasonably satisfactory hard core of farms to work with, for some years at any rate.

The forms and questionnaires for recording the information were given careful consideration. We bore in mind the warning issued by M. J. Moroney in his "Facts from Figures": "It is a common pastime in many organisations to collect vast quantities of data on a routine basis . . . . with the vague intention of submitting it to analysis 'one day when things are not so busy.' Of course, things are never slack, so the 'piles of useful stuff' get more comprehensive—and out of date—as the years go by. Pious intentions to analyse its some day are of little value. If data is not worth analysis at a suitably near date it is rarely worth the labour of collection."

For our purpose it was necessary to concentrate on four broad aspects of each farm: (1) its physical features and location; (2) its livestock and general management policy; (3) the financial side, including the capital invested and details of annual revenue and expenditure; (4) the quantities of meat and wool produced.

On these aspects we wanted all the information possible. Because of this fact, and because of the physical limit to the number of farms that each field officer can handle, the progress of the survey has been steady rather than spectacular. The following table shows the increase in the number of farms in the survey:

No. of farms under survey	At end of year
170	1951
220	1952
290	1953
350	1954

III. ANALYSIS OF THE DATA.

For ease of study, sheep farms have been divided into five classes, ranging from the high country of the South Island to the intensively farmed fattening country of both Islands.

The flow of information in the survey is briefly as follows:

The field officer obtains from the farmer, his stock firm, and his accountant the information relating to the four aspects mentioned previously, i.e., details of the farm itself, livestock and management, revenue and expenditure, and physical production. This information is sorted up, systematically recorded, and then forwarded to head office. At head office it is checked, summarised and tabulated, and is then ready for more critical analysis in order to isolate the effects of the various factors which are believed to influence the results. Up to the present time the sorting and tabulation work has been done by hand (for the arithmetical computations, adding and calculating machines are used), but within a month or two we hope, with the co-operation of the New Zealand Wool Commission, to be able to use Powers-Samas punched card equipment for much of the classification and tabulating. Although in general terms punched cards are unsuitable for analyses (as in the present survey) which require detailed examination of the whole complex of information relating to individual units, it is expected that there will be considerable savings in time spent on routine work through the use of these cards.

Statistical techniques for scaling up the results of the sample survey to give estimates of population totals (e.g. multiplying the sample value by the reciprocal of the sample fraction) have not been put to use as yet, on account of the fact that we have been seeking averages and the dispersion about these averages, rather than population totals. It is well known that the arithmetic mean of the sample values provides an estimate of the mean of the population from which the sample was drawn; though it will not, owing to sampling errors, be exactly equal to the mean of the population. Knowledge of the mean moreover, does not convey much if the range from highest to lowest is not known (or, more technically, the standard deviation of the distribution). In our work to date we have thought it a little premature to carry out any refined statistical examination of the extent of the sampling error or the standard error of the mean—we do not consider that there are enough sample units in each stratum for such an examination to yield any reliable indication as to the efficiency of the sampling methods. Nor has there yet been occasion to apply to any result a precise test of its statistical significance. There is, of course, no possibility of attaining absolute certainty in any statistical test of significance. All we can do is to say that such-and-such a result is very unlikely to have arisen by chance.

When the sampling procedure is defective in one respect or another, attempts are sometimes made to adjust the results in order to

compensate for the defects, e.g. different classes of the population may be found to be represented in incorrect proportions in the final sample, and the results may be altered by re-weighting the different classes. Yates however, considers this practice undesirable, and suggests that if any such adjustment is made, the unadjusted results should also be presented.

Some of the fields in which we are reaching tentative conclusions are (1) patterns of revenue and of expenditure for various classes of sheep farms, (2) average revenue and average expenditure per farm, (3) revenue and expenditure per unit of livestock carried, and per acre, (4) quantitative measurement of meat and wool production, per farm and per acre, (5) the ascertainment of break-even points for different classes of farm—not true costs of production as yet, (we are still grappling with the problems of costing joint products), (6) the factors determining the prices paid for store stock of various classes, (7) lambing percentages from breeding flocks where differing replacement policies are carried out, and (8) the calculation of district and class averages against which the farmer can measure his own results. For this purpose it is planned to send to interested farmers a summary of their returns for the years they have been in the survey. Complete coverage of all districts in this manner will take some time, and we are making a start with those districts which were included earliest in the survey.

Uses have been made of the survey data at a high administrative level, including the ascertainment of movements in the cost of production of meat, in the later years of the bulk purchase agreement with the U.K. The New Zealand Wool Commission in its deliberations on the current season's floor price had before it some of the survey findings; and extensive use has been made of our data in the present discussions on the proposed floor price scheme for meat.

In conclusion, however, many particular instances one may quote of the use to which the results of a survey have been put, it is impossible to assess in monetary terms the value of the information provided by such surveys. We must not be deterred from undertaking a survey by reason of the fact that it is difficult or impossible to determine exactly the optimal sampling fractions and size of sample required; for these surveys themselves provide information which will enable future surveys on similar material to be more efficiently planned. There is a need for thorough investigation of the efficiencies of different sampling methods, but such investigations are often neglected in practice because they are regarded as merely of historical interest to the particular survey organisation concerned. With the establishment however, of permanent organisations for the conduct of research and investigational surveys, we may expect to build up a body of experience which is relevant to the special problems of such surveys.

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Discussion

Professor McMAHON: Is Mr. Keen aware of the cost of wool production study which was carried out recently by the Rural Bank of New South Wales? The technique used was to construct five hypothetical cases typical of various classes of sheep farms and to make use of a large team of expert valuers—some 40 or 50 I think—to work out the probable costs involved in growing wool on these farms. The average cost was somewhere between 50 and 60 pence a lb. Has this sort of technique been used for similar studies in New Zealand, and do you think it has any applicability to the survey you are engaged upon.

Mr. KEEN: Yes, I was aware of the Rural Bank's study, from several published sources. It seems to have attracted a good deal of attention. That method of estimating costs of production, that is by budgeting for hypothetical farms, has its place, and might be useful a a check against the results of a sample survey; but I think from most points of view it would be less satisfactory than a survey of actual farms.

Dr. WILLIAMS: Was the pilot survey undertaken to see what the main problems of the sample survey would be, and how such problems might best be tackled? Have estimates of the sampling error been made?

Mr. KEEN: Unfortunately there was no time to conduct a pilot survey. We had to get straight onto the job and plan the survey as best we could, without the benefit either of a pilot survey or of any similar survey having been undertaken in this country. As to the estimation of the sampling error, it is a little premature to perform any very precise calculation of the extent of the sampling errors. We know that the number of units in each stratum is inadequate at present, and until we have built up the numbers in districts and classes we do not consider such statistical examination would yield any reliable indication as to the efficiency of the sampling methods.

Dr. CARTER: I note that the survey is a continuing one. Are only the original farms being studied from year to year or do you include new farms in the survey each year? If the practice is to add new farms to the original sample would it not be better to take a completely new sample each year to avoid bias in the results?

Mr. KEEN: It would possibly be more sound statistically to take an entirely new sample each year but it would be quite impracticable. A sample of several hundred units is considered to be a large sample, large enough to avoid the undue influence of abnormal items. At the moment we have over three hundred farms in the survey so that overall results on a Dominion basis are fairly reliable—given the fact that the selection, being random, is unbiased. The results for earlier years when the number of farms was smaller could not be considered as accurate as those from the present number, and by the time we have reached our full quota (about 500 farms) we shall, we hope, have achieved greater reliability still. The results may be regarded as gaining in accuracy year by year even though there is a slight loss in strict comparability.

Professor COOP: You said that one of the fields in which you were reaching tentative conclusions was in lambing percentages in different districts. I notice that Southland has a much higher lambing percentage than the Waikato. Can you comment on this?

Mr. KEEN: Lambing percentage figures as published on a county basis may not mean very much, because a large county will comprise various types of sheep farms, from the extensive runs where lambing

precentages are low, to the intensive fattening places which have higher lambing percentages. Preliminary results from our survey investigations do however confirm the higher lambing percentages in Southland shown in the published figures. By means of our classification of sheep farms into more or less homogenous groups we are able to effect more valid comparisons between districts than grouping by counties can yield.

Mr. SEARS: Do you consider that after a farmer has been visited by the Field Officers for several seasons and subjected to their influence, he may make changes in his policy or farming practice which he would not otherwise have done, and that the sample would, therefore, cease in time to be a strictly random one?

Mr. KEEN: Yes, that could happen but there are reasons for not regarding it as a very important consideration at the moment. One reason is that the Field Officers do not offer advice or comments unless they are asked to do so. The Field Officers tell me that there are very few farmers who do in fact ask for such advice and, therefore, only a small percentage of the sample could be affected in this way. Even when advice is given, it may not be followed by the farmer. Moreover any important changes would take some years to put into full effect. We may have to tackle this problem at some time in the future—perhaps by introducing fresh blood into the sample, but that, of course, creates problems of its own.

Mr. GRIFFITHS: There is a tremendous mass of information being made available to the Economic Service. What use is being made of this information?

Mr. KEEN: The information derived from our operations is primarily for the use of the Boards themselves. They set up the Economic Service to collect data on the sheep farming industry so that they might be informed on all aspects of the industry.

Dr McMEEKAN: I am disappointed in this paper. The Economic Service has been collecting data for 4 or 5 years now but there are no results at all given in the present paper. The sheep industry is not well documented as the dairy industry and it is only from the activities of such an organisation as the Economic Service that statistics can become available. Does the Service intend to publish an annual report like the Dairy Board or is the information going to be regarded as secret and not available to anyone but the Meat and Wool Boards?

Mr. KEEN: I am sorry if Dr. McMeekin is disappointed but there was no intention of giving any results in the present paper. It is intended as nothing but a description of the principles underlying sample surveys and how we applied these principles to our own survey of the sheep industry. On the question of the future availability of our findings, since Mr. Bevin, the Executive Officer of the Economic Service is present, I will ask him if he will comment on this aspect which is a policy matter affecting the Boards.

Mr. BEVIN: As Mr. Keen has stated, the Economic Service was set up primarily as a service organisation of the Meat and Wool Boards. The Boards have kept us busy on special work for them such as ascertainment of movements in the cost of production of meat and wool, and background data to such problems as floor prices for wool and meat. Up to now this information has been confidential to the Boards but it is intended to make it available untimately to bodies other than the Boards, to whom the information may be of use and interest.

Mr. FAWCETT: I would like to say how useful the data collected by the Economic Service proved to be in the meat price negotiations with the United Kingdom Ministry of Food in 1952. In the winter of

that year I was a member of the New Zealand delegation which negotiated the contract price for the 1952/53 season. All we were entitled to under the contract itself was a 7½% increase but we knew that, due to increased costs, a greater increase than this was merited. But we had no evidence to lay before the Ministry except the memorandum prepared by the Economic Service showing an increase in costs of production on fat lamb farms of 12.7%. However meagre the data may have been on which this result was based, it was considered reliable enough by the Ministry to form a basis for agreement on the overall price increase granted which turned out to be 12½% on the previous season's price. The meat industry is therefore indebted to the Economic Service for the additional 5% gained in the 1952/53 season. In monetary terms this 5% was worth some £2 million, which means that the Economic Service has already paid for itself many times over. I consider, therefore, that the industry should not be afraid to spend generously on expanding and improving the work of the Service and in publicising its findings.

Mr. CASSELBERG: Since meat and wool are joint products and one is not produced without the other it seems that the separate costing of meat and wool would be a difficult if not impossible matter. How do you attempt this? A further point I would like clarified is, how do you estimate the production of meat per acre on store sheep country?

Mr. KEEN: The allocation of costs between joint products which are produced in virtually fixed proportions, is a problem which to the best of my knowledge has not been solved anywhere in the world. It may, in fact, be impossible to solve it with any degree of exactitude. We have used a technique which gives us not the actual costs of production of either meat or wool but the "break-even" point. The break-even point is defined as the price which a farmer must receive for his main product in order to cover his costs. Costs in this connexion are total costs less receipts from sidelines. Total costs may be defined in various ways, for example cash expenditure on the one hand or on the other hand cash expenditure plus allowances for value of owner-operator's labour, full depreciation charges, and full interest on the total capital invested in the farm. We study the break-even point for wool on wool-dominant farms (where meat production is a sideline), and the break-even point for meat on fattening farms (where wool production is the sideline activity).

The estimate of meat production is done by means of an accounting technique in which we use, not standard values as in the financial accounts, but standard **weights** for the stock on hand at the beginning of the production year and at the end of the production year. This is necessary to take account of increases or decreases in opening and closing stocks of sheep and cattle. Purchases are debited to a Meat Production Account at estimated weights, and sales whether fat or store, are credited to the Account at weights which are either given exactly (in killing sheets) or can be estimated fairly closely through knowledge of the prices at which the stock was sold. The net balance on the Account is the meat production for the farm ,and when this figure is divided by the productive area of the farm we arrive at the meat production per acre.