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Index of the Net Value of Industrial Production

Grouping of Commodities

Considerations on the Census Programme 1960

Seasonal and other Recurrent Influences on Short-Term Economic Indicators

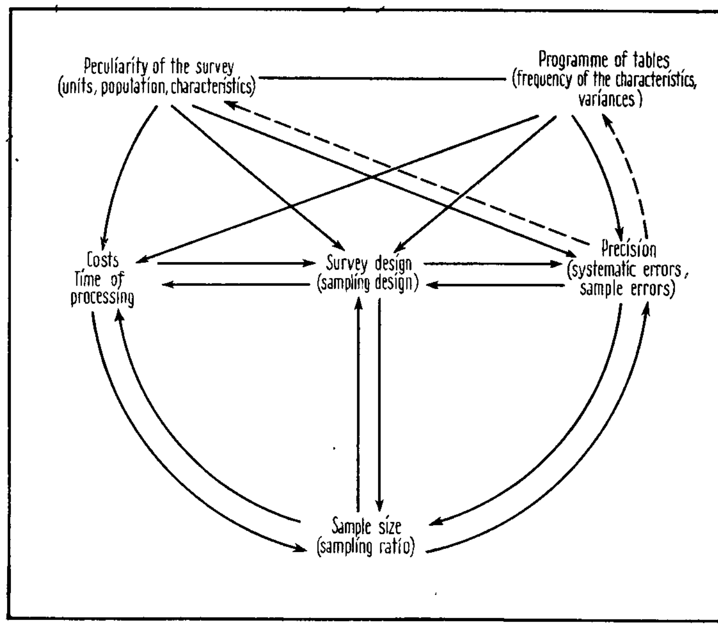
The Statistical Unit in Economic Statistics

SIZE AND PRECISION OF SAMPLES

Sampling has to an ever-growing extent been used in official statistics. Its preference is first due to the endeavours centering around the reduction of the time lag between the collection and the release of statistical information, the reduction of the costs involved and of the number of respondents covered (persons, establishments, or others). Another reason requiring the use of sampling in official statistics results from the necessity that in order to answer their purpose they are more and more thrown upon the ascertainment of facts which owing to the difficulties encountered in the collection of information and to the amount of work and expenses involved in the processing of data can be taken up in statistics only on a limited scale. This development is still far from having come to its end. An ever-growing number of statisticians and consumers of statistics have come in touch with this procedure. Thus it appears advisable to give a general description of one of the central points of each sample, namely of its size and precision with special attention to their interrelation and their dependency upon other factors.

Speed and low costs, and to a certain extent also the reliability of the survey itself depend upon the size of the sample. The smaller is the sample, the shorter is the time at which the results become available; the lower are the costs, the greater is the care which can be exercised in the collection and processing of the individual data. But clear limits have been set to an on and on reduction of the size by the fact that according to laws of mathematics the precision of the results decreases along with the decreasing number of items under observation. The most adequate and rational sample is that which at minimum costs and after a minimum time of processing supplies the desired results at the necessary degree of precision.

The size of the sample is one of the essentials of the sample design. However, it is not fixed from the very beginning, but has to be developed as an optimal solution by taking account of the required precision, the justifiable costs, and the peculiarity of the information to be collected and of the procedure to be used in collecting it. All these factors are interrelated with one another in the way illustrated by the ring-shaped chart below. It is the purpose of the survey that is decisive of the type of statistical units and of the population to be covered, of the characteristics to be ascertained and of the special problems involved in their definition, delimitation, completeness, etc. The programme of tables which by the amount of details to be accounted for in the breakdown by subject-matters and in the regional breakdown determines the frequency of the individual characteristics must also be available before the sample design is prepared. However, all this does not cogently lead to the design the final fixation of which requires still another decision, which directly concerns either the necessary precision or the costs or the size of the sample. Approaching the problem from the angle of the methodology of statistical sampling the situation is least complicated when the first step taken in this field is to fix the precision required for the preparation of the programmes of tables, and the second step to find that sampling design which meets this requirement at a minimum of costs. In practice, however, we are frequently faced



with the reverse case in which the costs or the size of the sample is given and the sampling design must be prepared so as to yield the most precise results which can be obtained by means of the available resources.

Account has been taken in the following of this complex of interdependencies involved in the problems concerning the size and precision of samples by describing - after an introductory review of the size of samples hitherto chosen in official statistics - the relationship between the sample size and the sample error in simple sampling designs. As a next step, attention has been given to the influences exercised upon this relationship by peculiarities of the sampling design, and following these considerations the problems involved in the determination of the necessary precision and the decisive importance of systematic errors have been dealt with.

The Sample Size in the Surveys Conducted in Recent Years

The samples used in the official surveys which were conducted in recent years were of many different SIZES. In this connection, the absolute size as well as the relative size related to the total population considered or the "sampling ratio" are of importance.

Agricultural statistics were those in which the greatest number and most different kinds of sample surveys were conducted. Already in this field we find an extraordinarily wide range of the sample size and the sampling ratio. In the sample SURVEYS OF PIGS which are conducted as intercensal surveys approximately 290,000 pig farmers of a total of 2 millions are included. The sampling ratio is 14 %. The sample is not taken from the population of individual pig farmers, but from so-called enumeration areas, each of which includes approximately 20 pig farmers. Of the 102,832 enumeration areas, 14,595 are included.

Beginning with 1952, surveys on LABOUR IN AGRICULTURE were conducted at approximately 150,000 agricultural holdings of a total of 2 millions (8 %). The monthly surveys 1956-57 included 10 % of the basic survey, namely 0.8 % of the holdings.

The sample SURVEY ON SOIL UTILIZATION now being reorganized was in 1957 conducted in one Land of the Federal Republic of Germany at 25 %, in 3 Laender at approximately 17 % of the communities, and in 2 Laender at approximately 7 % of the holdings.

In the LIVESTOCK and the SOIL UTILIZATION SURVEYS, QUALITY CONTROLS are regularly made on a sampling basis for the purpose of tracing the enumeration error in the main survey and of obtaining figures for corrections. These controls are based on a considerably smaller amount of material. In the pig survey they are restricted to approximately 400 enumeration areas (0.4 %), and in the soil utilization survey to approximately 3,000 holdings (0.15 %) throughout the Federal Republic of Germany.

As regards the principal crops, CROP STATISTICS are based on a special sample established as follows: in individual fields selected at random the yield is precisely ascertained by means of five crop cuttings, each comprising one square metre. In 1954, these sample statistics of square metre cuts included, for instance, 2,150 fields on which winter wheat was grown. For estimating the usual harvesting and threshing losses as compared with those ascertained in the crop cuttings use is made of a sub-sample obtained in the following way: in approximately 15 % of the fields selected for crop cuttings the crop of the total field is harvested and threshed under the supervision of a special commission. The area of winter wheat covered by these total threshes amounted to 210 hectares. These correspond to a sample size of 0.02 %, while the area covered by the square metre cuts was only 0.0001 %.

Sample STATISTICS ON WAGE TAX were executed with an average sampling ratio of approximately 25 % in 1950 and of approximately 15.4 % in 1955; in other words, use was made of approximately 1,950,000 wage tax cards of a total of approximately 16 millions throughout the Federal Republic of Germany (without Hamburg and Bremen). It is intended in future, to conduct between two large-scale statistics on wage tax executed at several years' intervals intermediate surveys which will be based on a much less extensive programme of tables. The sampling ratio will probably be 1 % unless the highest groups of gross wages are included totally. In an analogous way, sample statistics on income tax will be conducted in the years between the large-scale statistics, the sampling ratio being approximately 12 % (about 300,000 cases).

Sample STATISTICS ON ELECTIONS conducted on the occasion of the 1953 elections to the "Bundestag", in which the voters were distinguished by age and sex, included 470 polling districts of a total of 47,197 polling districts and approximately 1.5 % of all persons entitled to vote. In 1957, 904 districts were included.

STATISTICS ON THE PARTICIPANTS IN SOCIAL SECURITY SCHEMES, in which all family names beginning with L were included, covered approximately 4.5 % of this group of persons.

The advance compilations made on a sampling basis in the large-scale CENSUSES 1946 and 1950 and the subsequent investigations into the households were based on a sampling ratio of 1 %.

The 1956-57 HOUSING STATISTICS were executed in three phases: the total statistics conducted in September 1956 were only based on a small programme of tables; additional tables were established for a 10 % sample, which were regionally sub-divided, the smallest units being Kreise or groups of Kreise respectively. The 1% subsequent survey which was conducted from March to May 1957 on the basis of a detailed programme of questions the majority of which were to provide information on the demand for dwellings, included approximately 135,000 dwellings.

The MICRO-CENSUS - a sample survey of the population and economic activities - first conducted in October 1957 is undertaken once a year with a sampling ratio of 1 % (approximately 180,000 households). In the meantime, surveys are undertaken at quarterly intervals with a sampling ratio of 1 %.

The 1954 and 1957 WAGE AND SALARY STRUCTURE SURVEYS were based on a 15 % sample. In the case of large-scale establishments 15 % of the total number of persons employed by all establishments, and in the case of small-sized establishments 15 % of the establishments were covered.

In the survey on the NET PRODUCT OF INDUSTRY (1956) information was collected from 10,000 establishments (22 %) on commodities received by means of sampling.

In STATISTICS ON LONG-DISTANCE GOODS TRANSPORTS conducted by the Federal Institution for Long-Distance Goods Transports (Bundesanstalt für den Güterfernverkehr) one in three shipments (latterly one in four bills of lading) is compiled, the monthly size of the sample being approximately 100,000 cases. The same sampling ratio is used in the STATISTICS OF TRANSPORTS ON OWN ACCOUNT executed by the Federal Office for Motor Transports (Kraftfahrt-Bundesamt). In 1950 and 1958, the sample survey on road haulage was based on a sampling ratio of 10 % of all vehicles connected with goods transports (approximately 65,000).

The highest sampling ratio so far used in a sample survey conducted within the framework of German official statistics was 33 % (long-distance goods transports); the lowest sampling ratios are found in agricultural crop statistics (0.0001 %).

For the purpose of comparison it may be mentioned that the samples used in market and opinion research do usually not cover more than 2,000 respondents or about 0.05 % of the population at ages over 18, and that this number is seldom surmounted.

At the international level conditions are similar: we find a multitude of gradations of the absolute and relative sizes of samples. However, comparable samples abroad are smaller in size rather than larger.

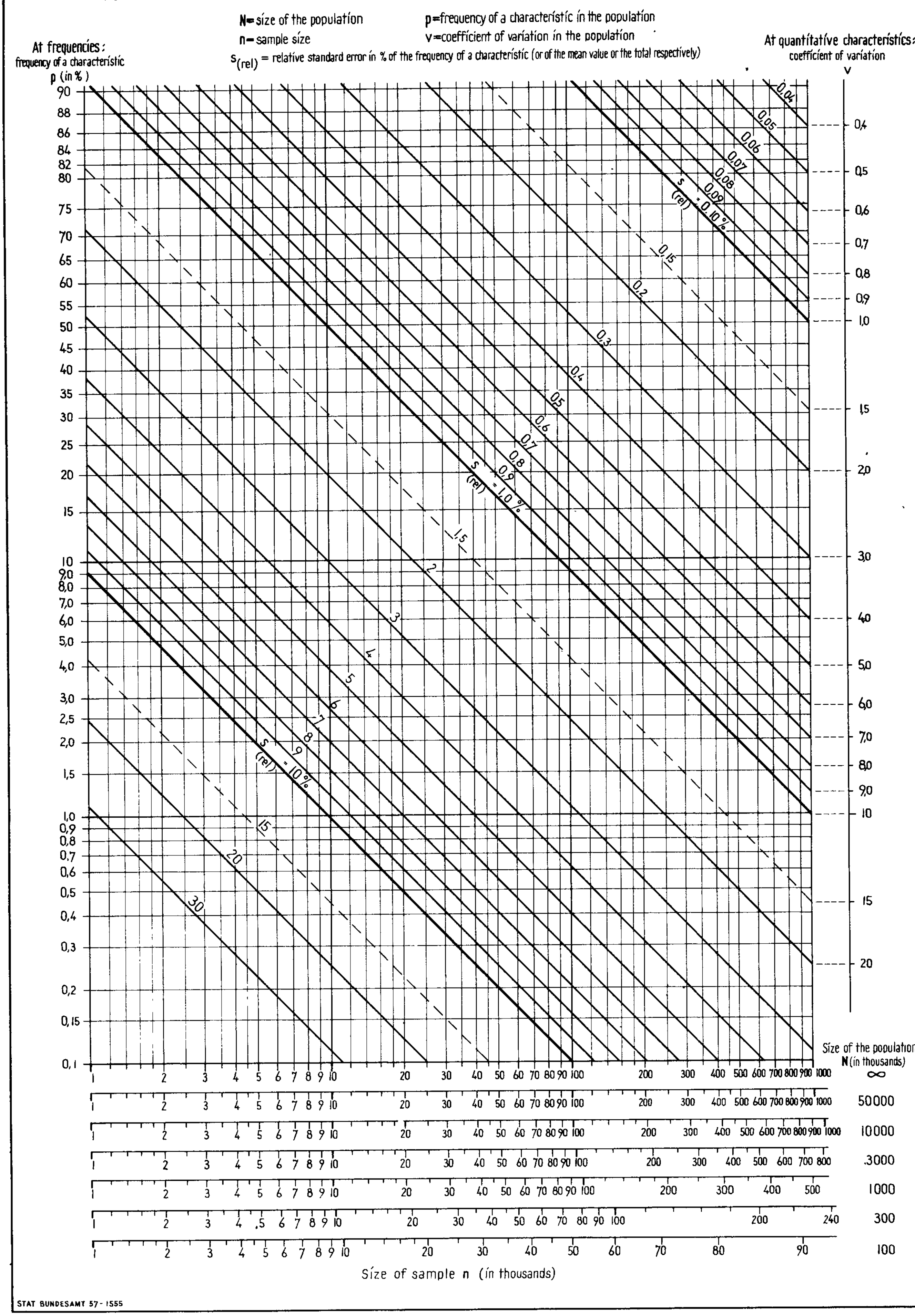
Accordingly, we recognize a considerable non-homogeneity, and not only with respect to the sampling ratios, but also in regard to the absolute size. What are the causes of these differences? Are they justifiable? Would smaller sized samples not have supplied the required results with sufficient reliability? Are smaller or larger samples desirable in future? The answers to these questions widely depend upon the project of the survey and cannot be generally valid. In the following, the general principles and main problems involved in a technically modified form in all sample surveys will be considered.

The Relationship Between the Size of Samples and the Precision of Results

In the first place, the size of the sample depends upon the required precision of the results. However, simple rules are applicable only to simple sampling designs, as for instance to a direct random selection of the elements to be considered when the population was not divided (stratified) by subject-matters or

RELATIVE STANDARD ERROR

FOR ESTIMATING THE FREQUENCY AND THE MEAN VALUE OR THE TOTAL OF A CHARACTERISTIC IN A SAMPLE



regions before the selection was made. The formulas used for the simple random selection offer a basis for the calculation of the sample SIZE; in complicated designs they remain valid also inside the various strata of the material, and they may be combined in more or less complicated formulas for the purpose of forming an opinion on the whole sample. Thus it is justified to put the simple random selection into the foreground.

The numerically clearest case is that in which enumerative characteristics, namely numbers or frequencies respectively, are to be ascertained. Then it is possible to show in a graph the relationship between the standard error serving as a measure of precision and the sample size by the relationships illustrated in the following chart.

The standard error is the unit of measurement for the possible deviations of the sample results from the actual figures which would have been obtained from a total survey. The interval of the single standard error is adhered to in approximately two thirds of the cases (68 %), the interval of the 1.5fold standard error in 87 %, the interval of the twofold standard error in 95 %, and that of the threefold standard error in 99.7 % of the cases. These figures are valid when certain prerequisites for the frequency distribution of errors (so-called "normal distribution" pursuant to the law of errors according to Gauss) have been given. The conditions are not always fulfilled completely, but frequently approximately, so that these figures permit of forming an adequate opinion on the precision from the numerical point of view. In an individual case considered separately it is not known whether the result is particularly satisfactory or whether it happens to belong, say, to the 13 % which are beyond the interval of the 1.5fold standard error. The average value of the deviations amounts to two thirds of the standard error.

In the chart, the abscissa represents the sample size and the ordinate (left) the frequency of the characteristic to be ascertained. Under the axis of abscissa several measures have been given. Of these we shall first consider the highest which relates to a parent population of 50 millions, so that it approximately corresponds to the population of the Federal Republic of Germany. The oblique straight lines indicate the relative standard error[1], referred to as s_{rel}. It is clearly recognizable that the standard error decreases along with the increasing size of the sample. If for instance a characteristic occurring at a frequency of 3 % is determined by a sample of 9,000 cases, the relative standard error is 6 % of the basic frequency of 3 %; if the sample is expanded so as to include 80,000 cases the error drops to 2 %.

To begin with, the illustration refers to the population of 50 millions; the errors are different when a parent population of another size is used. It is seen that the relative sampling ratio is less important than the absolute size of the sample. The relation to the size of the population, namely the sampling ratio, plays an essential rôle in those cases where the sampling ratios are high, e.g. higher than 10 %. When we then compare the error with that of a sample of the same size which has been taken from a larger population - i.e. with a lower sampling ratio - the error becomes slightly lower.

The chart has been generalized in a form easy to survey by making use of several scales in the abscissa. For various orders of magnitude of the parent population special scales have been inserted for the sample size. The scale of the acis of abscissa stands for an infinitely large population. The scales for smaller populations have been inscribed thereunder. As the influence of the size of the population is only of minor importance, we can manage with rough bounds for the purpose in mind. The chart should be read as follows: starting in each instance from the relevant point of the scale move perpendicularly upwards, and look for the intersection with the horizontal frequency line. The situation of the point of intersection indicates the relevant relative standard error.

Example: In a total population of 1 million units a sample comprising 9,000 cases provides a characteristic which occurs at a frequency of 3 % and has a standard error of approximately 6 %. The point indicating the 9,000 in the X scale of 1 million elements, compares in practice with the spot where it would be found if the population were 50 millions. Accordingly, a sample comprising 9,000 cases would provide the individual characteristics with the same relative errors as a much larger parent population.

Stating the standard error has the following meaning: the relative error of 6 % has been related to the 3 % frequency of a characteristic. If the standard error is converted to the scale indicating the frequency of the characteristic, it amounts to ± 0.18 %. In a concrete individual case, the "standard" error does not provide precise information on the error in this very case, but only gives an indication of probability of the following kind: if we start from the assumption that a characteristic of the frequency of 3 % is to be determined 100 times from such a sample, the values ascertained in the sample would range between 2.82 and 3.18 % in 68 cases, between 2.73 and 3.27 % in 87 cases, and between 2.64 and 3.36 % in 95 cases. The other 50 cases usually exceed these limits only to a minor extent, namely by 0.07 % on an average.

These figures on the distribution of the errors are verified when they are tested empirically by applying the same procedure to prior statistical data. In the 1950 population census a compilation was made in which one in 100 punch cards was selected. In these operations, 138 characteristics in 12 Laender were compared with the actual figures obtained in the population census. Per 100 cases included in these investigations the distribution of errors was as follows:

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1) The relative standard error is

$$s_{rel} = \sqrt{\frac{(1 - p)\,(N - n)}{p \cdot N \cdot n}}$$

p denoting the true frequency of a characteristic, n the size of the sample, and N the size of the parent population.

under 1/2 s	1/2 to under s	s to under 2 s	2 s to under 3 s	3 s and over
36.6	31.2	27.0	4.7	0.5

which compare with the following theoretical values:

38.3	30.0	27.2	4.2	0.3

This is a good agreement.

If we compare the scales under the network we clearly recognize that in the majority of cases the influence of the size of the parent population is scarcely of any importance. In the sample just considered, the sample error is practically not influenced by the size of the population in those cases where the latter is larger than 100,000. Not before the total population is as small as 100,000, the point of the scale for 9,000 shifts slightly to the right-hand side.

These outlines clearly show the dependence of the size of the sample error upon the frequency of a characteristic, the sample size, and the sampling ratio in the case of a simple random sample. The same chart may also be used for calculating the error with respect to a QUANTITATIVE CHARACTERISTIC, where the problem in question is, say, to ascertain a mean or a total. Where quantitative characteristics are concerned, the frequency of a characteristic, which does not exist in such a case, is replaced by the dispersion of the individual values around the mean value, which is measured by the so-called standard deviation. the relative measure of dispersion is the so-called coefficient of variation (v), i.e. the standard deviation divided by the mean. In applying it, the various possible scales of characteristics such as length, weight, value, time, etc. are evaded, so that a uniform illustration is arrived at. From the coefficients of variation the relative standard error of a mean value determined from a sample can be calculated by taking into account the sample size and the population. The formula for the calculation of the standard error of a mean[2] is so similar to the formula just given for the calculation of the error of a frequency that it can be shown in the same chart. A scale for the coefficient of variation has been inserted in the right-hand side of the chart. If this coefficient of variation is known (or can be estimated) for a characteristic, it is possible to read from the graph the relative standard error for the mean value by taking into account the size of the sample.

If it is not an average, but a total that is to be determined in the parent population of a sample, this total has the same relative standard error as the average.

Example: If the coefficient of variation is 0.5 (the standard deviation of a characteristic is half as great as the mean value, which is already quite a large variance where quantitative characteristics are concerned), the mean value in a sample comprising 10,000 elements of a population of 1 million is determined with a standard error of 0.5 %. This same relative standard error applies also to the total value raised to the population.

The graph illustrates still another important conclusion from the law of the large number: in order to bisect the error, the sample size must usually be made four times as large; in order to reduce the error to 1/3, the size must be made 9 times as large. Conversely, the error is proportional to the square root from the sample size. Hence it follows that, say, a 10 % increase in the sample size only reduces the error to a minor extent, namely by 5 %. Even a doubling of the size only reduces the error by 30 %. If from the viewpoint of the subject-matter concerned a sample error is regarded to be too large, it is not of any use to increase the sample size to a small extent; the size must at least be made twice, four times, ten times as large.

The Peculiarities of the Sample Design

The above considerations related to the case of a simple random sample. The peculiarity of the units to be collected and of the characteristics frequently result in the necessity to choose other procedures. For reasons of rationalization it will often be necessary to draw upon a "multi-stage" selection by making, say, on the 1st stage a selection of communities and on the 2nd stage a selection of persons or households or dwellings or establishments in the communities selected. These are operations that alter the sample error.

In an extreme way, such a situation turned up in the election statistics, in which complete polling districts were the only selection units in question, and inside the districts selected all votes had to be counted. It may be said that the 2nd stage was covered 100 %. As regards the units of the 1st stage we are faced with a so-called "cluster effect". It goes without saying that a much higher precision would have been obtained if the 500,000 persons entitled to vote, who were covered by the 1953 election statistics, had been selected according to their distribution throughout the total Federal Republic instead of regarding them - as in the present case - as clusters in 470 polling districts. The cluster effect may reduce the precision of a sample considerably.

On the other hand, much can be gained by occasionally dividing the parent population into so-called "strata" which in themselves are much more homogeneous than the total population. If the selection is made separately in each individual stratum, the variance may be reduced when compared with the single non-stratified random selection. In the case of stratified samples, different sampling ratios can be used in the individual strata, and in this way the precision can, if necessary, be adapted to different requirements at various points in the programme of tables. In statis-

2) The relative standard error of the mean value $\bar{x}$ is

$$s_{rel} = v \cdot \sqrt{\frac{(N - n)}{N \cdot n}}$$

the coefficient of variation being

$$v = \frac{\sqrt{\sum (x_i - \bar{x})^2}}{x \cdot n - 1}$$

tics of labour in agriculture, for instance, the selection is made separately according to size classes of holdings of the agriculturally used area. In this design, a higher sampling ratio is used in the higher size-classes not including so many items, because the number of labourers is greater in these classes and the variance between the holdings becomes larger. Certain smaller, but particularly important parts of the population can even be covered 100 %. In the majority of all samples this principle of stratification is successfully used in practice.

Another important peculiarity which in adequate cases can be used for making sampling designs most precise lies in the application of "ratio estimations". In these operations accurately known figures - in particular those obtained from prior total censuses - are used as a basis and the ratio of the characteristic to be collected to the relevant characteristic known from the prior statistical data is ascertained in the sample. This is frequently referred to as an "appending" to the basis figures, and the results obtained from this procedure are frequently more favourable than those obtained by the method of "raising" figures, the sampling errors of which have been shown in the graph. The regression estimation which in theory is regarded as favourable, too, has seldom been used in practice.

In many cases, it may become necessary to conduct small-scale pilot surveys for the purpose of obtaining the decisive methodical foundations for the preparation of the most rational sample design. Accordingly, a pilot survey may lead to a considerable reduction of costs or to a considerable increase in precision respectively.

These individual problems of sampling techniques which have to be adapted to the given possibilities and which in each instance cause a higher or lower standard error will not be discussed in detail within the scope of this article. The principles of the gradation of the precision in view of its dependence upon the size of the sample and the dispersion or frequency of a characteristic illustrated in the chart are in a similar way applicable to other procedures, too. The simple cases considered in the graph also offer a first clue in more complicated projects.

The Required Precision

If the required precision has been given in advance for one or several items of the table by numerical determinations on the standard error, it is possible to state that size of the sample which will supply the desired confidence interval, provided that sufficient clues are available for estimating the cell-frequency or the variances. It is quite a particular advantage of the sampling procedure that the required sample size can be calculated when the error has been given in advance or vice versa.

However, it should be borne in mind that in their essentials these forecasts are nothing but a determination of orders of magnitude, and that the claims laid to the precision of such a calculation must not be too high. Before the statistical survey itself has been conducted the only thing possible is to draw analogous conclusions on the cell-frequency and on the variances. Even in the most favourable cases, these conclusions have to be drawn from similar surveys conducted before and are then directly or in a modified way transferred to the survey intended to be undertaken. In many cases, the standard errors are ACCURATELY KNOWN not before the survey has been conducted.

In practice, the determination of the required precision frequently involves considerable difficulties. To begin with, it is already difficult to determine which of the characteristics is to be used as the measure. What is usually obtained from the surveys conducted within the framework of official statistics is not one single result, but a whole programme of tables is established, which includes numerous items. In the case of such tables which are frequently subdivided to a wide extent, it is often difficult or even impossible to say which of the figures is decisive in respect of the required precision. If several requirements of precision are raised, which are to be applied to various items of the tables, there frequently arise particular difficulties, as in some instances these requirements cannot be reconciled with one another. In many cases one of these requirements necessitates a larger sample size and a more complicated selection and compilation procedure than the others, so that a new variant enters into the calculation of costs. For instance, it may happen that a small supplementary table which in a total census would raise the costs only to a relatively small extent, involves a considerable amount of extra costs when a sample survey is concerned. These are new points of view the importance of which cannot be guessed at the time being.

In particular, the precision requirements simultaneously existing side by side with respect to subdivisions according to subject-matters and regions involve problems of special difficulties, which will be discussed later in this article.

The second difficulty is to determine the required precision itself. Discussions and negotiations centering around the precision of samples have again and again revealed that generally speaking clearly founded conceptions on the required precision of a statistical figure are not found. The figures should have that precision which in their later use is necessary for providing an answer to certain questions, for solving certain problems, or for deciding upon certain measures to be taken. The actual peculiarity of the precision requirement is best seen if it is related to these later purposes: the errors of the figures must only be so large that they do not cause a false solution of the problems, a false decision, etc. But what is the order of magnitude of the differences which becomes decisive later on? Not before the question is put in this way and thought over on the basis of the actual example concerned, the correct requirements of precision can be found. Without such a precise definition related to the SUBJECT-MATTER concerned, the lump sum of the precision requirements will in most cases be too high. It is an opinion frequently met that it is principally impossible to use figures which have a relative standard error of, say, 10 %. However, such a precision is in many cases sufficient and particularly with respect to smaller figures where larger differences are frequently the only ones that are of any importance in practice, though it certainly occurs that a standard error of 5 %, 2 %, 1 % is justified and even required.

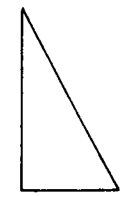
In some sampling designs it has held good to replace at the beginning standard errors numerically fixed in advance for different characteristics by a mere gradation of the sequence of precision. In the soil utilization survey, for instance, the individual types of crops were divided into 4 stages of precision. The numerical determination was made in a later phase in which the technical possibilities to realize them in a sampling design could be recognized.

The dependency of the requirement of precision upon the type of the characteristics and the breakdown of the tables will be discussed later in this article.

Random and Systematic Errors

When regarding the problem from the aspect of a special project existing in practice, it is noticeable that in each survey it is the size of the TOTAL error that is decisive of the requirement of precision, and not the individual components of the error. It is possible in a sample to calculate separately ONE component, namely the RANDOM ERROR in its order of magnitude. However, the requirement of precision always and principally relates to the possible deviation from an actual value, and all SYSTEMATIC ERRORS of the survey enter into this deviation. In this connection it is not of any importance whether the latter are due to deficiencies in the collection techniques, to the delimination of the population concerned, to the definitions, to the programme of questions, or to other deficiencies. Every statistical survey has deficiencies of this type, the total of which is referred to as "systematic errors".

If in an individual case we knew their direction and size, it would be possible to correct them by relevant calculations. Then a remaining systematic error would no longer exist. The disturbing systematic errors are those which are not known in an individual case in respect of their type, direction, and size, so that we are faced with the same situation as in the case of the random errors: they cannot be eliminated by means of relevant calculations. The actually existing systematic and random errors can increase or offset one another, which depends upon how they come together, and this is again at random. Large errors conceal the small ones, and it is not of any importance which of them are systematic and which are random errors. Systematic and random errors must be combined to a total error according to the Pythagorean formula as illustrated by the rectangular triangle below:



If for instance the systematic error has a certain order of magnitude, which may be called 1, the total error would be increased by the addition of a sample error in the following way:

Systematic error	Random error	Total error
1	2	2.24
1	1	1.41
1	0.5	1.12
1	0.3	1.045
1	0.1	1.005
1	0.01	1.00005
1	0	1

The high random error conceals the systematic error and is alone decisive of the total error. A smaller random error is concealed by a systematic error. In this case, the systematic error is decisive of the total error. From these ratios it is recognizable that a random error which is half as high as the systematic error effects only a minor increase in the total error. A further decrease in the random error, which in many cases must be bought with a considerable increase in both the sample size and the costs, is no longer worth-while. Even in a total census it would not be possible to force the error down to under 1. Hence it follows that in such a case it is not worth-while to undertake a total census, as in practice the latter would not be superior to a sample having a random error which is half as high as the systematic error.

The following should be regarded as a general rule:

THE EXTENT OF A SURVEY SHOULD NOT EXCEED A RANGE IN WHICH IT IS CERTAIN THAT THE RANDOM ERROR BECOMES SMALLER THAN ABOUT HALF THE SYSTEMATIC ERROR. IT IS NOT WORTH-WHILE TO EXPAND THE EXTENT OF THE SURVEY SO AS TO COVER AN ESSENTIALLY WIDER RANGE.

It is true that the quantitative estimation of the order of magnitude of systematic errors is as a rule extraordinarily difficult, but it will nevertheless be possible to give a certain gradation of the order of magnitude. However, it will scarcely be possible even in clear cases to give the order of magnitude of a systematic error more precisely than in a gradation according to powers of two, as for instance in the form of the series 0.5 % - 1 % - 2 % - 5 % - 10 % - 20 %. In some cases, it will only be possible to draw upon a geometric progression with powers of three, namely 1 % - 3 % - 10 % - 30 %, or even upon powers of ten.

In general, systematic errors are not dependent upon the frequency of a characteristic. Scarce characteristics may show large or small systematic errors, and the same applies to frequent characteristics. SYSTEMATIC ERRORS HAVE NOT ANY BALANCING TENDENCY WHEN THE SAMPLE IS INCREASED.

The problems of the interrelationship between systematic and random errors will be discussed below on the basis of a few examples:

1. It is the main purpose of the SOIL UTILIZATION SURVEY to ascertain precise areas for estimating the yield of crops. Up to now it was conducted as a total census. Subsequent controls revealed that ascertainment errors occur which vary among the various types of crops. The corrections reach an order of magnitude of 5 to 10 %. They themselves have only been determined vaguely by a small sample. If such a correction is made the precision of the total census drops down to the relative precision of the subsequent control, in which the ascertainment of the systematic error is connected with a random error. The yield per hectare is ascertained for the principal types of crops by a procedure thoroughly prepared from the methodical point of view and when applied at the Laender level it has a standard error of approximately 1 to 2 % in respect of the threshed crop. But this very high precision is reached only with four principal types of crops. As regards the other types of crops, the yield per hectare data are based on the estimations made by the crop reporters themselves, and it is no doubt that in these data the order of magnitude of the (systematic) error is higher. If these facts are taken into account when forming an opinion on the total soil utilization survey, it must be said that it is much too extensive and expensive for the use to be made of its results and that we should satisfy ourselves with a sample sûrvey at least in the majority of years by refraining from a more detailed regional breakdown, as in the case of crop estimations such a breakdown can never be of high precision.

To adapt in a sensible way the precision of the various parts of a survey to one another and the sample error to the systematic errors is a problem which is to be solved during the next years.

2. As a second example mention should be made of the well-known problem of NON-RESPONSE in interviews or in the completion of questionnaires. The cases of non-response are known in number and could be compensated numerically by altering the raising factor if it were known that the cases of non-response would only be a random sub-sample and apart form the random differences would have the same composition as the population. However, it is one of the most important basic theses of the sampling theory that this prerequisite is seldom realized. Insofar as cases of non-response occur at all at a noticeable number, it must be expected that there exists an one-sided and distorting selection which results in a bias. It is true that the particulars and the type of this selection vary from statistics to statistics and from table to table. But a certain one-sidedness, which frequently is only indirect and cannot be ascertained direct, must be assumed in any case. If the rate of non-response is only small, the bias effected by an extreme one-sidedness is relatively small, too, while in the cases of a high rate of non-response, all results and also those relating to frequent characteristics become uncertain. Accordingly, it does not pay to increase the sample size when the rate of non-response is high, as the systematic error will then be dominant in any case. The solution frequently tried in practice in those cases where a higher quota of non-response is expected, namely to make the sample so large from the very beginning that even in the reduced material favourable random errors can still be maintained, does not hold good. The principle of the composition of errors rather suggests a reverse argumentation: if in a sample high rates of non-response are to be expected, it principally does not pay to fill up the gaps because of the systematic error included therein.

These considerations apply also to all surveys which are based on the VOLUNTARY PARTICIPATION and the readiness of the respondents to render information. The biassing possibilities latently included in such a survey are as large as the quota of non-response would be in a sample survey. By limiting the selection from the very beginning to those persons who are ready to provide information, the only thing done is to spare the work of questioning a larger population selected by sampling and of ascertaining the percentage of non-response. An opinion on the reliability of statistics from the subject-matter angle can be formed only by taking into account the effect of the one-sided selection of the readiness to render information. These problems are most distinct in family budget statistics and have frequently been referred to in this connection. Because of the very strong selection effect these enquiries should only be conducted on a very small scale.

3. WAGE TAX STATISTICS may be quoted as a third example. In these statistics, the fact that the wage tax cards of a considerable part of the wage tax payers are not returned to the revenue offices at the end of a year has the effect of a systematic error in a similar way as the cases of non-response. The missing population itself is not the systematic error. For if its size would be known precisely or if we were only faced with losses distributed at random and not affected by an one-sided selection number and structure of the total population could be ascertained unobjectionably. But as this is not the case, a population of about 5 % missing from a certain group of gross wages or from a certain field or from certain tax-brackets could be estimated only at a considerable quantitative uncertainty and could, for instance, range between 3 and 7 %. The qualitative uncertainty in view of the structure lies in the fact that the missing population may distribute itself to the individual characteristics in another way than the population under consideration. If in another group the missing population would be estimated to be approximately 30 %, it may be assumed that the uncertainty of the estimate would be larger correspondently and probably range between 20 and 40 %. Hence it should follow for a sampling design of statistics on returned wage tax cards that it would certainly make sense to aim at a random error of approximately 1 % in the first group, but not in the second group. In this latter group a random error of approximately 5 % would probably be more adequate. In the 1955 wage tax statistics which were conducted on a sampling basis the principle of adapting the random errors to the systematic errors was applied only to some sub-groups (e.g. by subdividing the more precisely specified strata of gross wages of 1,200 DM into groups of 600 DM); in most of the groups the sample error is much smaller than in the standards referred to above.

The Dependence of the Precision upon the Type of Characteristics to be Ascertained

In practice it is not possible even in those cases where the programme of tables is not very detailed to design a sample in such a way that all characteristics collected are ascertained with an equal absolute or relative precision. The more detailed is the breakdown, the greater is the number of poorly occupied items in the tables, while the marginal totals remain densely occupied. Between the densely and poorly occupied items in a sample there is a natural gradient of precision insofar as generally the sample error is relatively smaller in the higher numbers. In some cases it is possible to evade this rule in view of some characteristics, namely in those where a scarce characteristic is ascertained with a high degree of precision by stratification and adaptation of the sampling ratios to the special distributuion of such a characteristic.

In many statistics the higher figures are also the more important ones and require a higher relative precision. As regards the smaller figures, a relatively wider range of uncertainty may be tolerated. However, this does not hold good in all cases, for in many instances the small figures are those which are of decisive importance. But on the whole, the gradation of the importance of the figure widely corresponds to the natural gradient of precision. For instance, it may be necessary to ascertain whether a frequency of 10 % must be altered so as to be 11 %. The relative standard error of these figures in a sample would then have to be approximately 2 to 3 % (related to the basic frequency of 10 %). If the figure is considerably smaller, say, 0.2 %, it may only be necessary to find out whether a change, say, to 3 % has occurred. But for this purpose, a relative standard error of approximately 10 to 15 % (related to 0.2 %) would be fully sufficient.

A cross-classification BY SUBJECT-MATTERS AND BY REGIONS in a programme of tables involves particular problems which are due to the fact that the figures have been split up in an extreme way. In principle it is possible to employ a regional breakdown also in samples; it is only required to adapt the selection procedure to the peculiarities of the regional distribution. While a programme with a detailed breakdown by subject-matters can frequently be accounted for in a methodically rational way by a two-stage selection procedure, in which the first stage is formed by regional units such as communities, this cluster procedure prevents that the results can be recorded in a detailed regional breakdown. Such a breakdown can be made in a sample only in those cases where a prior stage on which regional units are selected is refrained from. As an example housing statistics come to mind where in the 10 % sample one in ten dwellings was selected in all communities. The 1 % supplementary survey to housing statistics, however, is only conducted in a sample of communities; in this procedure it is not possible to sub-divide the figures by Kreise.

The usefulness of a sample for the Federal Republic, the Laender, and the Kreise can be seen from the graph. In samples of persons, the upper scale under the abscissa axis relates to the Federal Republic, the 3 million scale to a smaller Land, and the lowest scale to a Kreis of an average size. If the values of error are compared with one another, the rule shows up again according to which the main prerequisite for obtaining the same precision is to use the same absolute sample size. For the Laender the sampling ratio would have to be 10 times as large as for the Federal Republic in order to ascertain a characteristic with the same precision, but then the precision of the Federal results would be overestimated. This is the reason why in practice it is more important to pay attention to another version of the same fact: the details accounted for in the breakdown of the Laender programmes of tables are reduced as against the Federal tables; in the smaller Laender, the results will be of the same precision when the small frequencies of characteristics are made 10 times as high by concentration. In the Kreis tables a relevantly less detailed breakdown must be used.

The usability of a sample design can roughly be estimated for each individual breakdown by characteristics by estimating the probable cell-frequencies : IF IN A SAMPLE AN ITEM OF THE TABLE INCLUDES LESS THAN 30 TO 50 INDEPENDENT INDIVIDUAL CASES, THE RESULT IS NOT USABLE IN THE MAJORITY OF CASES. But larger figures cannot guarantee the usability either (e.g. in the case of the regional cluster effect). This rule should also be accounted for when items are combined in a regional breakdown: the items are combined in such a way that after concentration each remaining item includes at least 50 (or, which is still more adequate, at least 100) sample elements.

These guides are applicable not only to the cases where breakdowns by subject-matters and regions are combined, but also to those where the statistical material is sub-divided into sub-groups according to subject-matters. The considerations based on absolute figures and on ratios are interrelated with each other. As regards the 1 % sample in the Micro-Census which includes 180,000 households throughout the Federal Republic of Germany its size is, as a rule, large enough to be used for other types of questions, too. The Micro-Census has been arranged in a way that the information provided will also be sufficient for being drawn upon in special farther-reaching investigations in many sub-groups (e.g. gainfully occupied mothers or owners of motor cycles).

In an important group of sample investigations it is not the breakdown of characteristics in the meaning of structural investigations that is placed into the fore-ground, but the DEVELOPMENT IN THE COURSE OF TIME. In these cases the sample design is frequently conducted as a ratio estimation in that way that a ratio of changes to be ascertained in a sample is "appended" to the figures obtained from a total census or from a basic sample survey conducted on a larger scale. The characteristics to be ascertained are the changes occurring within the course of time. These are frequently not so large and sometimes not so inhomogeneous that they require a very large sample. If there is a high correlation between the values in the basic survey and the characteristic in the report period, it is sufficient to use a relatively small sample. In a sample repeated at regular intervals it may be advantageous to ascertain the same units as long as the repetition itself does not bring about an one-sidedness, e.g. by a decreasing readiness to render information, by an one-sided separation from the survey, by moving to another locality, etc. Forming an opinion on the precision at which changes in the course of time are desired to be ascertained involve special difficulties. Information on the variances has to be derived from empirical investigations of prior statistical data and can only be transferred to future conditions at a certain degree of uncertainty, for conditions of dispersion may be quite different in future trends particularly in those cases where they are influenced by cyclical events. This is the reason why in a ratio estimation in respect of time the projection of the random error is in principle less certain than it is in structural investigations in cross-section statistics. But in many cases experience gained in practice shows a marked homogeneity in the development in the course of time, which makes the ratio estimation in respect of time which in the end is also the basis of nearly all economic indices reliable enough. However, there is still a great number of methodical problems left to be solved.

Summary

Four points have to be given priority in further discussions on the size of samples, namely

1. Critical considerations on the EXTENT OF THE BREAKDOWN OF THE PROGRAMME OF TABLES BY SUBJECT-MATTERS AND REGIONS by taking into account the possibilities of sampling techniques and the costs involved in the individual parts of the programme.
2. Estimation of the ORDER OF MAGNITUDE OF SYSTEMATIC ERRORS in statistics as a basis for reasonable demands on the random errors.
3. Determination of the necessary PRECISION OF THE TOTAL ERROR on the basis of realistic considerations on the use to be made of the figures in practice.
4. Preparation of a SAMPLING DESIGN which guarantees the necessary precision AT A MINIMUM AMOUNT OF COSTS.

Dr.Klaus Szameitat / Professor Dr.Dr.Siegfried Koller

Appendix

Title of Statistics	No. in the Catalogue of Statistics	Collection or processing of data in sample surveys	Basic material: Primary or secondary statistics	Basic material: Enumeration papers	Basic material: Way in which facts are ascertained	Basic material: Unit of collection	Stages	Selection material: Selection unit (number)	Selection material: Records used
	1	2	3	4	5	6	7	8	9
Population Census 1950 (special sample enumerations of characteristics of households)	I A 1 a	processing	primary	questionnaires	filled in by respondent	household	one-stage	household (15 millions)	enumeration sheets and punch cards of the population census 1950
Micro-Census (Population and Labour Force Sample Survey) October 1957	I A 2	collection	primary	questionnaires	interview	household	two-stage		
							1st stage:	community (24,000) (in cities: sub-sample of enumeration districts)	population and occupation census 1950, results for communities
							2nd stage:	dwelling (13 millions)	housing statistics 1956-57; auxiliary lists
Election Statistics (elections to the "Bundestag" 1957: participation in the elections and votes cast by sex, age groups, etc.)	I F 1	collection	secondary	pollbooks voting papers	established by elective authorities filled in by voter	person entitled to vote (enumeration unit)	one-stage	polling district (48,000)	results of the 1953 elections by polling districts
Statistics on Family Workers in Agricultural and Forestry Holdings (1953, 1954)	—	collection	primary	questionnaires	filled in by holding	agricultural holding	one-stage	agricultural holding (2 millions)	census of agricultural holdings 1949, horticulture survey 1950
Statistics on Labour in Agricultural Holdings	II A 5								
Basic survey (1956)		collection	primary	questionnaires	filled in by enumerator or holding	agricultural holding	one-stage	agricultural holding (1,850,000)	auxiliary lists used in the soil utilization survey 1955
Monthly inquiries (1956 to 1958)		collection	primary	questionnaires (book on holding with monthly entries)	filled in by enumerator or holding	agricultural holding	one-stage	holding covered by the basic survey (144,000)	schedules on holdings used in the basic survey
Main Survey on Soil Utilization	II B 1 b								
in: Lower Saxony, Hesse, Rhineland-Palatinate, Bavaria, 1957		collection	primary	schedules on holdings	filled in by holding	agricultural holding	one-stage	community (17,000)	results for communities of the soil utilization survey 1956
in: Lower Saxony, Hesse, Rhineland-Palatinate, Bavaria, 1958		collection	primary	schedules on holdings	filled in by holding	agricultural holding	two-stage		
							1st stage:	community (17,000)	results for communities of the soil utilization survey 1956
							2nd stage:	agricultural holding (1,150,000)	schedules on holdings used in the soil utilization survey 1956

[1]) In each of the Federal Laender. — [2]) In case of stratified samples ordering of sampling units within the various strata.

and Processing in Sample Surveys

Sampling procedure: Stratification: Stratified or not stratified	Characteristics for stratification	Number of strata[1])	Ordering of selection units[2])	Sampling fraction in the strata	Selection techniques	Overall sampling fraction	Sample size	Peculiarities (col. 7-17)	Conversion to parent population: Procedure	Base (for appending)	Remarks
10	11	12	13	14	15	16	17	18	19	20	21
stratified	Federal Laender	—	by "Kreise" and communities	1%	systematic (1 in 100 punch cards, 1 in 100 enumeration sheets)	1%	150,000 households	—	free estimation	—	—
stratified	Federal Laender, size classes of communities, population and economic structure of the communities	1 to about 300	by "Kreise"	1 community per 10,000 of population	systematic and proportionate to number of inhabitants of communities	1%	170,000 households	norm: in communities with 500 and more inhabitants 100 persons per interviewer, in communities with less than 500 inhabitants 50 persons per interviewer	free estimation by making adjustments for the population figure according to the currently calculated population	—	Same selection as in the 1% sample of housing statistics 1956-57. The quarterly surveys conducted in the Micro-Census in January 1958 etc. with the sampling fraction of 0.1% are sub-samples of the survey conducted in October 1957
not stratified	—	—	by streets and houses	1% to about 25%	systematic (1 in ... dwellings)						
stratified	Federal Laender, size classes of communities, political structure	140 to 420	by proportion of votes of political parties in 1953	in 4 Laender 4%, in 6 Laender 1%	selection of 4 districts from 100 (400) successive polling districts (zones) each	2.1%	1007 polling districts	—	calculation of proportions in in subgroups	—	—
stratified	Federal Laender, size classes of holdings	6	by "Kreise", communities	4% to 100%	systematic (1 in ... holdings)	8%	160,000 holdings	—	free estimation	—	Account has been taken of the changes in the numbers of holdings since 1949
stratified	Federal Laender, size classes of holdings, in part types of holdings	14	by "Kreise", communities	3% to 100%	systematic (1 in ... holdings)	8%	144,000 holdings	—	free estimation	—	—
stratified	(as in the basic survey) additionally: soil utilization systems	about 100	by "Kreise", communities	10% of the basic sample	systematic (1 in 10 holdings covered by the basic survey)	0.8%	15,000 holdings	—	difference estimation and ratio estimation	basic survey number of holdings in the survey year (according to the soil utilization survey)	—
stratified	Federal Laender, acreage of special types of crops	4	by acreage of special types of crops	10% to 100%	systematic (1 in ... communities)	16%, in Rhineland-Palatinate 24%	3000 communities	stratification by ordering the communities mainly growing special types of crops in closed sub-populations prior to the systematic selection	difference estimation	acreage 1956	Sample of holdings in towns not attached to a "Landkreis" and in larger communities
						6.5%	75,000 holdings				—
stratified	Federal Laender, acreage of special types of crops	4	by acreage of special types of crops and by "Kreise"	20% to 100%	systematic (1 in ... communities)			(as for 1957)	difference estimation, ratio estimation	acreage 1956, arable land 1958	
stratified	arable land, acreage of special types of crops	6	by "Kreise" and communities	5% to 100%	systematic (1 in ... holdings)			—	free estimation	—	

Title of Statistics	No. in the Catalogue of Statistics	Collection or processing of data in sample surveys	Basic material: Primary or secondary statistics	Basic material: Enumeration papers	Basic material: Way in which facts are ascertained	Basic material: Unit of collection	Stages	Selection material: Selection unit (number)	Selection material: Records used
	1	2	3	4	5	6	7	8	9
Main Survey on Soil Utilization (cont'd)	II B 1b								
in: North Rhine-Westphalia, 1957-58		collection	primary	schedules on holdings	filled in by holding	agricultural holding	one-stage	agricultural holding (260,000)	schedules on holdings used in the soil utilization survey 1956
in: Baden-Wuerttemberg, 1956-58		collection	primary	schedules on holdings	filled in by holding	agricultural holding	two-stage		
							1st stage:	community (3400)	results for communities of the soil utilization survey 1955
							2nd stage:	agricultural holding (390,000)	schedules on holdings used in the soil utilization survey 1955
Subsequent Check of the Soil Utilization Survey (preliminary and main surveys)	II B 1a	collection	primary	schedules on holdings	filled in by commission	agricultural holding	two-stage		
							1st stage:	community (24,000)	census of agricultural holdings 1949
							2nd stage:	agricultural holding (1,850,000)	preliminary survey to the soil utilization survey
Enumeration of Fruit Trees 1958	II B 2	collection	primary	list of enumeration districts	ascertained by enumerator	fruit tree (enumeration unit)	one-stage	community (20,000) see col. 21	enumeration of fruit trees 1951
Special Yield Inquiry	II B 5								
1st phase		collection	primary	report forms	square metre cuts by commission, laboratory analysis	part of a field	four-stage		
							1st stage:	community (24,000)	soil utilization survey
							2nd stage:	agricultural holding (1,850,000)	soil utilization survey
							3rd stage:	field	information rendered by owner of holding
							4th stage:	part of a field (1 m²)	—
2nd phase		collection	primary	report forms	ascertained by commission	field	one-stage	selected field of the 3rd stage	list of addresses of the 1st phase
Intercensal Livestock Surveys (March, June, September)	II C 1b	collection	primary	list of enumeration areas	filled in by enumerator	livestock farming	one-stage	enumeration area (incl. approximately 20 pig keepers) (100,000)	list or card index of enumeration areas according to the survey conducted in June 1953

[1]) In each of the Federal Laender. — [2]) In case of stratified samples ordering of sampling units within the various strata.

Sampling procedure									Conversion to parent population		Remarks
Stratification											
Stratified or not stratified	Characteristics for stratification	Number of strata[1])	Ordering of selection units[2])	Sampling fraction in the strata	Selection techniques	Overall sampling fraction	Sample size	Peculiarities (col. 7-17)	Procedure	Base (for appending)	
10	11	12	13	14	15	16	17	18	19	20	21
stratified	districts of chambers of agriculture, acreage of special types of crops in communities	4	by "Kreise" and communities	6%, 20%	systematic (1 in .. holdings)	7%	19,000 holdings	stratification of communities according to the characteristics in column 11 prior to selection of holdings	difference estimation, ratio estimation	acreage 1956, arable land 1956	—
						6%	25,000 holdings (100 holdings each for 25 special types of crops)	separate selection for each of the types of crops	ratio estimation	acreage 1955	The sample consists of 25 independent parts. Final results by weighted concentration
stratified	acreage of types of relevant crops	3	by "Kreise"	10% to 100%	systematic and proportionate to the acreage of the relevant types of crops in the "Kreise"						
not stratified	—	—	—	about 0.5% to 10%	by drawing the lot						
						0.15%	2680 holdings	generally 3, in North Rhine-Westphalia 2 holdings per community; in "Landkreise" only	difference estimation, ratio estimation	characteristics of surveys of reference, arable land	—
stratified	Federal Laender	—	by "Kreise"	4%	systematic and proportionate to the agriculturally used area						
stratified	size classes of holdings	3	—	3.5% on the average	by drawing the lot						
stratified	Federal Laender, total number of fruit trees	9	by "Kreise"	1% to 100%	systematic (1 in ... communities)	10%	2000 communities	—	ratio estimation	numbers of fruit trees 1951	Selection units in Schleswig-Holstein and Baden-Wuerttemberg lots, enumeration areas
						0.001‰ of the total area per type of crops	square metre cuts in 1000 to 3000 fields per type of crops	—	computation of average yields (q per ha)	—	Ascertainments are made for winter rye, winter wheat, summer barley (only in southern Germany) and late potatoes
stratified	Federal Laender	—	by "Kreise"	about 18%	systematic and proportionate to the acreage of the type of crops						
stratified	size classes of holdings	2	—	(2 per community)	by drawing the lot (adaption to size classes of holdings in the "Kreis")						
not stratified	—	—	—	(1 per holding)	by drawing the lot						
not stratified	—	—	diagonally in the field	(5 m² per field)	systematic at equal distances						
not stratified	—	—	—	15%	systematic, by taking into account the harvesting procedures	0.06‰ to 0.3‰ of the total area per type of crops	150 to 400 fields per type of crops	—	ratio estimation	yield data of the 1st phase	(see 1st phase)
stratified	Federal Laender, number of sows for breeding	3	by "Kreise"	about 5% to 50%	systematic (1 in .. enumeration areas)	14%	14,000 enumeration areas	in the June survey: sub-stratification by milk cows in Lower Saxony	pigs: free estimation cattle: ratio estimation in some Leander free estimation	— preceding December survey —	In June, special procedure for sheep

Title of Statistics	No. in the Catalogue of Statistics	Collection or processing of data in sample surveys	Basic material: Primary or secondary statistics	Basic material: Enumeration papers	Basic material: Way in which facts are ascertained	Basic material: Unit of collection	Selection material: Stages	Selection material: Selection unit (number)	Selection material: Records used
	1	2	3	4	5	6	7	8	9
Subsequent Checks of the General Livestock Census and the Intercensal Livestock Survey in June	II C 1a, b	collection	primary	list of enumeration areas	filled in by senior enumerator	livestock farming	one-stage	enumeration area (incl. approximately 20 pig keepers) (100,000)	survey of reference
Annual Survey on the Net Product of Industry 1954 (sub-division of receipts of material)	IV A 3	collection	primary	questionnaires	filled in by enterprise	enterprise incl. establishments covered by the monthly industry report	one-stage	enterprise (48,000)	card index of enterprises
Housing Statistics 1956-57									
(10%) sample survey 1956	V 3a	collection	primary	questionnaires	filled in by respondent	dwelling, dwelling party	one-stage	dwelling (13 millions)	housing census 1956; guiding lists
Supplementary (1%) sample survey 1957	V 3b	collection	primary	questionnaires	interview	dwelling, dwelling party	two-stage		
							1st stage:	community (in cities: sub-sample of enumeration districts) (24,000)	population and occupation census 1950, results for communities
							2nd stage:	dwelling (13 millions)	housing census 1956; guiding lists
Statistics on Public Welfare Supplementary statistics 1956 and 1957	IX C 1	collection	secondary	enumeration sheet	extract from the files of the welfare unions	regularly assisted party (enumeration unit)	one-stage	regularly assisted party (1956: 530,000; 1957: 510,000)	card index of the welfare unions
Statistics on Social Conditions of Recipients of Pensions and Benefits	IX C 3								
Part 1		collection	secondary	enumeration sheet	extract from the files of all types of agencies paying pensions and benefits	recipient of pensions and benefits (enumeration unit)	one-stage	recipient of pensions and benefits (10 millions)	card index of the agencies paying pensions and benefits
Part 2		collection	primary	questionnaires	interview	household	one-stage	recipient of pensions and benefits whose name begins with L (470,000)	enumeration sheets used in the first part of the survey

[1]) In each of the Federal Laender. — [2]) In case of stratified samples ordering of sampling units within the various strata.

Sampling procedure									Conversion to parent population		Remarks
Stratification					Selection techniques	Overall sampling fraction	Sample size	Peculiarities (col. 7-17)	Procedure	Base (for appending)	
Stratified or not stratified	Characteristics for stratification	Number of strata[1])	Ordering of selection units[2])	Sampling fraction in the strata							
10	11	12	13	14	15	16	17	18	19	20	21
stratified	Federal Laender, number of sows for breeding	3	by "Kreise"	0.2% to 2%	systematic (1 in ... enumeration areas of the survey of reference)	0.4%	390 enumeration areas	same size of sample in the total census and in the sample survey of reference	ratio estimation	characteristics of the survey of reference	—
stratified	Federal Laender, industry group, number of persons employed	21 to 60	by number of persons employed	10% to 100%	systematic (1 in ... enterprises)	23%	11,000 enterprises	—	ratio estimation	receipts of commodities according to the main survey	—
stratified	Federal Laender	—	by communities, streets and houses	10%	systematic (1 in 10 dwellings on lines marked in advance)	10%	1.3 million dwellings, 1.8 million dwelling parties	—	free estimation by making adjustments for the number of dwelling parties	—	—
stratified	Federal Laender, size classes of communities, population and economic structure of the communities	1 to cir. 300	by "Kreise"	1 community per 10,000 of population	systematic and proportionate to the number of inhabitants in the communities	1%	130,000 dwellings, 170,000 dwelling parties	—	calculation of proportions and averages in sub-groups	—	Same selection as in the Micro-Census, October 1957
not stratified	—	—	by streets and houses	1% to about 25%	systematic (1 in ... dwellings); sub-sample from the 10% sample						
stratified	Federal Laender, welfare unions	600	names in alphabetical order	10%	systematic (all names beginning with certain letters of the alphabet)	10%	53,000 regularly assisted parties (1957: 51,000)	sub-division of the alphabet according to the frequency of letters with which names begin into 10 parts of 10% each. Systematically changing assignment of the parts to the welfare unions	free estimation	—	—
not stratified	—	—	—	—	systematic (all recipients of pensions and benefits whose names begin with L)	4 5%	470,000 recipients of pensions and benefits	data on pensions and benefits payed by different agencies to one and the same person are brought together in the process of mechanical tabulation	ratio estimation	number of cases in which pensions or benefits are paid	—
not stratified	—	—	by family names	20%	systematic (persons 1-50; 251-300; 501-550; etc. in accord with the first part of the survey)	0.9%	86,000 households	—	ratio estimation	number of households incl. recipients of pensions and benefits	—

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	1	2	3	4	5	6	7	8	9
Wage Tax Statistics 1955	X B 1	processing	secondary	wage tax card	filled in by local authority, employer and revenue-office	wage tax payer (enumeration unit)	one-stage	wage tax card (16. 3 millions)	wage tax cards for 1955
Salary and Wage Structure Survey in Industries 1957	XI B 4 a	collection	primary	enumeration list	filled in by establishment	establishment	two-stage		
							1st stage:	establishment (about 319,000)	schedules on establishments used in the total census to the industry report 1955 and in the building report 1955, census of non-agricultural establishments 1950, auxiliary records
							2nd stage:	dependently employed person (about 8,500,000)	card index of personnel

[1]) In each of the Federal Laender. — [2]) In case of stratified samples ordering of sampling units within the various strata.

and Processing in Sample Surveys (cont'd)

Sampling procedure									Conversion to parent population		Remarks
Stratification											
Stratified or not stratified	Characteristics for stratification	Number of strata[1])	Ordering of selection units[2])	Sampling fraction in the strata	Selection techniques	Overall sampling fraction	Sample size	Peculiarities (col. 7-17)	Procedure	Base (for appending)	
10	11	12	13	14	15	16	17	18	19	20	21
stratified	Federal Laender, gross wage, type of tax charge, duration of employment, sex, tax-brackets	1 to 160	by "Kreise"	0.5% to 100%	systematic (by last numbers of the consecutive numbering made within the strata)	17%	2.8 million wage tax cards	—	free estimation	—	Main results are free of random errors owing to manual assorting
						15%	about 1,300,000 dependently employed persons	—	free estimation	—	
stratified	Federal Laender, industry groups and branches, number of persons employed	192	—	15% to 100%	systematic (1 in ... establishments)						
not stratified	—	—	names in alphabetical order	15% to 100%	systematic (all names beginning with certain letters of the alphabet)						