Sampling in West German Official Agricultural Statistics

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This paper, which summarizes developments in the theory and practice of agricultural statistics in West Germany during the last 6 years, is reproduced here in an English version for the first time in an American journal. It was given at the 24th Annual Meeting of the German Statistical Association in October 1953, and published by the journal of that organization.[1] The translator, Mr. Hendricks, and Paul L. Koenig, also of the Agricultural Estimates Division, worked with the Food and Agricultural Offices of the Bipartite Control Commission in Germany in the summer of 1948. At that time they took part in some of the early work mentioned by Dr. Strecker.

SAMPLING is particularly fruitful in agricultural statistics. Factors that recommend the use of sampling here are the same as those in other areas of official statistics (*1, 3, 4*). An additional important reason for using sampling methods in agricultural statistics is the reduction of heavy workloads in the Government agencies that conduct surveys.

In the German Republic, official agricultural statistics for the last several years has been concerned with efforts to convert one-time censuses and large-scale current enumerations to a sample-survey basis as far as possible, or with the use of sampling to derive preliminary estimated totals from complete enumerations. This is particularly true for determinations of crop production, livestock enumerations, statistics on milk production, and farm labor-force enumerations.

In land-use censuses, the first studies to date on the possibility of substituting sample surveys for complete enumerations are being started. These should measure any bias that may be present in current complete enumerations and thus improve the results. So far as one can see today, practically all techniques developed in the theory of sampling are applicable. For individual agricultural surveys, the particular methods that are most appropriate become apparent.

The examples that follow indicate the present status of sampling in agricultural statistics; they also illustrate typical sampling methods used in agricultural statistics.

Objective Crop Yield Determinations

Sampling in official agricultural statistics in Germany began with an "objective yield determination," introduced in 1948 with the assistance of W. A. Hendricks and Paul Koenig, both of the U. S. A. It served—along with the estimates of crop reporters—to establish average yields per hectare of winter rye, winter wheat, and late potatoes. Recently, summer barley was included in Bavaria, Baden-Württemberg, and Rheinland-Pfalz.

Shortly before harvest, so-called harvest teams visit sample fields selected by the principle of probability (lot) and take small sample cuttings (or diggings). To reduce costs of travel, a multistage sample design is employed (*2*). This consists of drawing the sample in a number of stages, the randomly selected units becoming smaller at each stage. The sampling units at each stage are:

Village	=Stage 1.
Farm	=Stage 2.
Field	=Stage 3.
Crop sample	=Stage 4.

To make proper allowance for differences in plantings of grain and potatoes in the individual counties and States, a specified number of villages (stage 1) is selected at random within counties, by the cumulative method. The number of villages per State varies from State to State. The total number of villages selected in the whole country is approximately 1,300, which is a little more than 5 percent of all villages. Thereafter, maintaining the proper proportions of large and small farms, two farms (stage 2) are selected at random in each

[1] ALLGEMEINES STATISTISCHES ARCHIV (Organ der Deutschen Statistischen Gesellschaft) 38: 17–27. 1954.

selected village. On each of these in turn a field (stage 3; selection by lot as for stage 2) is taken for determination of yield.

For each of the grains sampled five sample cuttings of a square meter each are taken according to specific instructions. The technical instrument used for this is a square-meter frame. It consists of four iron bars each 1 meter long, three of which are tightly joined together at right angles. The fourth is pushed in only after the frame is in position at the sample spot.

For potatoes, five sample diggings, representing an area of about 25 square meters, are taken on the randomly selected fields. Sample cuttings and sample diggings measure only yields actually on the plants. No allowance is made for harvesting losses that occur under normal farm harvesting conditions (cutting, drying, transporting to shed, storage, and threshing in the case of grain). Therefore, a subsample of at least 15 percent of the sampled fields (subsampling) is selected for complete threshing or complete digging.

By pairing yields obtained from complete harvesting and from the small samples, we obtain the correct relationship between yields under farm harvesting conditions and those computed from exact measurements and weights in small samples. The numerical expression of this relationship is called a correction factor.

In Bavaria, for example, the yield of winter rye for the 1953 harvest, as computed from small samples in 500 sample fields, was 24.2 dz/ha. On 78 of these fields complete threshing data showed a yield of 23.4 dz/ha. The indicated yield from the small samples in these fields was 24.6 dz/ha. Thus the correction factor is 23.4/24.6 = 0.95. Multiplying the small-sample yield computed from all 500 fields by this correction factor gives the actual yield 24.2 x 0.95 = 23.0 dz/ha. These objective estimates (from small cuttings and complete threshings) are free of bias, despite the small size of the unit used for cutting—1 square meter.

Translator's Note: The expression dz/ha means "double-zentner per hectare." The double-zentner is equivalent to nearly 200 pounds (1.967 cwt.). Hectare is a land measure roughly equivalent to 2.5 acres (2.471). Hence, 1 dz/ha is just about equal to 80 pounds of product to the acre (79.6). For wheat (with 60-lb. bushels) a dz/ha, therefore, would convert to 1.33 bushels per acre; for barley (with 48-lb. bushels) to 1.67 bushels per acre, and so on.

By comparing yields estimated from small cuttings with those from complete threshings, P. V. Sukhatme in India, and F. Yates in England, showed that estimates of yield tend to be progressively higher as the units used for cutting are made smaller. Sukhatme (*12*) conducted his studies (in Moradabad, 1944–45) mainly on wheat. For convenience the sampling units used were equilateral triangles and circles of various sizes.

Translator's Note: Here Dr. Strecker reproduces a table from Sukhatme's paper. As it is readily available in this country, it is not repeated here.

The results show that small sampling units lead to heavy overestimates of yield and that the overestimation becomes progressively smaller as the sampling units become larger. The relative proportion of plants on the perimeter is greater in small sampling units than in larger ones. It is evident that with small sampling units the inclusion of a few too many plants on the perimeter will have greater influence on results than would be true with larger units. Results of the studies show further that yield estimates are influenced more by size of units than by their shape, although a circular unit is preferable because its perimeter is smallest in relation to area. In Germany large sampling units are not contemplated. Damage to individual fields would be too great. Therefore, correction for complete threshing must be made to adjust data from small samples.

Translator's Note: In discussing the bias that sometimes occurs with small samples, Dr. Strecker is here repeating explanations that have been offered by Sukhatme and others. But many statisticians believe, with good reason, that much of the bias results from selection of better parts of the fields in locating sampling units rather than from a "border effect." Furthermore, some of the discrepancy between yield estimates from small samples and complete harvestings is explainable by normal harvesting losses under farm operating conditions.

The Farm Enumeration of 1949

Preliminary tabulations of data from the agricultural census of May 22, 1949, were made from samples (*7*, *10*) in Bavaria to learn how closely results from a sample would approximate those from complete enumeration. It was also intended to show which items now obtained on complete enumerations would be most amenable to sample surveys. For these preliminary tabulations stratified sampling[2] was adopted as the most efficient.

Stratified sampling achieves its particular advantages over simple sampling by sorting heterogeneous statistical material into homogeneous strata so that the large differences are between strata. As items used for stratification must be correlated with items to be estimated, size of farm was used to delineate strata for the preliminary tabulation.

The following three strata were set up:

Stratum I: Farms of from 0.5 to less than 50 ha.
Stratum II: Farms of from 50 to less than 200 ha.
Stratum III: Farms of 200 ha and over.

After stratifying the questionnaires by county and by size of farm within counties, every 50th was selected from stratum I, and every 10th from stratum II.[3] All of stratum III was tabulated. Thus in Bavaria about 12,000 questionnaires, or a bit more than 2 percent of the approximately 504,000 in the universe, were selected. Results on individual items show that the sample estimates were satisfactorily accurate. For nearly half the items the differences between sample estimates and totals from complete tabulations were less than 1 percent; for four-fifths, less than 5 percent; and for nine-tenths, less than 10 percent.

Enumeration of the Family Labor Force

Previously, trends in numbers of farm operators and family coworkers could be observed only from farm enumerations that are taken at long intervals. For current observation of the family labor force, and to provide a basis for employment statistics such as wage rate and social-political data, it is important to have at hand semiannual figures on the farm family labor force. To save costs and time, and especially to lighten the work of village officials, these enumerations have been made by sampling since April 1952. It was required that for each of the major categories (farm operators and family workers by sex and age) the sampling error limits[4] should not exceed ±2 percent for each State and that the sample size for the entire country should not exceed 8 percent of all farms present (*13*).

Because a list of names and addresses for all farms in the universe was available, a stratified sample was chosen as the most efficient for this survey. Size of farm was used as the criterion for stratification. Altogether, six strata (farm size groups) were set up. The selection of farms from these strata in each State, for which different sampling rates were specified, was made from 1949 farm census data (farms of 0.5 ha and over) and from the 1950 market garden census (only market gardens of less than 0.5 ha because all large truck farms of 0.5 ha or more were included in the farm census).

For operational reasons a systematic selection procedure was again employed. For the entire country the classification of farms by strata is as follows:

Strata	Number of farms in sample	Sample size as percent of universe
I. 0.01 to less than 5 ha of farmland	77, 600	6. 5
II. 5 to less than 10 ha of farmland	37, 100	9. 2
III. 10 to less than 20 ha of farmland	25, 900	10. 2
IV. 20 to less than 50 ha of farmland	12, 700	11. 3
V. 50 ha of farmland and over	3, 500	22. 2
VI. Market gardens less than 0.5 ha	1, 100	20. 0
Total	157, 900	8. 0

Thus the total sample amounted to about 158,000 farms, or 8 percent of the total universe. After straightening out some small difficulties with the exact wording and arrangement of questions (with respect to farm operators and their family labor force) the results now come fully up to expectations.

Livestock Enumerations

As with all current agricultural enumerations, the general livestock census in December, the addi-

[2] See, for example, Deming, W. E., loc. cit., p. 213.

[3] As it is difficult to select a large number of farms entirely at random, systematic sampling is more popularly used in practice. In large surveys like farm enumerations, systematic samples can be regarded as the equivalent of genuine random samples without committing appreciable error (*5*).

[4] Sampling error limits=twice the standard error.

tional midyear livestock census in June, and the two semiannual pig censuses in March and September place a considerable workload upon the villages just as does the May land use census. Hence, it is planned first to put the semiannual pig enumerations, and later also other livestock enumerations, on a sample survey basis as might be done for the land use census. In pig enumerations it is required that the sampling error limits (two times the standard error) in any State shall not exceed ±2 percent for all pigs nor ±3 percent for any category of breeding sows.[5]

In no area of official statistics up to this time was the introduction of sample surveys preceded by so much preparatory work as for the semiannual pig enumerations. Much was learned about the efficiencies of different methods. The principal results are given here in some detail.

The first question that arose in planning such a sample survey was whether the sampling unit should be the village or the hog-farm operator. As a sample survey using the village as sampling unit is easier to carry out administratively than one using the hog-farm operator, studies were first conducted with the village as the sampling unit. A sample survey enumeration by villages, moreover, has the advantage that from one enumeration to another the unit remains a fixed administrative unit—the village—which is not subject to abrupt changes like the hog-farm unit. Proper allowance is made here for new hog-producing farms from one survey to the next.

Less preparatory work is required for a survey that uses the village as the unit than for one that uses the hog farm as the unit. But difficulties arise in the practical operation of a sample survey by villages, because of differences in the size of the pig population from one village to another (clustering). The larger and more variable such clusters are, the greater the error in the estimates. Pig numbers in individual clusters (villages) varied, for example, from 10 to 2,500 in the September 1952 census in Bavaria.

[5] At the beginning of this year the Ministry for Nutrition, Agriculture, and Forestry of the Republic established new error limits. It was desired that limits not exceed ±3 percent for total breeding sows in any State nor ±2 to ±3 percent for total pigs (Bavaria and Lower Saxony ±2 percent, North-Rhine Westphalia ±2.3 percent, all other States ±3 percent).

As past studies (*11*) on a sample with the village as sampling unit have shown, it is not possible even by applying refined methods, to reach a double standard error of the order of magnitude of 3 percent on prospective pig numbers by subclasses of breeding sows. This is due mainly to the heterogeneous composition of pig populations within individual villages, which causes standard errors computed from variability to be large for individual estimates.

One of the refined methods used consisted of a stratification of villages on the basis of pig numbers with a simple estimating procedure based on the sampling rate; another consisted of basing computations upon a ratio estimate (*6*), by utilizing data from a previous complete enumeration. As a relatively high correlation exists between sample counts and census data for almost all sex and age groups, appreciable improvement was obtained by using ratio estimates instead of a simple expansion.

But the improvement was not enough to attain the required degree of precision by subclasses of breeding sows. Therefore, studies were conducted with the hog farm as the sampling unit. Estimates were again made by both the simple and the ratio methods. To increase the efficiency of such a sample with the hog farm as the sampling unit and to make proper allowance for the heterogeneity of the universe, use was again made of stratification. The pig enumeration of December 2, 1950, was used to set up the following strata:

Stratum I: All hog farms having one or more breeding sows on December 2, 1950.

Stratum II: All hog farms having no breeding sows on December 2, 1950.

Results of this study showed that a sample pig enumeration, having the desired accuracy by subclasses of breeding sows, is feasible when hog farms are used as sampling units. Only the simple estimating procedure can be used because correlation between pig numbers from two enumerations is relatively small in individual class intervals. Low correlation appears because, for example, breeding sows which are pregnant in December are no longer pregnant at the time of the survey—March—and therefore shift from one category to another. Because narrow class intervals are used for age grouping in the census, a heavy shifting takes place in those groups. Therefore, the coefficient of correlation must be much lower in contrast to its value when villages are used as sampling units.

In accordance with these results, the pig enumeration was carried out by sampling for the first time in March 1952, with hog farms as sampling units. To increase the efficiency of the sample, stratum III, consisting of "large hog farms" with 50 or more pigs, with or without breeding sows, was added and was enumerated completely. For the country as a whole 6 percent of the hog farms—120,000 farms—were included in the sample.

Sampling rates in individual strata varied from State to State. To take account of new hog farms that had appeared since the most recent census, a special survey was conducted in 10 percent of the villages where all pigs were enumerated on hog farms that had appeared since the previous census. Estimates (*9*) from this first sample survey were within the required error limits for the country as a whole. But it was apparent that the results were not strictly comparable with previous and later census data because inherent bias caused by differences in quality of enumerators is different from that in a sample survey. In a partial enumeration, only a few, but careful, enumerators are employed. Because of the lack of comparability, the sampling method was not applied again in the September 1952 pig enumeration despite the high degree of confidence in the above results.

In 1952–53 the main effort was devoted to improving the sample with regard to comparability. If randomly selected localities were chosen for enumeration (area sampling), comparability could doubtless be improved. If sizes of areas that are too large were decreased, and sizes of those that are too small were increased, a further improvement in the survey would result. In March 1954 it is planned to apply, for the first time in official German statistics, the area-sampling procedure that is used so successfully outside the country, particularly in the United States. Area sampling consists of subdividing the entire geographic area that covers the universe of inquiry into small area segments (sampling units).

For this purpose, in July–September 1953 the total area of all villages in the entire country was subdivided into such "area segments." An "area segment" is here defined as an area that contains from 15 to 25 hog-farm operators. Clusters of about equal size thus serve as sampling units. They are more efficient than clusters of unequal size. Enumerators do their work in these segments just as in their previous enumeration districts. But conducting a survey by area sampling is possible only when every area segment in a village is delineated exactly and these units remain constant in every survey.

To make proper allowance for numbers of breeding sows, which are of particular importance in estimating prospective pig numbers, and to make the survey more efficient, use is again made of stratification. For Bavaria it is as follows:

Stratum I: Area segments with 0 to 7 breeding sows.
Stratum II: Area segments with 8 to 25 breeding sows.
Stratum III: Area segments with 26 and more breeding sows.

Class intervals and sampling rates for individual strata are different from State to State. In the Federal Statistics Office, and in the State Statistics Offices of North Rhine-Westphalia and Bavaria, sampling studies were made on data from the pig enumerations of September 3, 1953. The sample estimates made were within the required limits of error. The sample for the entire country will amount to about 8 to 10 percent of all area segments in the universe.

Statistics on Fruit Yield and Milk Production

Sampling is used in German official agricultural statistics not only to reduce the workload of State and village officials and to reduce costs, but also to improve data resting on judgment appraisals. Statistics on the fruit crop and on milk production and utilization are based on judgment appraisals, because objective sampling procedures, although possible in theory, are difficult to apply in practice. To find a workable way of eliminating the effects of subjectivity, with which these judgment appraisals are encumbered, cooperative studies on objective measurement surveys were made by the Federal Statistics Office and the State Statistics Offices of Baden-Württemberg, Lower Saxony, and Bavaria.

In the future, it is planned to estimate the fruit crop, parallel to current fruit estimating procedures, by a multistage sample survey (*14*) similar to that used in objective crop-yield surveys. For this purpose, villages will need to be selected at random in each State in which harvested fruit weights are taken from randomly selected trees.

In the crop year 1951–52, studies were set up in the Bavarian State Statistics Office with the help of ERP funds to estimate monthly milk production on farms in Bavaria by sample surveys. The project was a stratified sample survey, the sampling units being farms that had cows. All farms with cows on the list from the 1949 farm census were divided into three strata:

Stratum I: Cow farms of size 0–50 ha.
Stratum II: Cow farms of size 50–150 ha.
Stratum III: Cow farms of size 150 ha and over.

In total, from a universe of about 500,000 farms with cows, 11,100 were reached monthly by mail, but only 5,600 gave information on milk production for their farms. To estimate milk production the monthly production for the farm was not asked, but instead the production for 1 day of the month (sample day). As it may be assumed that reported production for a single day is more accurate and that this report imposes less strain on the farm operator, the sample day was used in these surveys.

To make allowance for effects of weather and feeding and for other such short-time variations in milk production, the production on the sample farms was not asked for the same day of the month in question. Instead the farms in each size group were classified into six groups of equal size and were allocated uniformly over the State. Each of these groups was asked to report on milk production for a different sample day in the month. The monthly milk production was computed by multiplying the average daily production by the number of days in the month.

Determination of Errors in the Land Use and Livestock Censuses

In agricultural statistics sample surveys are used not only to reduce costs, time, and labor by substituting them for complete village enumerations, but also to ascertain the errors in current large-scale enumerations. Thus sample spot checks are made regularly on the accuracy of land-use data reported by farmers in the land-use censuses and of livestock numbers reported in the livestock enumerations. This is done by experts, but never by persons directly connected with the complete enumeration.

As travel costs of experts are considerable, checks are generally made according to a two-stage sample design. The two sampling stages are village and farm. As the error is conveniently expressed in percentage terms, the ratio, sample check/census report, is computed for each farm that is checked. From these ratios an average ratio, f, and a ratio estimate are computed. The average ratio indicates whether the data reported by farmers in the enumeration were too high or too low. If, for example, too low a figure was reported, f would be greater than 1 and the percentage error would be 100 (f–1).

Since high correlation[6] generally exists between farmers' reports and data found in the checks, the ratio estimate gives good results with a relatively low sampling rate. Because of the requirement that estimates have a similar level of accuracy by regions, the number of farms checked is different from State to State. In the check on the 1952 land-use census the selection of villages was similar to that for the objective yield surveys. Sample villages for the entire country totaled about 790. This is a little more than 3.5 percent of all villages. Within villages, three farms were selected at random, with a control on the proportions of large and small farms. For these farms, experts made objective checks on practically all reported land-use data with respect to cultivation and commodity.

The check on the livestock enumeration was made in several States during recent years—Schleswig-Holstein, Lower Saxony, North Rhine-Westphalia, Württemberg-Baden, and Bavaria. For example, in March 1953, 70 villages from about 7,000 in Bavaria were selected at random by counties in proportion to numbers of hogs found. In each of these villages hog numbers were checked on six livestock farms.

Possibly future checks on the livestock enumeration should be made by multistage area sampling with area segments as sampling units. Pig numbers on livestock farms in those segments could be checked by an expert in half a day. Such a survey would have the advantage that boundaries of segments could be checked accurately. Moreover, it

[6] In a check on the 1952 land-use census, correlation coefficients larger than ±0.80 were found for the principal items (area in farmland, cropland, bread and feed grains). In the checks on the pig enumerations the correlation coefficients are also relatively high for individual age and sex classes; for the total pig population a value of +0.95 was actually determined.

might provide a means of learning whether livestock farms were skipped in the enumeration, because the check would be made on the area segment as the unit and not by livestock farms.

Summary

Results so far obtained in studies of sample surveys and sample tabulations in agricultural statistics indicate:

I. Sample Selection

1. If an up-to-date list of names and addresses is available, the sample design is governed only by the degree of precision needed and the costs. One would choose the design that gives greatest efficiency at minimum cost.

2. If the list is incomplete, or if no list is available, area sampling should be used. Here it is most important that the geographic area segments, which are the sampling units, be delineated accurately. When this sampling procedure is used for current surveys, the area segment must be kept constant from one survey to another.

3. If new farms, new livestock farms, or other such items are to be included in the sample (there being practically no list of such individuals at hand) there is no choice but to use area sampling.

4. When interviewers are used to make spot checks in agricultural statistics (for example, determining errors in censuses), multistage sample designs should be chosen, to reduce costs. But a geographic area under investigation may also be divided into such segments that an interviewer can complete his questioning in approximately 1 or 2 days. Segments to which interviewers are to be sent are then selected at random.

II. Overall Conclusions

1. If a previous complete enumeration is available, sample estimates can be derived from base data:

(*a*) By a simple expansion of the data from a stratified or pure random sample or an area sample. The estimate is computed by multiplying the sample average by the total number of units in the universe. In stratified sampling it is appropriate to weight by numbers of units in individual strata.

(*b*) By applying a ratio estimate to data from a stratified or pure random sample or an area sample, using data from a previous complete enumeration. With the ratio estimate instead of the simple expansion, an appreciable improvement in the estimates is achieved when there is a relatively high correlation[7] between the two sets of data (complete enumeration and sample).

2. When no previous complete enumeration is available, estimated totals can be derived only from simple expansion.

3. To discover the errors in censuses the ratio is most suitable because it is convenient to express the error as a percentage—100 (sample check/census)—and because a high correlation exists between farmers' reports and the sample checks.

III. Unification of Agricultural Statistics

It is apparent from the evidence that the individual agricultural enumerations stand isolated from one another. A policy that might be followed is suggested by M. Rauterberg (*8*), Federal Statistics Office, Wiesbaden; that is, to test whether or not an agricultural census should be taken every 5 years as a complete enumeration and to conduct intervening enumerations as sample surveys. The result would be a comprehensive and unified system of statistical surveys in official agricultural statistics in Germany.

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[7] If r is the correlation coefficient, C_x the coefficient of variability in the sample and C_y that in the base data, the ratio estimate is more efficient than the simple expansion when r is larger than (1/2) (C_y/C_x).

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Short-Time Price Movements of Farm Products

Day-to-day price fluctuations in the markets in which farmers sell result in windfall gains and losses that are inequitable as between farmers, and that arouse their suspicions of monopolistic manipulation of prices. These fluctuations would also appear to be symptomatic of frictions that might be eliminated in a more perfectly functioning market. If patterns could be found in these price movements that would enable farmers to anticipate and take advantage of them, this would improve the markets from the standpoint of farmers and contribute toward improving the responsiveness of supplies to prices. The research here reported, undertaken by the Illinois Agricultural Experiment Station under contract with the former Bureau of Agricultural Economics, was an attempt to discover such patterns. The attempt was unsuccessful. But because the problem is important, the negative findings are set forth for the information of others who may be interested in research in this area. This article was prepared by Richard J. Foote of Agricultural Marketing Service. It was based on the research report submitted by G. L. Jordan of the University of Illinois.

MANY PEOPLE who observe day-to-day prices in commodity markets believe that prices follow certain patterns of movement, or that their fluctuations can be traced to various causal factors. In an effort to discover relationships of this kind, analyses were made of fluctuations in prices of hogs, corn, and soybeans at terminal markets. The length of period studied varied from 1 to 14 days. Thirty-four separate hypotheses were tested, falling into 4 main types: Those that relate to (1) patterns in prices of the products, in prices of futures contracts (for corn and soybeans), or in market receipts; (2) relations between cash and futures prices; (3) relations (for soybeans) between prices of beans and value of oil and meal; and (4) relations between prices and receipts. Presented here are representative examples from each type, including those that showed most promise.

Patterns in Prices

If many farmers made a practice of holding back shipments on a rising market until prices had risen for several days, prices would continue to go up, but then would react sharply when the accumulated supplies came to market. Four hypotheses relating to such short-time cyclical effects were tested. Results for corn and hogs are summarized here.

For No. 3 Yellow corn at Chicago, no significant relation was found between the deflated [1] price on a given day and the level 1, 2, and 3 days later. But continuous increases or decreases in prices of corn occur more frequently than would be expected in a random series. For those periods in which prices of corn rose or fell for 2 or more consecutive days, no relationship was detected between the duration of the movement and the amplitude of the first day's reaction following termination of the movement.

For the period October 1950 through December 1953, a 5-day moving total of day-to-day price changes was computed. The beginning of a price rise (or fall) was defined as the point at which this 5-day total was up (or down) by at least 3 cents per bushel. Thirty-four rising and falling phases were observed in this period. Their duration showed no clear modal behavior.[2] Nor did the average rise or fall appear to increase or decrease with the duration of the phase.

A pattern of sorts was found in prices of hogs. From 1949 through 1952, if prices at the National Stockyards on a given Monday were above those on the preceding Monday, in two cases out of three the average price for the week was higher than for the preceding week. For the separate years, the movements corresponded in from 63 to 70 percent of the cases.

Tuesday-to-Friday prices moved in the same direction as Tuesday in relation to Monday 54 percent of the time (48 to 59 percent in the individual years). Similar results for the remainder of the week were obtained when comparing Wednesday with Tuesday, Thursday with Wednesday, and so on. Under these circumstances farmers would gain somewhat over a random choice by using Monday-to-Monday price changes as a guide to the level of prices during the rest of the week. But they would gain only slightly over a random choice by following price changes within the week.

Results based on receipts of hogs were almost identical with those based on prices. Apparently, if farmers increase their shipments to market on a Monday over those of the preceding Monday, they are likely to increase their shipments for the entire week over those of the preceding week. Patterns in prices that were found can be assumed to reflect chiefly these tendencies with respect to marketings.

In studying phase lengths for hogs, a turning point was defined as the point at which prices changed in the direction opposite to the preceding movement by as much as 10 cents, or enough to reach the level on the day immediately previous to the low or high point. When this method of counting was used, 40 percent of the price movements were of 1 day's duration, 30 percent of 2 days' duration, 13 percent of 3, and 18 percent of 4 or more. When a change of 25 cents instead of 10 cents was used in defining a turning point, 26 percent of the price movements persisted for 1 day, 27 percent for 2, 12 percent for 3, 25 percent for 4 to 6, and 10 percent for 7 or more. These numbers differ from those that would be expected in a random series, but in general the phase lengths are neither long enough nor uniform enough to be of value to farmers in planning their marketings.

[1] In many analyses, prices were deflated by the index of wholesale prices of 28 basic commodities published in the *Weekly Supplement* to the *Survey of Current Business* issued by the United States Department of Commerce (interpolating, where necessary, to obtain daily figures). In a number of analyses, adjustments were made to allow for normal seasonal variation in both prices and receipts. Mention of these refinements is not repeated in succeeding examples.

[2] Of the rises, durations of 2 and 12 days occurred 5 times each; 7 days, 4 times; 5 days, 3 times. The remaining 17 rises ranged from 1 to 30 days, with no duration occurring more than twice. Of the falling-price phases, durations of 4, 5, and 6 days occurred 4 times each; 8, 10, and 13 days, 3 times each. The remaining 13 ranged from 1 to 18 days, with no duration occurring more than twice.

Results from studies of patterns in futures prices of corn were similar to those from the studies of cash prices. Similar hypotheses were tested for soybeans, with about the same results.

Relations Between Cash and Futures Prices

It is frequently stated that the price of a commodity is discovered first on the futures market but that the price in the cash market quickly adjusts to changes in futures. During the period covered by this study, there was no evidence that prices of cash corn rose or fell with rises or falls in the price of corn futures on the previous day. In October and November large daily changes in prices of cash corn were associated with a large volume of trading in corn futures, but the variation was great. For other months some relationship was found when median prices were used, but the scatter around the median was excessive. No significant relationship between volume of trading and daily changes in cash prices was evident the last 2 weeks before a delivery month.

It is sometimes asserted that the spread between prices of cash corn and prices of December corn futures is affected by receipts at primary markets and by the supply of corn per animal unit. Several approaches were used to study this hypothesis and, with some of them, some relationship was found. But observations were so few and correlations so low that no conclusions are justified.

A second hypothesis concerning factors that affect the spread between cash and futures prices is that a wide departure of the actual from the theoretical spread leads to prompt changes in cash prices in the direction that brings the spread closer to the theoretical. The theoretical spread was obtained by calculating the average difference between the price of December futures during the first 10 days of August and the cash price of No. 3 Yellow corn at Chicago on the same days. This spread then was reduced an equal amount each day so that on the last day of trading in futures in December the cash price was 1½ cents above the December future.

A statistical analysis was run for which the dependent variable was the percentage that the average cash price in the current week was of the price in the previous week. The independent variable was the difference between the actual and the theoretical spread for the preceding week. If this difference were large, prices should decline in the week under consideration so that the difference in that week would be smaller. Thus, if the hypothesis were true, an inverse relationship between the two variables would be expected. But positive correlations ranging from 0.1 to 0.5 were found for the 3 years used separately in the analysis.

The same type of analysis was run for May futures. Here a slight inverse relationship was found but it was not close enough to verify the hypothesis. A similar study was run for soybeans but no significant correlations were found.

Relationship of Prices of Soybeans to an Earlier Value of the Oil and Meal

Statistical analyses made by the Agricultural Marketing Service indicate that for 1931–40 and 1948–50 practically all of the variation in season-average prices received by farmers for soybeans can be explained by changes in the combined value of the oil and meal obtained per bushel crushed.[3] This suggested that short-term changes in the price of soybeans might be forecast from changes in the value of the oil and meal in an earlier period.

For the period October 1949 through September 1950, prices of soybeans at Decatur, Ill., on Tuesday through Friday were correlated with the value of 10 pounds of soybean oil and 48 pounds of soybean meal on the preceding Monday, with a separate analysis for each day. In all cases, more than 80 percent of the variation in prices was explained by changes in the value of the products. When the crop year was divided into two periods, the percentage of variation explained declined to 23 to 40 percent from October through January but during the rest of the marketing year, it was in the 85 to 95 percent range. An interesting modification of this study would have been to measure the

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[3] The nature of the relationship has changed considerably in recent years, reflecting (1) the increased use of solvent extraction and the concomitant increased capacity of the crushing industry, and (2) the tendency on the part of farmers to market a smaller proportion of their beans immediately following harvest. However, it can be presumed that this value is still the major one that affects prices of soybeans. See SIMON, MARTIN S., SOYBEANS: ECONOMIC ANALYSES RELATING TO PROCESSING. U. S. Dept. of Agr. Marketing Research Report No. 35, 1953. Pages 30–32, 40–43.

association between week-to-week changes in prices of soybeans and Monday-to-Monday changes in the value of the products.

Relationship Between Supplies and Prices

The most obvious explanation of short-term price movements is that they are associated with short-term changes in supplies or market receipts. Many hypotheses related to this were explored. Some of those that relate to corn and hogs are discussed here.

One hypothesis is that when daily receipts of corn at all primary markets are larger (or smaller) than the seasonal pattern for the year, deflated prices of No. 3 Yellow corn at Chicago are lower (or higher) than the seasonal pattern for the year. This was also tested, using receipts at Chicago. An additional hypothesis is that there is some relationship between the amplitude of rises (or declines) in the volume of receipts corrected for seasonal and the duration of declines (or rises) in deflated prices corrected for seasonal. A third hypothesis is that there is some relationship between the weekly deflated price of corn and cumulative receipts as a percentage of the production of corn. No significant relations were observed for any of these hypotheses.

For hogs, likewise, several tests were made for relationships between short-term changes in supplies and prices. The closest was found between the ratio of the current price to that of the preceding day and the ratio of the current volume of receipts at the 12 major markets to the average volume for the same day in the preceding 1 and 2 weeks. If allowance is made for other influences, such as wholesale pork prices, the relationship appears to be linear. Volume figures at the National Stockyards alone gave less significant results.

Based on these studies, changes in supplies appear to have important effects on day-to-day changes in prices. Separate analyses were made for each month except November and December, when a strike that took place at packing plants affected the relationships. The relationship was closest in January through March and August through October. From April through July, short-term changes in supply appeared to have little influence. Poor results for these months may be due chiefly to limitations in data. The price data were for barrows and gilts, but the volume data included sows which become a more important component of supplies in late spring.

A similar set of analyses was run using shipments from the National Stockyards instead of receipts, or in addition to receipts. These shipments apparently have little direct effect on prices of barrows and gilts.

Several studies were made to learn whether the relationship between receipts of hogs and prices of barrows and gilts is inverse when both series relate to the same time period. Receipts at both the National Stockyards and the 12 leading markets were used. Data at the National Stockyards indicated that changes in Monday and Tuesday receipts from those of the preceding week and in Monday and Tuesday prices from those of the preceding week move inversely about two-thirds of the time. In working with receipts at the 12 markets, 3-week moving averages of the data for Monday and Tuesday were used in addition to the actual data. From May through December no definite inverse relationship between the two series was found when moving averages were used for each. From February through April only a slight degree of relationship was indicated.

Summary

A representative group of hypotheses dealing with the predictability of day-to-day price movements was tested for three commodities: corn, soybeans, and hogs. Many others might have been tested but those used in the study were representative. The general conclusion was that these short-term price movements are unpredictable. This implies that prices adjust almost instantaneously to changes that take place in the basic factors that affect the immediate supply and demand situation.

No significant relationships were found between short-term changes in receipts and in prices of corn. This would be expected of a storable commodity; if receipts were temporarily out of line with market requirements, an adjustment could be made at low cost by moving part of the supply into or out of storage.

For hogs, on the other hand, significant relationships were found between approximately simultaneous changes in receipts and prices. Hogs cannot be stored at low cost. When large supplies come to market they must be either slaughtered at higher than normal costs or held over at the terminal market at considerable cost. When receipts are smaller than normal, packers attempt to buy as much as possible in order to keep their plants operating at efficient rates. Thus the differences between the commodities found in this phase of the study are consistent with expectations.

Book Reviews

The Measurement of Consumers' Expenditure and Behaviour in the United Kingdom, 1920–38. Volume 1. By RICHARD STONE. Cambridge University Press, New York. 448 pages. 1954. $18.50.

"THE FIRST CONDITION for the development of any branch of research is that it shall attract scholars of imagination and technical ability." So writes Professor Stone in the introduction to this impressive volume. Econometric research on demand has attracted many scholars of imagination and technical ability—Moore, Ezekiel, Schultz, Tinbergen, Frisch, Haavelmo, and Fox, for example. Now Professor Stone demonstrates that he belongs in the ranks of these men, and that in many ways he has gone beyond them.

Stone's book is a new landmark in demand research. In one huge volume he presents and criticizes the data on consumption and prices, explains the basic economic theory, develops the necessary mathematical and statistical principles, and summarizes more than 200 demand equations. Without doubt this is the most comprehensive book yet published in the field of statistical demand analysis.

Inevitably Stone's book will be compared with Schultz's well-known masterpiece.[1] As I see it, the two books have the same merits, and share the same major defect. Both books are excellent in their presentation of economic theory, mathematical techniques, and research results. In my opinion, the actual statistical analysis in both books is too mechanical and routine. More on this defect later.

More than half of the volume is used to present and criticize data on consumption, expenditure, and prices. This feature of the book distinguishes it from most publications in the United States. Here the statistician too often takes the data for granted. He can easily get published estimates of the prices and consumption of almost any commodity, and often knows little about their accuracy. Stone found it necessary to make many estimates, himself. This gave him a real appreciation of the reliability of the basic data, and of the kinds and degrees of error to be expected in various series. This important subject is badly neglected by most analysts in the United States who sometimes compute results to 5 or 6 "significant figures" without realizing that the data may be accurate to perhaps 2 or 3 significant figures.

Stone leans heavily upon Hicks[2] in his excellent treatment of the pure theory of consumer demand. It would be hard to exaggerate the importance of this theory. Basic research in demand requires an understanding of such concepts as total and marginal utility, indifference surfaces, and elas-

[1] SCHULTZ, HENRY. THEORY AND MEASUREMENT OF DEMAND. University of Chicago Press. 1938.

[2] HICKS, JOHN R. VALUE AND CAPITAL. The Clarendon Press, Oxford. 1939.