ABSTRACT

AN ENQUIRY INTO THE RELATIONSHIPS BETWEEN CHANGES IN OVER-ALL PRODUCTIVITY AND REAL NET RETURN PER FARM, AND BETWEEN CHANGES IN TOTAL OUTPUT AND REAL GROSS RETURN, CANADIAN AGRICULTURE, 1926 TO 1957

By Siepko Hendrik Lok

In this study the truth of the commonly encountered belief that rising productivity in agriculture has been detrimental to farm income is examined for Canadian agriculture. The evidence usually used to support the belief is found inadequate, and an appropriate verification is considered important because the belief may be unfounded and yet become a guideline for policy if it remained unchallenged.

The following hypotheses were tested for the period 1927 to 1957:

1. the relationship between annual percentage changes in over-all productivity and real net return per farm is negative or zero for Canadian agriculture, and
2. the relationship between annual percentage changes in aggregate output and real gross return is negative or zero for Canadian agriculture.

In preparation for the construction of an over-all productivity index for Canadian agriculture problems involved in its measurement are discussed.

The ratio of total output to total input is used as a measure of over-all productivity. Sixteen separate output classes and eleven

separate input classes were aggregated to get measures of total output and total input.

In view of discrepancies caused by different weight periods and to avoid an arbitrary choice, six indexes of total output and total input were determined. Four of these are based on the fixed weight index number formula (Laspeyres) using as weight periods: (1) 1935-39, (2) 1940-44, (3) 1945-49, and (4) 1950-54. In addition the Paasche and chain index formulas were used to get two sets of index numbers based on variable weighting. The construction of the indexes was programmed for, and the results obtained by electronic computer. The index numbers of total output were divided by the corresponding index numbers for total input to give an index of over-all productivity with the same base as the output and input indexes.

Real net return is the value of all outputs, net of depreciation and operating expenses, in dollars of constant purchasing power. The annual measures of real net return per farm were obtained by dividing the sum of real net cash income minus supplementary Government transfer payments, and real value of income in kind by the number of farms. The index number formulas and base period used are the same as those used in constructing the productivity indexes.

For testing the second hypothesis the total output index numbers based on the four constant weight periods were averaged for each year because the slight discrepancies between the four indexes did not warrant separate analysis for each.

The same procedure was applied — and for the same reason — in determining the annual measures of real gross income. The transfer pay-

ments were again deleted, and in view of the uncertainty whether adjustments should be made for changes in inventory values the measures real realized gross return (i.e. no adjustments are made) and real total gross return (increases in inventory values are included and decreases excluded) were both determined.

Simple linear regression equations of annual per cent changes in real net return per farm and over-all productivity reveal, for each of the six index formulas used, a positive relationship between the two variables, and the coefficients of correlation are well above the value required to be significantly different from zero at the one per cent level. The first hypothesis is, therefore, not supported by the evidence.

The regression and correlation analyses for the averages of annual per cent changes in output and real total gross return, and in output and real realized gross return, also produce positive regression coefficients, and correlation coefficients significantly different from zero at the one per cent level. The second hypothesis also is not supported by the empirical evidence and this brings into question the notion that the aggregate demand for Canadian agricultural products has been inelastic. Thus support is given to Gislason's contention that "Contrary to Canadian beliefs in general, the evidence at hand indicates that the demand for this wheat is not highly inelastic if inelastic at all."

Shortcomings of the data and methods used are recognized in the study. These shortcomings may weaken the results but it remains to be seen whether more accurate data and more refined methods would support the hypotheses.

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I. INTRODUCTION

Background

In speeches and literature pertaining to farm income problems in the United States and Canada, one encounters the belief that rising productivity in the agriculture of these countries is detrimental to farm income.

To substantiate this belief reference is made to declines in farm income (the terms net income, net income per farm, or real net income per farm are variously used) between certain periods, while agricultural productivity has been rising.[1] The conventional explanation for this occurrence is based on two notions: (1) greater productivity in agriculture invariably means greater output, and (2) the response of demands for, and supplies (particularly when farm prices drop) of agricultural products to changes in the prices of agricultural products is relatively inelastic.

It has been demonstrated that the demand for some agricultural products is indeed quite inelastic and a decline in gross income accruing from such products will inevitably follow an increase in output. Without offsetting effects from lower costs net income will decline as well.

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1 After determining the decline in net income per farm in the United States between 1951 and 1955, E. O. Heady and J. Ackerman conclude: "Hence we are in a period when national 'prosperity' has been moving rapidly upward, but farm income has been going as rapidly downward, even though physical productivity in agriculture is still increasing"; "The Income and Resource Problem", Agricultural Adjustment Problems in a Growing Economy (Heady, E. O., et al, eds.), The Iowa State College Press, Ames, 1958, p. 4.

Unfortunately, however, the belief is often expressed in general terms, as if it applied to agriculture as a whole. The implication is that the aggregate demand for all farm products is inelastic. And the inevitable inference is that agricultural research, as one of the factors raising productivity, is undesirable from the farmers' viewpoint. It has been said that such research may well benefit society as a whole but at the farmers' expense. The migration of labor from agriculture is no longer deemed sufficient -- research should be curtailed as well.

Not only is output-increasing research felt to be harmful to farmers but cost-reducing research also, because as far as the latter is concerned the savings can be used on other inputs which raise production.[2] After all, since the production of the individual farmer does not affect prices, and since he lacks control over the collective action of other farmers, it will be to his advantage to increase output at any level of farm prices as long as marginal cost does not exceed marginal revenue.

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It is difficult to establish just how prevalent is the belief that agricultural research, greater productivity and increasing farm output cause a decline in the average net farm income. The belief is certainly not new. When those in agriculture prosper technical research is taken for granted and accepted, but whenever prices are falling the blame is placed on over-production and output-increasing research.

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2 Cf. Heady, E. O., "Basic Economic and Welfare Aspects of Farm Technological Advance", Journal of Farm Economics, Vol. 31, No. 2, May 1949; and Johnson, D. Gale, "Labor Mobility and Agricultural Adjustment", Agricultural Adjustment Problems in a Growing Economy (Heady, E. O., et al, eds.), op. cit., p. 170.

Statements about the conflict between technical advance and welfare in agriculture can be found in connection with the farmers' plight during the thirties,[3] and again after World War II.[4] Since the Korean War concern over agricultural research has been expressed more frequently.[5] The belief that the aggregate demand curve for farm products is inelastic in the United States appears well established.[6]

These allegations could not go unnoticed by the farmers and their leaders. Some, in no uncertain terms, put the blame for low farm incomes

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3 Cf. "... technological developments have been one of the important causes of at least temporary distress to many farm groups.", Johnson, S. E., "Farm-Management Problems in an Era of Change", Farmers in a Changing World (1940 Yearbook of Agriculture), United States Department of Agriculture, Washington, D.C., p. 495.

4 Cf. "The fruits of our scientific farming and our agricultural colleges are found on the tables of the masses, not in the pocketbook of the farmers", Boulding, K. E., "Economic Analysis and Agricultural Policy", The Canadian Journal of Economics and Political Science, Vol. 13, No. 3, Aug. 1947, pp. 440-441.

5 Referring to the implication that the program of the conference on "Adjusting Commercial Agriculture to Economic Growth" (Chicago, 1947) "appears to take for granted that research and education are at least partly responsible for some of the present farm income difficulties", S. E. Johnson and G. T. Barton continue: "This is not the first time that the finger of suspicion has pointed to research and education. The charge has been made rather frequently in the last two or three years."; "Effects of Technological Research and Education", Agricultural Adjustment Problems in a Growing Economy, (Heady, E. O., et al, eds.), op. cit., p. 39.

6 D. E. Hathaway in a recent article dealing with United States agriculture as a whole considers "... generally accepted ..." and "... verified by research in recent years" that, "The price elasticity of demand for food is low at the retail level and even lower at the farm level", and that, "As a result in (sic) the low elasticity of demand for food the changes in aggregate demand tend to cause large changes in the ratio of farm prices to non-farm prices over the business cycle, ..."; "Agriculture in an Unstable Economy Revisited", Journal of Farm Economics, Vol. 41, No. 3, Aug. 1959, p. 488.

squarely on rising productivity and research.[7] So strong were these convictions that in the fall of 1956 twenty Iowa farmers visited the administrators of Iowa State University to request the curtailment of technical research because there was "too much efficiency" in agriculture.[8]

The belief that increasing productivity and production is detrimental to farm net income has found ready acceptance in Canada.[9] The belief seems to be supported by some of the recently published findings of the Royal Commission on Price Spreads. Volume II of the Commission's report contains a table indicating that between the years 1949 and 1958 the average annual increase in the "Index of Farm Output" has been 1.5 per cent, whereas "(Real) Net Farm Operating Income" per farm declined by an average of 0.8 per cent a year.[10]

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7 Cf. "While there are good and sufficient reasons for the large program of research on production technology ... I don't believe we farmers should deceive ourselves in believing that such programs will increase our net income", Buck, R. K., "Can We Shrink Production?", New Approaches on the Farm Problem, Proceedings Nineteenth Annual National Farm Institute, Feb. 15 and 16, 1957, Des Moines, Iowa, p. 99; and "The greatest crime that the American farmer has committed for himself is not inefficiency, but too much efficiency which has produced an abundant food supply", Stayley, O. L., (National Farmers Organization), "Diverted Acres, Food Reserves, and Livestock Supports", ibid., p. 84.

8 Reported by E. Eldridge, "A New Focus for Extension", Farm Policy Forum, Vol. II, No. 4, 1958-59, p. 18.

9 Cf. "Too often the farmer increases his productivity only to find that it has been a blessing to almost everyone else in society except himself", Bentley, J. M., "Objectives of Canadian Agricultural Policy", Canadian Journal of Agricultural Economics, Vol. 7, No. 2, 1959, pp. 17-18.

10 Report of the Royal Commission on Price Spreads of Food Products, Vol. II, The Queen's Printer, Ottawa, 1959, p. 16.

Although the economic argument explaining a decline in farm income seems plausible, and at times an increase in productivity and output appears to be associated with a drop in both gross and net incomes, the question still remains whether increasing productivity can be held responsible for declining farm incomes. The relationship between these variables cannot be obtained from a comparison of changes in productivity or output and net income between two selected periods. Should these changes move in opposite directions, this situation in itself would not be sufficient to warrant the inference of an inverse causal relationship.

The objection lies with the likelihood that other factors affecting income will not be the same for the two periods compared. A few examples may be helpful. Between the end of the 1940's and the end of the 1950's farm income came down, but to ascribe this drop to a rise in productivity would be to ignore the different economic conditions of the two periods. Shortly after the war when foreign demand for agricultural products was strong farm prices were, of course, higher than in the late 1950's when foreign customers had greatly reduced their purchases from abroad.

One might have chosen two other periods and found that higher productivity is associated with higher incomes. Such a situation might be expected between the 1930's and the immediate post-war period. This occurrence only shows that the years with low over-all productivity (years of drought in the Prairie provinces) were also the years of world-wide economic depression, and that during the years when agricultural productivity was on a rather high level the market conditions for agricultural products were generally good.

Obviously the requirement that in regression analyses of time series "... the residuals z be random with respect to time" is not fulfilled.[11] One way to reduce intercorrelation between time series which is due to existing trends is to apply the regression and correlation analysis to the first differences of the time series,[12] or as has been done in this study, to the percentage changes in the index numbers.

Further study to test the alleged negative relationship between agricultural productivity and farm income is desirable because a belief in this relationship could be unfounded and yet become a guideline for policy.

Objectives

This study sets out to examine for Canadian agriculture as a whole the relationship between annual percentage changes in productivity and real net return per farm over the years 1926 to 1957. Since this relationship is at least partly determined by the elasticity of the aggregate demand curve for agricultural products, the relationship between annual percentage changes in output and gross income were also examined for the same period and country.[13]

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Canadian agriculture is a convenient test case. Before 1958 Government price supports for Canadian agriculture were of minor

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11 Ezekiel, M. and K. A. Fox, Methods of Correlation and Regression Analysis, third ed., John Wiley and Sons, New York, 1959, p. 328.

12 Ibid., p. 340.

13 The conclusions reached with respect to Canadian agriculture cannot ipso facto be applied to agriculture in the United States. Further research would be required to establish whether or not a parallel case exists.

proportions.[14] From August 1944 to March 1958, the period over which the (Canadian) Agricultural Prices Support Act was in effect, a total of about 100 million dollars was spent to aid producers of hogs and cattle, apples, potatoes, dried white beans, extracted honey, dry skimmed milk, cheddar cheese, creamery butter, shell eggs and fowl.[15] Of this amount, the greatest portion (about $70 million) went to hog and cattle producers, largely to compensate them for losses caused by the foot and mouth epidemic in 1952.

But these price supports are not the whole story. Throughout the 1926-1957 period other forms of support have been in force.[16] Since 1929 the Federal Government has endeavored to maintain stable prices for wheat, first through the Central Selling Agency, and since 1935 through the Canadian Wheat Board. At times the same price stabilizing policy was applied to barley and oats. For several other farm products, marketing boards were also set up and some legislation enacted to promote "orderly marketing" and to eliminate undue price fluctuation. During World War II the Federal Government established price ceilings on all products, and for four more years wheat prices were at a maximum under the Canadian-United Kingdom

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14 "Although the Canadian Government has at various periods since the war bought farm products, the prices paid were ordinarily not high enough to entail any significant element of subsidy. In fact all the stock acquired was sold on the free market usually with relatively very slight losses or no losses at all, so that the expenditure on stabilizing farm incomes was unusually small.", Agricultural Policies in Europe and North America, The Organisation for European Economic Co-operation, Paris, 1956, pp. 288-289.

15 Canada, Department of Agriculture, The Current Review of Agricultural Conditions in Canada, Vol. 19, No. 6, Nov. 1958, Conference issue, Ottawa, p. 60.

16 Cf. Shefrin, F. and M. R. Cameron, Agricultural Assistance, War and Post-War, Department of Agriculture, Ottawa, 1949.

wheat export agreement.[17] Maximum prices were set in similar agreements for other agricultural products, such as cheese and pork.

To the extent that price stabilizing programs did not cause the Government to pay subsidies to the farmers, they can be considered as attempts to remove market imperfections, and thus do not interfere with conclusions about aggregate demand elasticity based on the relationship between changes in output and income. But a subsidy-free situation has not always prevailed for the wheat farmers. During the operation of the Wheat Board, the initial price payable to the farmers has in some years been higher than the average price that could be obtained for the available supply. As a result extra storage costs were incurred. Since 1955 the storage charges of reserves in excess of a normal carry-over of 178 million bushels, were paid by the Federal Government.

Farmers were also aided in numerous other ways.[18] Many of these programs were designed to raise the productivity of the inputs (e.g. experimental farms) and the efficiency of management (e.g. extension service), to raise the quality of farm products (e.g. hog and cheese quality premiums), and to equalize the "laid-down" costs in the various regions (e.g. freight assistance). Such programs were meant to be income-raising but as they were continuous it would be unwarranted to consider them income-stabilizing.

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17 Shefrin, F., Exports of Canadian Farm Products, War and Post-War Developments, Department of Agriculture, Ottawa, 1949.

18 Cf. Cameron, Marjorie R., and F. Shefrin, Federal Agricultural Assistance Programs, Canada, 1900-1951, Department of Agriculture, Ottawa, 1952, pp. 44-49; and Cameron, Marjorie R., Federal Agricultural Assistance Programs, Canada, 1945-1956, Department of Agriculture, Ottawa, 1957, pp. 79-82.

There are, however, several programs (e.g. compensation for crop failure) that are welfare programs designed to raise the farmers' income in years when an adjustment of income is needed. In this study such transfer payments are eliminated from the annual income estimates.

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For the objectives of this study annual measures of productivity, output and incomes are required. The main concern is with the appropriate measurement of changes in productivity.

In recent decades considerable changes have taken place in the productive capacity of Canadian agriculture. These changes are most impressively reflected in output/single input ratios such as average yield per acre or per animal, and in the reduction of labor requirements. Net productivity per acre of improved land rose by about 22 per cent between the periods 1935-39 and 1947-55.[19] The Canadian average 1957 milk production per cow amounted to 5,493 pounds, an increase of about 65 per cent over the preceding 30 years.[20] Average annual egg production per layer rose by 110 per cent over the same 30-year period.[21]

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19 Drummond, W. M. and W. Mackenzie, Progress and Prospects of Canadian Agriculture, Royal Commission on Canada's Economic Prospects, Queen's Printer, Ottawa, 1957, p. 81.

20 The estimate was obtained by dividing the total milk production by number of milk cows (1927 data: Canada, Department of Trade and Commerce, Dominion Bureau of Statistics (hereafter abbreviated in the footnotes as D.B.S.), Ottawa, Dairying Statistics of Canada, 1947, p. 6 and Monthly Bulletin of Agricultural Statistics, Feb. 1931, p. 54; 1957 data: ibid., Dairy Statistics, 1957, pp. 8 and 9).

21 Canada, Department of Trade and Commerce, D.B.S., Ottawa, The Canada Yearbook, 1933, p. 248, and Production of Poultry and Eggs, 1957, p. 8.

An output/single input ratio may increase because the innate qualities of the input are improved, as has happened with higher-yielding and disease-resistent crop varieties and animal breeds. The ratio may also increase when separate and unique inputs, such as labor-saving machinery and well-ventilated stables with controlled temperature, are added to the production process. Increases in the productive capacity of the soil may be the result of proper fertilization and other soil management practices as well as of the use of improved varieties of seed and breeds of animals, pesticides and other inputs. All these changes must be considered in devising a measure of productivity for agriculture as a whole.

Realizing the shortcomings of the single input productivity ratios, economists have developed methods to estimate over-all productivity ratings, which account for not just one but for all scarce resources. Because such over-all productivity measures are not available for Canadian agriculture it is an important task of the present study to fill this gap.

Outline of Study

It is important that the limitations of the procedures for measuring over-all productivity be made explicit. Two methods, therefore, are discussed in Chapter II, and the relationship between the two methods is pointed out.

The so-called constant dollar method has been used to get an index of over-all productivity for Canadian agriculture. The problems associated with this method include those inherent in the construction of index numbers. Of particular concern in this study are the discrepancies between indexes when prices of different periods are used to weight the classes of

outputs and inputs. Often the choice of a weight period [22] makes little difference in the numerical value of the index numbers but as it turns out the discrepancies among the total input indexes for agriculture are considerable. The underlying reason for this troublesome aspect of the method is discussed in chapter III.

Chapter IV contains a description of the steps involved in estimating aggregate output and input indexes for Canadian agriculture from 1926 to 1957. To establish the effects of different weight periods on the aggregate output and input indexes, and also on the index of over-all productivity itself, the outputs and inputs were weighted by the approprate average prices of the four periods: 1935-39, 1940-44, 1945-49 and 1950-54. In addition to these indexes based on fixed weights, two more sets of index numbers were determined by using quantity index formulas in which the weights vary from year to year. One is commonly referred to as the Paasche formula, after its original proponent; the other is the chain index, which is advocated by some researchers [23] and rejected by others. [24]

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22 The weight period is the period whose commodity prices (or commodity quantities as in the case of price indexes) are used as weights. The term must not be confused with base period, which is the period in a time series whose index number has been made equal to 100. Cf. Black, J. D. and B. D. Mudgett, Research in Agricultural Index Numbers, Social Science Research Council, Bull. No. 10, New York, March 1938, p. 63; or Loomis, R.A., "Effect of Weight-Period Selection on Measurement of Agricultural Production Inputs", Agricultural Economics Research, Vol. 9, No. 4, United States Department of Agriculture, Washington, D.C., October 1957, p. 129.

23 Cf. Mudgett, B. D., Index Numbers, John Wiley and Sons, New York, 1951.

24 Cf. Persons, W. M., The Construction of Index Numbers, Houghton Mifflin Co., Boston, 1928, p. 83.

The six indexes of the total output/total input ratios, i.e. over-all productivity, based on the different weight periods and index number formulas mentioned above, are presented in chapter V. This chapter also contains the construction of similar indexes for real net return per farm, and of estimates of the annual real gross return to agriculture.

In chapter VI regression analyses are made to test the following hypotheses:

(1) the relationship between annual percentage changes in over-all productivity and real net return per farm is negative or zero for Canadian agriculture between 1926 and 1957, and

(2) the relationship between annual percentage changes in aggregate output and real gross return is negative or zero for Canadian agriculture between 1926 and 1957.

The concluding chapter VII contains a summary of the findings of the study.

II. OVER-ALL PRODUCTIVITY[1]

In the previous chapter the term productivity was used as if its meaning were simple enough to be easily understood. However, when the concept has to be measured, particularly for an industry or a whole economy, its complexity becomes readily apparent.

The output/labor input ratio, usually referred to as labor productivity,[2] has often been used to indicate the productivity of firms, industries, and also of the economy as a whole. One reason for this popular custom has been the availability of labor statistics while information on other inputs was notably scanty.

When mechanization of production was comparatively primitive and the volume of production almost entirely determined by the number and skill of workers, the labor productivity ratio did serve as a measure for the productive capacity not only of labor but also of the production process as a whole. The relative importance of labor, however, has greatly diminished and with other inputs varying from firm to firm and from industry to industry the output/labor input ratio can no longer serve to measure the productive capacity of labor, firm, or industry.

There are thus good reasons for criticizing the indiscriminate

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1 Also called total or global productivity.

2 The modifier 'labor' has often been omitted. Even now the term productivity by itself is usually intended and understood to mean labor productivity.

use of the labor productivity ratio.[3] The connotation of the term is of particular concern because the uninitiated may be misled into interpreting a high ratio as necessarily preferable and something for which labor is to be credited.[4] Such beliefs may be conducive to over-capitalization and undue wage demands when other inputs merit greater emphasis.[5] In general the output/single input productivity ratios are useful only to indicate resource requirements, but for that purpose the reciprocals would be less ambiguous formulations.

Because an increase in one output/single input ratio is often associated with the decline of another the question arises how to obtain a measure of over-all productivity that takes into account all inputs used. At the same time the measure must allow for changes in outputs.

Economists have used two related approaches in their attempts

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3 Cf. "... this measure is so obviously unsatisfactory that one would not waste space discussing it ..." (Farrell, M. J., "The Measurement of Productivity Efficiency", Journal of the Royal Statistical Society, Vol. 120, Part 3, 1957, p. 263).

4 In view of the misleading connotation, it has been suggested labor efficiency be defined as the function of attitude and knowledge or skill, and labor productivity as the function of the total productive system (Wiles, P. J. D., "Notes on Efficiency of Labour", Oxford Economic Papers, Vol. 3, No. 2, June 1951, pp. 158-159. F. G. Sturrock prefers to define labor productivity as the amount of work accomplished per worker ("The Productivity of Labour in Agriculture", Journal of the Proceedings of the Agricultural Economics Society, Vol. 9, No. 1, July 1950, p. 36).

5 Some national studies provide evidence that the marginal returns to "organization" are higher than those to capital and labor (See Aukrust, O., "Investment and Economic Growth", Productivity Measurement Review, European Productivity Agency, O.E.E.C., No. 16, Feb. 1959, p. 47).

to measure over-all productivity.[6] One is called the production function method and the other the constant dollar method.

Production Function Method

For the production function method one requires the parameters of the production function of the industry for a certain period. Suppose the functional relationship between inputs and output is known for period t_o, then by substituting the inputs used in any other period (t_n), the output for t_n can be obtained on the basis of the productive capacity of the inputs used in t_o. The difference between the derived output and the actual output is ascribed to changes in the over-all productive capacity of the inputs, and the ratio of actual output to derived output is a measure of this change.[7]

The production function approach has appeal to those who consider the shift to a new function a measure of technical change,[8] as distinct from changes in the organization of inputs which, they feel,

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6 The aggregation of inputs in terms of embodied labor is of academic interest only. Cf. Concepts and Problems in the Measurement and Analysis of Productivity, Report II (mimeographed), Interdepartmental Committee on Productivity Analysis, Ottawa, Jan. 1954, p.5.

7 For a discussion of the assumptions involved, see: Kuttan, V. W., Technological Progress in the Meatpacking Industry, 1919-47, Marketing Research Report No. 59, U.S. Department of Agriculture, Washington, D.C., Jan. 1954, pp. 23-24.

8 See, for instance: Schumpeter, J. A., Business Cycles, Vol. 1, McGraw-Hill, New York, 1939, p. 87; Heady, E. O., "Basic Economic and Welfare Aspects of Farm Technological Advance", Journal of Farm Economics, Vol. 31, No. 2, May 1949, pp. 294-295; and Plaxico, J. S., "Discussion", Agricultural Adjustment Problems in a Growing Economy, (Heady, E. O., et al, eds.), The Iowa State College Press, Ames, 1958, p. 55.

are reflected in moves over the same function and therefore not included in the ratio of actual output to derived output.[9]

Attempts to separate changes in organization from changes in other inputs seems unnecessary and arbitrary.[10] Such a separation would be warranted if one were to provide a basis for the allocation of research funds, but it is irrelevant for the purpose of this study which requires a measure of the changes in the over-all productivity of all inputs, including their organization.

Furthermore, a meaningful production function for an industry would be well nigh impossible in view of the need for a period during which techniques of production remained unchanged, and which is long enough to provide the data necessary to estimate the parameters. It would be particularly difficult to determine a production function for agriculture where output is affected to such a large extent by weather

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9 For an application of the principles of the production function method, see: Johnson, D. G., "The Nature of the Supply Function for Agricultural Products", The American Economic Review, Vol. 40, No. 4, Sept. 1950, p. 559; Hutton, V. W., "The Contribution of Technological Progress to Farm Output: 1950-'75", The Review of Economics and Statistics, Vol. 38, No. 1, Feb. 1956, p. 67. Another approach to measuring the shift to a new function separately has been followed by Solow, R. M., "Technical Change and the Aggregate Production Function", The Review of Economics and Statistics, Vol. 39, No. 3, Aug. 1957.

10 Cf. Johnson, G. L., defines technical changes as "... the discovery of a new input which, like all other known inputs, is fixed or variable depending on economic conditions ...", and continues, "If ideas are recognized as inputs, as indeed they are, then new organizations can be regarded as technological changes." ("Supply Function - Some Facts and Notions", Agricultural Adjustment Problems in a Growing Economy, (Heady, E. O., et al, eds.), op. cit., p. 91 ft.). Cochrane, W. W. amends this definition by substituting "use" for "discovery" ("Some Additional Views on Demand and Supply", ibid., p. 96).

and other exogeneous conditions affecting growth.[11] Even if this problem were overcome there still remains the problem of aggregating various outputs.

Constant Dollar Method

This method also has shortcomings that should not be underestimated and the user of results obtained from this method should be wary of the limitations of their validity. But up to the present it is the only feasible way to get estimates of changes in over-all productivity for an industry.

The procedure involves weighting the inputs and outputs of each period (usually a year) in the time series with their prices for a given period. By adding the resulting constant dollar values of all inputs and all outputs for each year single input and output measures are obtained. The annual total output/total input ratios are purported to reflect changes in the over-all productive capacity of the inputs.

Since productivity is an ordinal concept the annual ratios are usually expressed as a percentage of the ratio for a selected period to give an index of over-all productivity. The annual ratios of the index numbers of total output to the corresponding index numbers of total input would give an over-all productivity index with the same base and weight periods as the output and input indexes.

The constant-dollar method is based on certain assumptions. First, it is assumed that the economic system in which the industry

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11 The construction of a weather index will help to meet this difficulty. See Stallings, J. L., Indexes of the Influence of Weather on Agricultural Output, unpublished Ph.D. dissertation, Michigan State University, East Lansing, 1958.

functions is in competitive equilibrium. Under this assumption market prices of outputs reflect consumers' marginal satisfaction, and market prices of inputs reflect the marginal productivity (valued at prices of the resulting output) of these inputs. Since the marginal satisfaction of the last item bought applies to all members of its class the dollar value spent on the class represents its total satisfaction. Similarly the marginal productivities of all members of an input class are the same, and the total expenditure on that class represents its total productive capacity.

Under the same assumption the satisfaction derived from each dollar spent by the consumer is the same, and so is the productive capacity of each dollar spent by the producer on inputs. Therefore, the dollar values of all output classes can be added to give a measure of the total satisfaction from all outputs, and the dollar values of all input classes can be added to combine the productive capacity of all inputs into a single measure. The ratio of total output values to total input expenses will thus measure the relationship between the sum total of consumers' satisfaction attained and the sum total of productive capacity applied.

By weighting the outputs of all years in the time series by their respective prices for a given year, the total output value of each year represents the total amount of satisfaction for that year if tastes were the same as in the given year. Similarly, the total input value at given year prices represents the total productive capacity used in terms of the productivity of the inputs in the given year.

At this point the need for another assumption becomes apparent because equal changes in inputs for production or consumption will not necessarily have the same effects on production output and consumers' satisfaction. To overcome this difficulty it must be assumed that all functional relationships between producers' inputs and outputs, and between consumers' goods and attained satisfaction are linear.

Under the assumptions of competitive equilibrium of the economic system and linearity of all functional relationships involved, the weighted total output/total input ratios would have the same numerical value for all years and be equal to that of the weight period[12] as long as the productive capacity of the weight period inputs remained unaltered. Or,if tastes are assumed to remain constant, any deviation from the weight period ratio thus becomes a measure of change in the over-all productive capacity of inputs. The numerical values of the annual total output/total input ratios can be expressed as a percentage of the ratio of a selected period (the base period) to get an index of over-all productivity.

The constant dollar method with arithmetic aggregation is essentially a linear case of the production function method. In the former the annual comparison is between average over-all productivities whereas in the latter it is between total products.

In terms of index number construction, the use of constant prices as weights to aggregate inputs and outputs which are different in kind corresponds to the Laspeyres' method for establishing quantity in-

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12 See ft. 23, Chapter 1.

dexes. The problems connected with the construction of index numbers are, therefore, inherent in the constant dollar method. One of these problems is the choice of weight period. Frequently the discrepancies in indexes caused by different weight periods is insignificant and can be ignored, but this is so only under certain circumstances. What these circumstances are will be discussed in the following chapter.

. . .

In concluding this chapter some of the causal factors behind the changes in the over-all productivity ratio will be briefly examined. Knowing these causes is not essential for the purpose of this study, but it is of value in avoiding misinterpretation of the results.

Sometimes changes in over-all productivity (in some studies only the "technical" changes, i.e. excluding the changes in organization by management, are meant)[13] are used to indicate changes in production resulting from research and education. This inference may be justified for some industries, but not for agriculture where the uncontrolled environmental factors are so important. Indeed as far as Canadian agriculture is concerned most, if not all, of the year to year fluctuations in the over-all productivity ratio can be ascribed to the variable weather and pest conditions.

The over-all productivity ratio of the industry will also change with certain inputs leaving the industry. If the proportion of poor

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13 The distinction between organizational and non-organizational changes in production has already been discussed. Here it may be added that under the assumption of linear production functions the organization would not affect the over-all productivity ratio.

managers among the farmers leaving the industry is higher than among the farmers in the industry, the over-all productivity ratio will rise. Economies of size would have the same effect on the productivity ratio if firms are expanding.

Another reason for a rising over-all productivity ratio that is not the direct result of research and education would be greater adherence to the principle of comparative advantage. Specialization within farms may have become possible through risk reducing research, and regional specialization through improvements in transportation and storage facilities, but the concomitant rise in the productivity ratio as a result of these shifts in farm enterprises is clearly not something for which additional research effort had to be exerted in the technical sciences.

There probably are still other factors affecting the productivity ratio,[14] but these few examples illustrate sufficiently that research and education are not the only factors that can change productivity.

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14 Cf. Johnson, G. L., op. cit., pp. 89-92.

III. WEIGHT PERIOD PROBLEM

One may wonder why the different output and input classes for all years in the time series should be weighted with prices pertaining to one particular period. Why not use current prices? The question is important and should be dealt with before entering into a discussion of the reasons for causing discrepancies in the numerical values of index numbers when constant weights pertaining to different periods are used.

Current or Constant Prices as Weights

As far as outputs are concerned, tastes become satisfied at different rates as time passes. Some acquisitive desires may disappear altogether while others are aroused with the appearance of new products. These changes cause shifts of the demand curves and establish new price relationships. The change in price, however, is not only a function of the shift in the demand curve but also of the elasticity of both the demand and supply curves. Since these elasticities vary with different commodities a unit change in the price of each commodity does not represent an equal change in consumers' satisfaction.

Insofar as price changes are consequences of alterations in goods and services they may reflect changes in consumers' satisfaction. But added novelties do not necessarily add to the utility of an article. As long as the consumer is free to choose between

goods with or without the novelty, any shift towards purchases of the former is likely to indicate that the novelty represents additional satisfaction for which the consumer is willing to pay.[1] But when there is no choice and the consumer has to pay for a novelty which he does not value the price increase does not reflect greater satisfaction. Instead it will result in a decline of total satisfaction because less can be bought with the remainder of his income. The resulting overestimation of consumers' satisfaction from using current prices as weights may or may not be offset by quality improvements which are appreciated by consumers but not reflected in higher prices.

Prices also change as a result of shifts in the supply function, unless the demand for these products is perfectly elastic. The supply function can shift for a variety of reasons. Some of these are changes in techniques, in the availability of raw products, or in market conditions (e.g. a shift towards monopolistic markets). This kind of price change does not necessarily reflect a change in taste. Suppose, for instance, that research caused a shift of the supply function from MC_o to MC_1 (Figure 1), and that demand (D_a) for the output is perfectly inelastic below the point where MC_o intersects. The amount consumed will thus remain unchanged and there is no reason for thinking that less satisfaction will be enjoyed just because the price declined from P_o to P_1.

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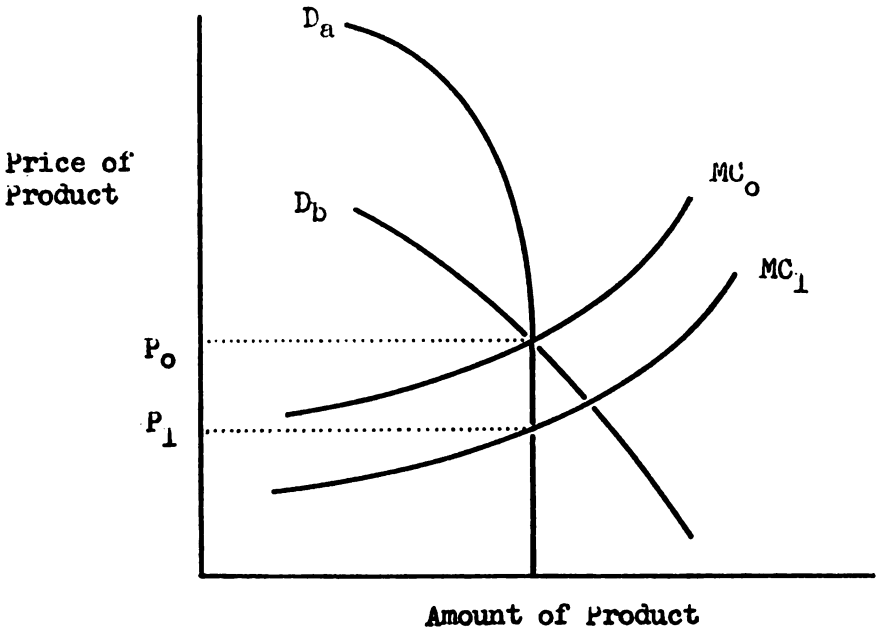
1 The term "free choice" is not without ambiguity. Two of the necessary prerequisites that ensure the meaning the concept is supposed to convey are (1) the knowledge that makes rational choices possible, and (2) the opportunity to make choices.

Figure 1.- Effects of Shift of Supply Function on Prices and Sales of Hypothetical Products



The illustration is extreme in that the level of satiation has not been reached for most products. A lower price will usually attract potential consumers and will induce active consumers to buy more. Should a similar technical change have taken place in the production of a product for which the demand is D_b, a decline in satisfaction per unit might have followed. It should be noted that the drop in price is less than that of a product whose satisfaction did not decline at all.

Price changes caused by inflationary or deflationary movements also do not indicate greater or smaller consumers' satisfaction. For those whose incomes rise proportionately less than the general price level total satisfaction will even decline.

This brief examination of the causes of price changes leads to

the conclusion that changes in prices fail as indices of changes in consumers' satisfaction. If the economic system were in competitive equilibrium each dollar spent would give the consumer equal satisfaction at any point in time, but for different periods a dollar's worth of satisfaction would be liable to be different. The use of current prices for weighting outputs would not provide comparable measures of satisfaction and it would be preferable to accept as weights the prices of one particular period, i.e. to aggregate in terms of constant consumers' satisfaction.

. . .

A similar line of reasoning will reveal that changes in the prices of inputs cannot be used to measure changes in productive capacity, even if the equilibrium condition were to prevail.

There is, moreover, another reason which makes it necessary to use input prices of one period as weights. Price changes are frequently associated with changes in quality, but if the output/input index is to reflect changes in productivity the quality changes of the inputs must be excluded from the denominator. Should, for instance, tractor A perform twice as much work as tractor B, then the difference in productive capacity between the tractors is expressed by the ratios 2 w/1 and w/1, and not by 2 w/2 and w/1.

Weight Period Bias [2]

It is a well-known phenomenon that different sets of weights produce discrepancies in the resulting index numbers. These discrepancies, usually referred to as weight period biases, can occur only in aggregate indexes. Whatever weights are used (except zero values) to construct simple index numbers, the weighted annual values stay in the same proportion and thus result in the same index numbers.

As long as the discrepancies among aggregate indexes are relatively small, the error is likely to fall within the error of estimating the data. Or should one be interested in the quotients of two sets of index numbers, as is the case in productivity ratios, errors in each set of index numbers are less important than the resultant error in the quotient. If the errors have opposite signs, i.e. an overestimation for one and an underestimation for the other, they will be compounded in the quotient. Errors with the same sign have an offsetting effect.

In the following discussion of the reasons for the occurrence of the bias the simple case involving only two periods will first be considered. It should be noted that this simplification shifts the discussion to the Laspeyres (when beginning-period weights are used) and Paasche (when end-period weights are used) index number formulas.[3]

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2 The word bias has been defined as "... a foreseeable tendency to err in one particular direction" (Fisher, I., The Making of Index Numbers, third ed., Houghton Mifflin, Boston, 1927, p. 80).

3 Hereafter the letters L and P will refer to the terms Laspeyres and Paasche respectively.

Although the discussion is not ipso facto applicable to index numbers based on beginning and end-period weights in a time series covering more than two periods it will expose the general nature of the bias.

Comparison Between Two Periods

The conditions under which the L and P formulas will give the same results can be ascertained for two periods and two commodities by equating the L and P index numbers of the following data:

Period	Commodity			
	A		B	
	Quantity	Price	Quantity	Price
t_0	q_0^a	p_0^a	q_0^b	p_0^b
t_1	q_1^a	p_1^a	q_1^b	p_1^b

The L and P aggregate quantity index numbers [4] for period t_1 are $\frac{q_1^a p_0^a + q_1^b p_0^b}{q_0^a p_0^a + q_0^b p_0^b}$ and $\frac{q_1^a p_1^a + q_1^b p_1^b}{q_0^a p_1^a + q_0^b p_1^b}$ respectively. After equating the two ratios cross-multiplication will give:

$$q_0^a q_1^a p_0^a p_1^a + q_1^a q_0^b p_0^a p_1^b + q_0^a q_1^b p_0^b p_1^a + q_0^b q_1^b p_0^b p_1^b = q_0^a q_1^a p_0^a p_1^a + q_0^a q_1^b p_0^a p_1^b + q_0^b q_1^a p_0^b p_1^a + q_0^b q_1^b p_0^b p_1^b \quad ; \quad \text{or}$$

$$p_0^a p_1^b (q_1^a q_0^b - q_0^a q_1^b) = p_1^a p_0^b (q_1^a q_0^b - q_0^a q_1^b) ,$$

which reduces to $p_0^a p_1^b = p_1^a p_0^b$; (1)

4 The same conclusions would have been reached for price indexes.

and also $q_1^a q_0^b (p_0^a p_1^b - p_0^b p_1^a) = q_0^a q_1^b (p_0^a p_1^b - p_0^b p_1^a)$,

which reduces to $q_1^a q_0^b = q_0^a q_1^b$. (2)

It thus appears that the L and P formulas will give the same result if (a) regardless of quantity changes, the prices of the items change in the same proportion, or (b) if, regardless of price changes, the quantities change in the same proportion.[5]

Two special cases can be exposed. Equation (1) is true if the price-quantity relationships of the items show perfect elasticity, because under this condition the prices of the items do not change and the products of the prices as indicated in the equation will be the same regardless of the change in quantities between t_0 and t_1. Equation (2) is true if the price-quantity relationships of the items are perfectly inelastic, because then the quantities do not change and the quantity products as indicated in the equation will be the same regardless of the change in prices.

In the second case the L and P index numbers are not only the same but also will equal unity. This conclusion can also be reached when the general forms of the L and P quantity index numbers for period t_1 are written as:

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5 The contention that the difference between the L and P index numbers "will equal zero only when $q_1 = q_0$ for all commodities involved" (Mudgett, B.D., Index Numbers, John Wiley and Sons, New York, 1955, p. 57) is incorrect; the word "only" should be deleted because absence of change in the quantities of the items between t_0 and t_1 is a special case of the general condition stated above under (b).

$$L_{01} = \frac{\Sigma q_0^i p_0^i (q_1^i / q_0^i)}{\Sigma q_0^i p_0^i} \quad \text{and} \quad P_{01} = \frac{\Sigma q_1^i p_1^i}{\Sigma q_1^i p_1^i (q_0^i / q_1^i)}$$

Should the quantity of each item change in the same proportion between periods t_0 and t_1, the bracketed fractions can be placed in front of the summation sign. As indicated before, both index numbers will have the same value; it now turns out to be the value of the q_1^i/q_0^i ratio. In the special case of quantities remaining constant both index numbers would equal unity.[6]

It is obvious that the conditions under which the L and P formulas give the same aggregate index numbers are hypothetical. Knowing these conditions may be helpful in selecting an appropriate weight period, as will be shown later, but they neither explain the direction of the bias, i.e. under what circumstances is the L index number higher than the P index number and vice versa, nor do they explain the magnitude of the bias.

L. von Bortkiewicz was first in providing these explanations. He formally demonstrated that the criterion determining the direction of the bias is the sign of the weighted coefficient of correlation between the price and quantity relatives, i.e. weighted by the beginning-period values of the items comprising the aggregate

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6 Mills, F.C. fallaciously states that the L price index has a downward bias and the P index an upward bias if quantities remain constant (Statistical Methods, Holt, New York, 1955, p. 452 ft.).

index.[7] Should the sign of this coefficient be negative the L index number will be higher than the P index number; if positive the L index number will be lower than the P index number.[8] Only if the

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7 $$r\ (\text{weighted}) = \frac{\Sigma p_0 q_0 (p_1/p_0 - L_p)(q_1/q_0 - L_q)}{\sigma_1 \sigma_2 \Sigma p_0 q_0}$$

where p_0 = price of an item in the first period
p_1 = price of an item in the second period
q_0 = quantity of an item in the first period
q_1 = quantity of an item in the second period
L_p = Laspeyres aggregate price index number
L_q = Laspeyres aggregate quantity index number

$$\sigma_1^2 = \frac{\Sigma p_0 q_0 (p_1/p_0 - L_p)^2}{\Sigma p_0 q_0}$$

$$\sigma_2^2 = \frac{\Sigma p_0 q_0 (q_1/q_0 - L_q)^2}{\Sigma p_0 q_0}$$

To facilitate calculation the formula can also be written as:

$$r\ (\text{weighted}) = \frac{\Sigma p_0 q_0 \cdot \Sigma p_1 q_1 - \Sigma q_0 q_1 \cdot \Sigma p_1 q_0}{\Sigma q_0 p_0 \sqrt{\Sigma p_0 q_0 (p_1/p_0 - L_p)^2 \cdot \Sigma p_0 q_0 (q_1/q_0 - L_q)^2}}$$

(Bortkiewicz, L. von, (a) "Zweck und Struktur einer Preisindexzahl", Nordisk Statistisk Tidskrift, Vol. 2, 1923, p. 376, and also in (b) "Die Kaufkraft des Geldes und Ihre Messung", Nordic Statistical Journal, Vol. 4, Parts 1 - 2, 1932, pp. 15 and 16. See also: Staehle, H., "International Comparison of Food Costs", International Comparisons of Cost of Living, International Labour Office, Series N, No. 20, Geneva, 1934, p. 15; and Siegel, I.H., "The Difference Between The Paasche and Laspeyres Index-Number Formulas", Journal of the American Statistical Association, Vol. 36, No. 215, Sept. 1941, p. 345).

8 Diagrammatical explanations are given in APPENDIX I.

spread in the base year values is not large will the sign of the unweighted coefficient of correlation be a sufficient criterion.[9]

Von Bortkiewicz established furthermore that the magnitude of the discrepancy between the L and P index numbers, expressed as a fraction of the aggregate L index number, is determined by the arithmetical product of (1) the weighted coefficient of correlation between the price and quantity relatives, (2) the ratio of the weighted standard deviation of the price relatives and the L aggregate price index number, and (3) the ratio of the weighted standard deviation of the quantity relatives and the L aggregate quantity index number.[10]

It thus follows that the larger the weighted coefficient of correlation the larger will be the difference between the L and P index numbers. If the coefficient is zero, as would be the case with price-quantity relationships that are perfectly elastic or inelastic (cf. p. 28) both index numbers will be equal.

The explanation by von Bortkiewicz provides an answer to some seemingly contradictory statements in the literature about the direction of the bias. One author states, for instance, that the L formula usually gives index numbers with a downward bias.[11] Others

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9 Evans, G.H., "The Index Numbers A.M.$_I$ and A.M.$_{II}$", Journal of the American Statistical Association, Vol. 31, No. 196, Dec. 1936, p.726.

10 $\frac{P - L}{L} = r.\frac{\sigma_1}{L_p} \cdot \frac{\sigma_2}{L_q}$

(Bortkiewicz, L. von, (a) op. cit., p. 376, (b) op. cit., p. 15; Staehle, H., op. cit., pp. 15 and 16; Siegel, I.H., op. cit., p. 345.

11 Mills, F.C., (quoting Irving Fisher), op. cit. p. 451.

claim that the L index has an upward bias and the P index a downward bias.[12] Empirical results show, however, that sometimes the L and at other times the P formula will give the higher numerical value.[13]

The reason for the contradictory statements can be traced to the acceptance of the same price-quantity relationships for all items that make up the aggregate and between all periods in the series. An inverse relationship between prices and quantities over time is assumed because consumers and producers will shift purchases to substitutes that become cheaper. A positive relationship is assumed for outputs because the producer will shift production to goods whose prices are rising.

A conflict in conclusions becomes immediately apparent if one considers that the outputs of a production process are also inputs either for further production or as consumer goods.

The assumed price-quantity relationships pertain to a single moment in time and reflect negatively sloping demand curves (for inputs) and positively sloping supply curves (for outputs). But as far as the problem of weight period bias is concerned, it is the price-quantity relationship displayed over time by the points of intersection

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12 Cf. Croxton, F. E. and D. J. Cowden, Applied General Statistics, Prentice-Hall, Englewood Cliffs, 1958, p. 429.

13 Fisher, I., referring to the Laspeyres and Paasche index numbers, observed already that the "two curves are very close together and even cross each other", and "there is no tendency for either of the two curves to be constantly above or constantly below the other" (op. cit., pp. 58 and 238 respectively); Rudgett, B.D., commented that the situation in which the Laspeyres index is smaller than the Paasche index "happens repeatedly" (op. cit., p. 35).

of prices and quantities pertaining to the commodities included in the aggregate index that counts. This relationship is not necessarily the same for all inputs or for all outputs. It may also change for any particular input or output between different periods. A few examples will illustrate the variations that may occur in these relationships.

The demand for agricultural products is, by and large, more stable than their supply. The intersections of their supply and demand curves are thus likely to show an inverse relationship between prices and quantities for periods not too far apart in time. Such a negative relationship need not exist, however, between two distant periods. Through inflationary pressures and possibly through increases in demand, prices in the later period may well be higher than in the earlier period regardless of the changes in production.

The price-quantity relationship between two periods is likely to be more erratic for inputs. Many of the industries supplying inputs are oligopolistic or price-making. Supplies (and prices) can be controlled to meet shifting demands and where that is done a positive price-quantity relationship may be expected. It can happen, of course, that a future demand is misjudged. An anticipated rise in demand may not take place, or it may even decline. In that case a comparison of two periods may show that a higher price is associated with a lower quantity.

For other inputs the price-quantity relationship may be predominantly negative. Labor would be an appropriate example; because wages are raised in response to a declining labor supply the

intersections of the supply and demand curves for labor will tend to follow the demand curve.

The price-quantity relationships for farm machinery and labor are depicted in Charts 1 and 2. The charts clearly show that the price-quantity relationship of these two inputs can have opposite signs between the same two periods, and also that the sign of the relationship for either input depends upon the two periods compared.

From this cursory examination it can already be inferred that some items comprising the aggregate index number of inputs and of outputs will tend to make the L index number larger than the P index number, whereas others will have just the opposite effect. The determination of the resultant weight period bias in the aggregate index number is thus a matter of weighting opposing tendencies.

Comparison Between Several Periods

When more than two periods are taken into consideration the terms Laspeyres and Paasche no longer apply to beginning and end-period weighting. The P method involves variable weighting, i.e. the weights to be used are those of the given year and not those of the end-period of the time series.[14] The L formula describes fixed weights but these weights do not necessarily have to pertain to the beginning-period in the time series. In general, therefore, weighting with beginning-year prices is an application of, but is not synonymous with

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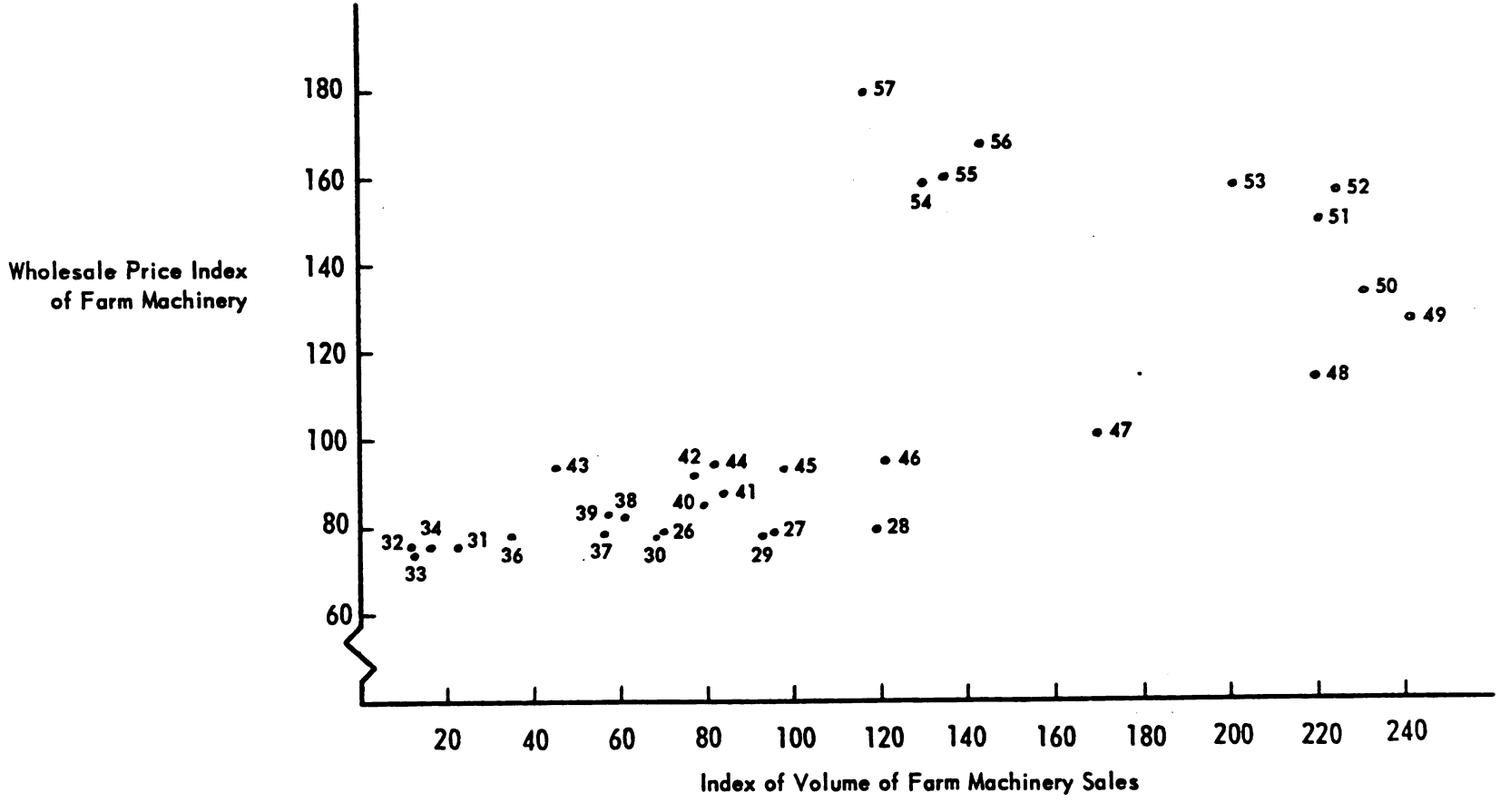
14 Cf. Fisher, I., op. cit., pp. 492-93.

Chart 1. – Price-Quantity Relationships of Farm Machinery, Canada, 1926-1957

(Average price and volume of sales of the 1926-57 period = 100)



Sources: Canada, Department of Trade and Commerce, D.B.S., Prices and Price Indexes and Farm Implement and Equipment Sales

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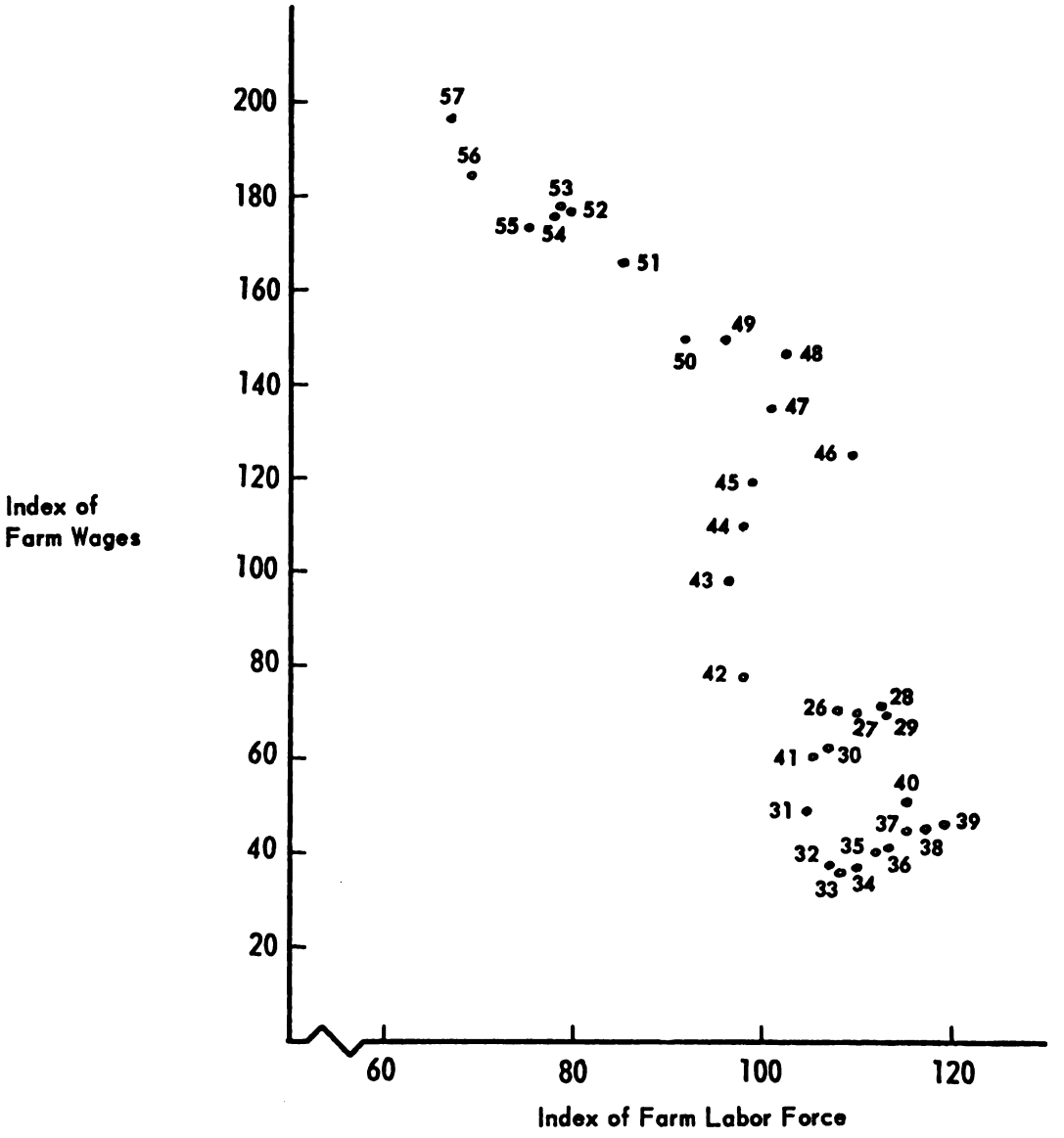
Chart 2. -- Price-Quantity Relationships of Farm Labor, Canada, 1926-1957

(Average wage and labor force of 1926-57 period = 100)



Sources: Canada, Dept. of Trade and Commerce, D.B.S., Quarterly Bulletin of Agricultural Statistics, and Canadian Labor Force Estimates, 1931-1945 and The Labor Force, November 1945 – July 1958

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the L formula; and weighting with end-year prices is not synonymous with the P method.

Failure to recognize this distinction, as has been the case with some authors,[15] engenders the danger of applying conclusions based on the L and P formulas to beginning and end-period weighting. Thus Ruttan's erroneous contention that "the 'true' measure of technological change can be bracketed by using both beginning-period and end-period weights" [16] is based on his conclusion "that the Laspeyre (sic) and Paasche indexes set the limits between which the 'true' measure of technological change must lie." [17]

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15 For misuse of the term Paasche see, for instance, Ruttan, V.W., "Agricultural and Nonagricultural Growth in Output Per Unit of Input", Journal of Farm Economics, Vol. 39, No. 5, Dec. 1957, pp. 1567-68; Stout, T.T. and V. W. Ruttan, "Regional Patterns of Technological Change in American Agriculture", Journal of Farm Economics, Vol. 40, No. 2, May 1958, pp. 198-201; and Thomson, P., The Productivity of the Human Agent in Agriculture: An International Comparison, unpublished Ph.D. dissertation, University of Chicago, Illinois, 1951, pp. 22-23.

16 Ruttan, V. W., "Agricultural and Nonagricultural Growth in Output per Unit of Input", op. cit., p. 1568.

17 Cf. Ruttan, V. W., Technological Progress in the Meatpacking Industry, 1919-47, Marketing Research Report, No. 59, U. S. Department of Agriculture, Washington, D.C., Jan. 1954, p. 18. Because Ruttan has published extensively on productivity (pertaining to agriculture and allied industries in the U.S.) in recent years three reoccurring conceptual errors in his writings warrant recapitulating: (1) his use of static production economics diagrams to demonstrate the direction of the weight period bias for inputs and outputs is fallacious, (2) he incorrectly applies the term Paasche to end-year weighting in time series, and (3) he compounds errors by concluding from errors (1) and (2) that the limits of the bias are set by beginning and end-year weighting.

The way in which different weighting affects aggregate index numbers in time series can be shown by a simple illustration. Suppose that a time series consists of four periods, and that the prices of each are used to weight quantities. The four sets of L index numbers and one P index are indicated as follows (the first subscript of each index number refers to the period in time, the second to the period whose prices are used as weights):

Period	Laspeyres Index Numbers Using Different Weight Periods				Paasche Index Numbers
	t_0	t_1	t_2	t_3	
t_0	I_{00}	I_{01}	I_{02}	I_{03}	I_{00}
t_1	I_{10}	I_{11}	I_{12}	I_{13}	I_{11}
t_2	I_{20}	I_{21}	I_{22}	I_{23}	I_{22}
t_3	I_{30}	I_{31}	I_{32}	I_{33}	I_{33}

The discrepancies between any two of the constant weight indexes (all indexes having the same base period) can be explained by considering the indexes with weight periods t_0 and t_1. The changes between t_0 and t_1 in the quantities and prices of the items that make up the aggregate index determine the difference between I_{10} and I_{11}. Although the price weights remained the same for periods t_2 and t_3, the quantities between t_0 and t_2, and between t_0 and t_3 will have changed differently than between t_0 and t_1. Consequently the discrepancies between I_{10} and I_{11}, between I_{20} and I_{21}, and between I_{30} and I_{31} will be different.

For one period each of the L indexes will have an index number that is the same as the P index number. For the other periods the L and P index numbers will be different, and the discrepancies will vary because in these cases not only the quantities but also the prices of the items are liable to change.

Choice of Weight Period

When the discrepancies between index numbers based on different weight periods exceed an acceptable margin of error, the question arises as to which period provides the most appropriate set of weights, i.e. a set of weights that would produce index numbers that are the best possible reflection of the true changes in aggregate quantities or prices.

One of the criteria of appropriateness is the representativeness of weights throughout the time series.[18] As for quantity indexes, the closer the proportions between prices of the weight period come to those of other periods in the time series, the smaller will be the maladjustments between weight period prices and non-weight period combinations of inputs or outputs. If all input and all output prices were to change in the same proportion there would not be any weight period bias (cf. p. 28).

Some researchers believe that the center period in the time series

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18 Cf. Mudgett, B. D., op. cit.; and Black, J. D. and B. D. Mudgett, Research in Agricultural Index Numbers, Social Science Research Council, Bull. No. 10, New York, March 1938, p. 35.

provides the most appropriate set of weights.[19] Although such weighting may be preferable to either the beginning or end-period weighting, the center period does not necessarily provide the most appropriate set of weights, as will become apparent.

To establish a measure of changes in the proportions in which the input prices of this study stand to one another, the price index numbers were expressed as a percentage of the index number of real estate value for each year in the time series. Instead of real estate any other input could have been chosen as a basis for comparison. If all prices change in the same proportion the percentages would all be 100. The deviations of these percentages from 100 indicate, therefore, greater or smaller proportional price changes as compared with the changes in real estate values. For each input the deviations (without signs) were averaged over the years in the time series. The results are shown in Table 1, where the items are arranged in order of decreasing percentage change in volume between 1926 and 1957 (see Tables 19, 22 and 25, Appendix III). Consequently the higher the item is on the list, the heavier the average deviation must be weighted in deciding upon the most appropriate weight period.

It is apparent that the input prices of the 1935-39 period on the whole deviate less from the prices of other years in the time series than those of any of the other weight periods tested; the prices of

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19 Cf. "On theoretical grounds the year 1889 should have been selected, as it is situated somewhat nearer the center of our interval", Frickey, E. in "Some Aspects of the Problem of Measuring Historical Changes in the Physical Volume of Production", Explorations in Economics, McGraw-Hill, New York, 1936, p. 480.

Table 1.- Average Annual Deviation from 100 of Price Indexes of Selected Inputs Expressed as a Percentage of the Price Index of Real Estate for Different Weight Periods, Canadian Agriculture, 1926-1957

Farm Input	Weight Period				
	1930-34	1935-39	1940-44	1945-49	1950-54
1. Fertilizer	27	12	20	19	27
2. Supplementary machinery inputs (gasoline, oil, etc.)	16	15	16	14	19
3. Feed	72	12	44	32	36
4. Property taxes	37	4	36	26	33
5. Repairs and depreciation on machinery	38	11	28	28	34
6. Miscellaneous	38	10	27	28	34
7. Machinery investment	38	11	28	28	34
8. Labor	128	52	60	42	43
9. Real estate investment	0	0	0	0	0
10. Livestock investment	91	24	44	37	41
11. Repairs and depreciation on farm buildings	96	28	49	41	43
12. Interest	17	30	12	16	14

the 1945-49 period come second best.[20] The 1930-34 period provides the least desirable weights. But the most appropriate index according

20 This procedure is reminiscent of one of the tests suggested by R. A. Loomis for selecting the most appropriate weight period. There is, however, one important difference. In the process of determining an average measure of deviation Loomis averaged (for the period 1910-40) the percentages (the price index number of a particular input as a percentage of the wage rate index) pertaining to each input. In so doing, plus and minus deviations were cancelled against each other which is undesirable. ("Effect of Weight-Period Selection on Measurement of Agricultural Production Inputs", Agricultural Economics Research, Vol. 9, No. 4, U.S. Department of Agriculture, Washington, D.C., p. 131). The conclusions of both approaches are nevertheless much the same. Loomis concluded in his analysis that the 1935-39 weight period is one of the suitable ones to use for the period 1910-39, and the 1947-49 weight period appeared to be the best choice for the 1940-55 period (ibid., pp. 134-35).

to this test may still be inadequate. Particularly when price changes are large, which is likely to be the case over a lengthy period such as the one considered in this study, the weights of any one period will be inappropriate for some years in the time series.

A difficulty closely related to the problem of representativeness of weights arises in connection with the introduction of new and the disappearance of obsolescent items. In long time series an early weight period may lack weights for new items, and a weight period towards the end of the time series may lack weights for those which are no longer used. It is conceivable that there is no weight period which will provide weights for all items in the time series.

To meet the problem of representativeness lengthy time series have been split into smaller, more homogeneous sections, and an appropriate weight period selected for each. The indexes pertaining to these subsections are then linked in the customary manner so as to get a continuous series. What happens in a theoretical sense is that the inputs in each subperiod are aggregated in terms of different productive capacities, and the outputs are aggregated in terms of different units of consumers' satisfaction. By linking the indexes of the subperiods an attempt is made to establish a uniform meaning for all index numbers in the whole time series.

The extreme case of splitting a time series is the adoption of the chain index method. This method, like the Paasche one, involves different weighting for each period in the time series. But whereas the Paasche index number is based on a comparison between given and

base year, using weights pertaining to the former, the chain index number is based on a comparison between two successive years, using weights of the one that comes first in temporal order. Insofar as linking cannot be expected to be wholly satisfactory in converting all index numbers in terms of productive capacities and utilities of the first period in the series, the chain index primarily reflects changes between successive years. This characteristic will not be a handicap if one's interest lies with year to year changes; one's only reservation would be the unlikelihood that the prices of each year will be equilibrium prices.

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This study deals with the year to year changes in productivity and income. The Paasche formula would therefore be the least appropriate of the three types of index formulas mentioned. Apart from the problem of representativeness to which this index gives rise, its values for two successive years have a different meaning. As long as the weights for such years do not differ too much, however, this index may be used.

The chain index is designed to provide comparisons between successive years. It offers a solution to the problem of representativeness but it is likely that the equilibrium condition will be violated.

The fixed weight index formula can be used when comparisons between all periods are required. The constant weights will lead to the problem of representativeness but it may be possible to select a weight period during which equilibrium conditions were most closely

realized.

When dealing with lengthy periods (i.e. periods long enough to cause problems of representativeness of weights) there is no sure way in which to measure annual changes for aggregates. The simplicity of linking two or three subperiods, each with its own constant weight period, has an immediate appeal.[21] But this same simplicity carries the danger of overlooking the likelihood that the linking procedure is inadequate to establish a uniform meaning for all index numbers in the series.

In this study an experimental approach has been followed. Instead of trying to choose an index that would be most appropriate for the purpose of the study, six different sets of indexes were determined: four sets of constant weight indexes, one Paasche index, and one chain index. In so doing evidence is provided for the pattern and magnitude of the various weight period biases, and it becomes possible to show to what extent these biases affect the conclusions of this study.

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21 Such an index can easily be derived from the four sets of constant weight indexes determined in this study.

IV. PROCEDURE FOR ESTIMATING AGGREGATE INDEXES OF TOTAL INPUT AND OUTPUT FOR CANADIAN AGRICULTURE, 1926-1957

The period considered in the productivity analyses of this study runs from 1926 to 1957. Reliable information on most farm inputs is not available for the years before 1926, and 1957 was the last year for which payments to farmers by the Canadian Wheat Board were completed at the time the calculations were made.

Historical data on quantities and prices are not readily available for most inputs and outputs. Instead current values and price indexes are published.[1] The easiest way, therefore, to determine quantities at prices described by the index number formula used was to divide the value by the appropriate index number or ratio of index numbers.

To find out the variation in index numbers associated with different ways of weighting items measured in different physical volumes, six sets of quantity index numbers of both inputs and outputs were determined for Canadian farms as a whole. The first year in each of these series was adopted as base period. Four of these sets are based on the constant weight formula, one on the Paasche and one on the chain index formula. The general forms of these formulas are:

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1 In this study the term 'current' is used to refer to the period under consideration, not necessarily the present time.

(1) $\frac{\leqslant (V_n / I_n / I_w)}{\leqslant (V_o / I_o / I_w)}$ for the constant weight formula,

(2) $\frac{\leqslant V_n}{\leqslant (V_o / I_o / I_n)}$ for the Paasche formula, and

(3) $\frac{\leqslant (V_n / I_n / I_{n-1})}{\leqslant V_{n-1}} \cdot C_{n-1}$ for the chain index formula, where

V_n = the current value of the item for the n^{th} period

V_o = the current value of the item for the base period of the quantity index (i.e. 1926)

I_n = the price index number of the item for the n^{th} period

I_w = the average price index number of the item for the weight period of the quantity index

I_o = the price index number of the item for the base period of the quantity index (i.e. 1926).

C_{n-1}= the chain aggregate quantity index number for the n-1 period.

The four sets of constant weight index numbers are based on weight periods 1935-39, 1940-44, 1945-49, and 1950-54. Since nearly all of the price indexes used have the average price of the 1935-39 period as their base (i.e. equal 100) the inputs at 1935-39 prices were determined simply by dividing the appropriate price index numbers into the current dollar values. The constant dollar values of all inputs were then added for each year and the annual totals expressed as a percentage of the total value of the base year. To get quantities at prices of periods other than the base period of the price indexes, the

base period was shifted to the required weight period and the division repeated. The same procedure was used to get quantity indexes for total output.

The calculations for the constant weight formula were programmed for the Burroughs-205 computer. The Paasche and chain index numbers were obtained by the I.B.M. 650 computer using the automatic coding system (For Transit).[2]

Reproduction of the intermediate steps for all six sets of index numbers would take too much space. Only those leading to the index numbers based on 1935-39 prices are included (see Appendix III).

Farm Inputs

Official estimates of annual "Farm Operating Expenses and Depreciation Charges" are readily available for Canada and the provinces (except Newfoundland) for the years beginning with 1926.[3] The breakdown is as follows:

1. Taxes (excluding rented land and buildings)
2. Gross rent
3. Hired labor
4. Interest on indebtedness (excluding rented land and buildings; secured and unsecured debt)
5. Feed and seed (purchased through commercial channels only)
6. Tractor
7. Truck

- continued /52

2 The computer programs are in Appendix II.

3 For method of compiling these estimates see source: Canada, Department of Trade and Commerce, D.B.S., Ottawa, Handbook of Agricultural Statistics, Part II (Farm Income, 1926-57), Ref. Paper No. 25, rev. ed., 1958, pp. 17-22.

8. Automobile (expenses incurred from farm business only)
9. Engine and combine
10. Machinery repairs (repair parts and machinery shop charges)
11. Fertilizer and agriculture lime
12. Fruit and vegetable supplies (pesticides, containers and nursery stock)
13. Building repairs (excluding rented buildings)
14. Electric power (reported since 1941)
15. Miscellaneous (veterinary expenses, binder twine, irrigation charges, fence repairs, rope, salt, hardware, artificial insemination charges, purebred livestock registration fees and livestock purchases)
16. Depreciation buildings (excluding rented buildings and machinery).

Information on capital invested in agriculture is also available since 1926. Separate estimates are given for real estate, livestock and machinery.

The grouping of inputs in this study was largely determined by the available price indexes. Under the heading "Price Index Numbers of Commodities and Services Used by Farmers" index numbers covering the years 1926 to 1957 are available for (1) tax and interest rates, (2) farm wage rates, (3) farm machinery, (4) building materials, (5) gasoline, oil and grease, (6) feed, (7) fertilizer, (8) binder twine, (9) seed, and (10) hardware. This list was extended by a breakdown of the index numbers for tax and interest rates (provided by the Dominion Bureau of Statistics upon request), the wholesale price index of animal products (published), and an index of farm real estate values (computed). Also, since the published index of farm wage rates is based on equal weighting of wages with and without board and room, a new index of farm wages was calculated to include fully an allowance for board and room.

With this information on current values and prices the following input categories could be set up:

1. Labor
2. Service of providing capital
   a. Interest on real estate investment
   b. Interest on machinery investment
   c. Interest on livestock investment
3. Supplementary real estate inputs
   a. Repairs and depreciation
   b. Taxes
4. Supplementary machinery inputs
   a. Repairs and depreciation
   b. Other (fuel, lubricants, tires, etc.)
5. Other inputs
   a. Feed and seed
   b. Electric power
   c. Miscellaneous

Since the estimates of the Dominion Bureau of Statistics for the current values of seed pertain to the amounts purchased through commercial channels, which is only a small portion of the total seed input, estimates of the annual total seed input were also determined. These estimates called for a rather elaborate procedure of determining separate estimates for forage and other seed inputs. The total estimates were surprisingly high but since these values changed little from year to year the aggregate input index was scarcely affected. With all seed included, the constant dollar value of total inputs would be proportionally higher in 1926 than in later years; and the aggregate index numbers for the later years would thus be somewhat lower than the index numbers which do not include all seed.

The inclusion of non-commercial seed on the input side would necessitate an adjustment of cash sales on the output side. This would affect the aggregate output index in the same way as the input index.

Since the remaining effects of seed on both the input and output index numbers are in the same direction and of the same magnitude the effects are further eliminated in the productivity ratios. The procedure of determining the total seed input would have complicated the computer programs considerably and this extra work did not appear justified. Only the commercial seed was therefore included.

The procedure of weighting the inputs will be described in detail for the fixed 1935-39 weight period only. The different weighting required for the other fixed weight periods, and for the Paasche and chain index number formulas is indicated by the respective formulas (see p. 52).

Labor

The annual labor input could have been obtained by multiplying the agricultural labor force estimates (i.e. persons with jobs in agriculture in early June or at the end of May) and the average yearly wage (including an allowance for board and room) of the weight period. To keep the computer program as simple as possible, however, the annual current cost of the labor input and a wage rate index were prepared so that this input could be treated the same as were other inputs. The annual cost of the labor input was divided by the wage index to get the weighted labor force input.

The available data have obvious shortcomings. Since the hours of work per day or week have been declining the labor input based on man-years will be increasingly overestimated as time goes on. On the other hand by evaluating all agricultural labor, including the operator, at

the same rate changes in the composition of the labor force are ignored. If it is true that the share of child labor and that of old people has been declining (data on child labor are not available; Table 2 shows a small decline in the proportion of farm operators of age 60 and over between 1931 and 1951) the labor input would for this reason be underestimated in later years.[4] Because the effects of these shortcomings are offsetting and also because the labor force estimates are rough to begin with, any attempt to improve these estimates was considered unwarranted.

Table 2.- Changes in Age Distribution of Farm Operators, Canada, 1931 and 1951

Age Group	1931	1951
	- per cent -	
Under 24 years	3.1	3.5
25 - 29	7.0	7.6
30 - 39	21.2	23.2
40 - 49	26.3	24.8
50 - 59	21.9	21.3
60 years and over	20.5	19.6

SOURCE: Canada, Department of Trade and Commerce, D.B.S., Ottawa, Ninth Census of Canada, 1951, Vol. VI (Agriculture), Part 1, p.2-1.

Regular labor force surveys (first quarterly; monthly after November 1952) were not undertaken until November 1945. The estimates of the Dominion Bureau of Statistics before this year are based on

4 Cf. Schmookler, J., "The Changing Efficiency of the American Economy: 1869-1938", The Review of Economics and Statistics, Vol. 34, No. 3, Aug. 1952, p. 217.

census data which do not pertain to the labor force but to the slightly different concept of gainfully occupied.

The labor force includes persons "14 years of age and over who, during the survey week: did some work; had jobs but did not work; or did not have jobs and were seeking work." [5] The unpaid female family worker on the farm would have to spend more than 20 hours per week on farm work to become part of the agricultural labor force. By gainfully occupied is meant that the person so classified "earns money or assists in the production of marketable goods." [6]

The main difference between the labor force and gainfully occupied concepts is that questions with respect to the labor force enquire about employment status during a specific period of time, whereas no such time limitation was employed when enquiring about the gainfully occupied. Consequently the labor force includes people "whose chief activity during a period of one year is student, homemaker, and retired, as well as persons never gainfully occupied but seeking employment, merely because they worked a specific number of hours during the survey week or were actually looking for work at that time." [7] These people were not considered gainfully occupied. On the other hand, the "voluntarily idle

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5 Canada, Department of Trade and Commerce, D.B.S., Ottawa, The Labour Force, November 1945-July 1958, Ref. Paper No. 58, rev. ed., 1958, p. 5.

6 Canada, Department of Trade and Commerce, D.B.S., Ottawa, Eighth Census of Canada, 1941, Vol. VII (Occupations and Industries), p.xii.

7 Canada, Department of Trade and Commerce, D.B.S., Ottawa, Census of Saskatchewan, 1946, Vol. II (Occupations, Industries, Earnings, Employment and Unemployment), p. xii.

are excluded from the labor force, whereas some of them, on the basis of usual activity, would be included in the gainfully occupied." [8] It was established, however, that the change in definition did not "appreciably affect the comparability of the occupation statistics." [9]

The labor force estimates are classified by occupation and by industries. Agriculture as an occupation comprises (1) farmers and stock raisers, (2) farm managers and foremen, (3) farm laborers, (4) flower growers and landscape gardeners, and (5) others. Under agriculture as an industry come the various farm enterprises, agricultural services, experimental and university farms. Although the labor force in agriculture as an industry includes people who are not immediately concerned with commercial farming, these data were nevertheless used because they are available for a greater number of years for Canada as a whole, and also are published for the provinces. Consideration of provincial data is relevant if the productivity analysis is to be extended to the regional level.

The data on use of labor by industry have less serious shortcomings than at first appear. Actually the difference between the occupational and the industrial groupings is small (approximately 0.03 per cent in the 1951 census), and an error has little effect on the

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8 Canada, Department of Trade and Commerce, D.B.S., Ottawa, Canadian Labour Force Estimates, 1931-1950, Ref. Paper No. 23, p. 2.

9 Canada Department of Trade and Commerce, D.B.S., Ottawa, Ninth Census of Canada, 1951, Vol. X (General Review), p. 246.

index numbers as long as it is approximately the same for each year.

The labor force estimates are also broken down into (1) persons without jobs and seeking work, and (2) persons with jobs. It is the latter category that provided the estimates of the labor input for this study.

Because the census data pertain to the beginning of June all annual estimates of the Canadian labor force are published as of this period. The procedure may seem to impose shortcomings for an industry in which employment is determined to such a large extent by seasonal weather conditions. Yet during the period for which monthly labor force data are available the changes in the June estimates follow reasonably closely the changes in the annual averages (see Table 3).

Table 3.- June Estimates as a Percentage of the Annual Average of the Agricultural Labor Force (Persons with Jobs), Canada, 1953-1959.

Period	1953	1954	1955	1956	1957	1958	1959
	-			per cent			-
June	106	103	107	104	104	104	106

SOURCE: Canada, Department of Trade and Commerce, D.B.S., Ottawa, The Labour Force, November 1945-July 1958, Ref. Paper No. 58, rev. ed., 1958, pp. 58-59; The Labour Force (monthly).

Service of Providing Capital (Interest Charges)

The annual input of this service in constant dollars was estimated by (1) dividing the current value of each of the three investment inputs by the most appropriate price index to get these investments at base period prices, and (2) multiplying the investments at base period prices

by the average rate of interest on farm mortgages of the base period.

The inclusion of services of providing capital, particularly capital fully owned by the farm operator, in the total input measure may need some elaboration. The question of which inputs to include for short-run comparisons (and how to quantify the inputs most appropriately) has not been completely settled by researchers in the field of productivity analysis.[10] Some authors have suggested, however, that for annual comparisons inputs that do not affect changes in output over such a short period should be excluded from the denominator of the productivity ratio. Interest on the farm operators' own capital is a case in point.

The interest charge on all capital invested in agriculture has nevertheless been included, because (1) annual interest on investment has remained relatively stable throughout the years 1927 to 1957 (see Table 19), and as long as the over-estimation of total input would be about the same for each year its effect would be largely eliminated in the ratio, and (2) the item has been customarily included and it will be useful to make the productivity index for Canadian agriculture comparable to those constructed for agriculture in other countries.

Insofar as farm real estate is rented, the service for the use of this capital item is likely to be accounted for in the rent. Instead of treating all farms as if they were owner-operated, the above described procedure could be restricted to that value of real estate which was actually owned by farm operators, and rent could be included as an

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10. Cf. Hathaway, D. E., "Agriculture in an Unstable Economy Revisited", Journal of Farm Economics, Vol. 41, No. 3, Aug. 1959, p. 495; Griliches, Z., "Measuring Inputs in Agriculture: A Critical Survey", ibid., Vol. 42, No. 5, Dec. 1960, pp. 1411-27.

additional input. This alternative procedure would also conveniently take care of depreciation and taxes on rented real estate. Or, since "... rented rates are likely to more accurately reflect the value of alternative uses of land for any particular year than a return based on a percentage of land value or price" [11] all farms could also be treated as if they were rented.

Whatever procedure is followed one needs to know the proportions in which farm real estate is operated by the owners and by tenants. First, if all real estate is assumed to be owner-operated, this proportion is required to adjust the charges for depreciation and taxes (both reported for owner-operated real estate only) to include all farms. Second, if all farms were treated as if they were rented by the operators, the proportion must be known so that the rent can be extended to include all farms. And third, if rented and owner-operated real estate were treated separately, the proportion must be known so that an interest charge can be levied against the value of real estate owned by the operators.

The proportion in which the two types of farm tenure occur is known for the census years, and estimates for the inter-census years can be determined by interpolation. The validity of this procedure is affected somewhat by the fact that the proportion of farm ownership first declined and later increased during the 1921-1956 period. It is

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11 Johnson, D. Gale, "Allocation of Agricultural Income", Journal of Farm Economics, Vol. 30, No. 4, Nov. 1948, p. 730.

assumed, however, that 1940 can be used as a breaking point between the years of decline and increase.

With regard to the first and second methods there is also the assumption that owned and rented real estate belong to the same statistical population. This assumption is doubtful. If the better farms are operated by the owner, extending taxes and depreciation to include the rented farms would overestimate these inputs, and extending the published gross farm rent estimates to include the owner-operated farms would underestimate the total real estate input. The error of overestimation is likely to be less than the error of underestimation because the larger proportion of farm real estate has been operated by owners. Neither error arises with the third approach in which owner and tenant-operated farms are treated separately.

As it happens, the gross farm rent reported by the Dominion Bureau of Statistics is a synthesized estimate based on "... taxes, return on investment, repairs and depreciation on buildings" which "... were calculated from Census of Agriculture data projected annually according to official estimates of the values per acre of farm land and the value of field crop production".[12] In these circumstances it is doubtful whether the third approach offers an improvement over the first. The first approach was therefore followed which also eliminated the need for a price index of rent which is not available.

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12 Canada, Department of Trade and Commerce, D.B.S., Ottawa, Handbook of Agricultural Statistics, Part II (Farm Income, 1926-57), Ref. Paper No. 25, rev. ed., 1958, p. 18.

Supplementary Real Estate Inputs

The annual estimates of building repairs, depreciation and taxes[13] published by the Dominion Bureau of Statistics are for owned buildings and land only. To get estimates of these items for all farms the figures of the Bureau were multiplied by the ratio of all farm land to that operated by owners (see Table 4). Possible biases introduced by this procedure have been discussed in the preceding section.

Table 4.- Percentage of Farm Land Operated by Owner, Canada, 1926-1957

Year	Per cent	Year	Per cent	Year	Per cent	Year	Per cent
1921	* 85.4	1931	* 77.0	1941	* 70.3	1951	* 74.5
-	-	1932	76.3	1942	70.7	1952	74.4
-	-	1933	75.7	1943	71.1	1953	74.3
-	-	1934	75.0	1944	71.6	1954	74.3
-	-	1935	74.3	1945	72.0	1955	74.2
1926	81.2	1936	73.7	1946	72.4	1956	* 74.1
1927	80.4	1937	73.0	1947	72.8	1957	74.0
1928	79.5	1938	72.3	1948	73.2		
1929	78.7	1939	71.6	1949	73.7		
1930	77.8	1940	71.0	1950	74.1		

SOURCE: Canada, Department of Trade and Commerce, D.B.S. Ottawa; census years (*): Census of Canada, 1956, Vol. II (Agriculture), Canada, table 1; other years: interpolated (1957 extrapolated).

Repairs and Depreciation.- The yearly totals of the cost estimates of building repairs and depreciation pertaining to all farms were divided by the price index numbers of building materials used by farmers, to obtain estimates of these inputs at base period prices.

13 Insofar as taxes are unrelated to short-run output it can be argued that they should be excluded from the total input measure. Because of the practical difficulty of separating the relevant input part of taxes and by reasons of its relatively minor importance, and also for comparability, all real estate taxes were included.

Taxes.- The yearly taxes pertaining to all farms were divided by the index numbers of property taxes to get estimates of the weighted annual tax payments.

Supplementary Machinery Inputs

Repairs and Depreciation.- The yearly total costs of machinery repairs and depreciation were divided by the price index numbers of machinery used by farmers to get estimates of these costs at base period prices.

Other.- The cost of fuel, lubricants, tires, tubes, labor for repairs and insurance were totalled for tractors, trucks, combines and automobiles (only in the amount incurred by farm business). For each year this total was divided by the price index number of gasoline, oil and grease to get estimates of these costs at base period prices.

Other Inputs

Feed and Seed.- The feed and seed that are home-produced and the inter-farm transfers are not included in the sales figures of farm products published by the Dominion Bureau of Statistics. This portion of these items can therefore be ignored on the input side also. Only the feed and seed which were bought beyond the inter-farm transfers and thus either became recorded as a sale on the output side or had been imported from outside the industry, need be entered as an input.

Considering that seed is only a small portion of the total of feed and seed going through commercial channels, the annual estimates were divided by the price index numbers of feed to get estimates of this combination of inputs at base period prices.

Fertilizer.- The fertilizer costs were divided by the price index numbers of fertilizer used by farmers to get estimates of the fertilizer input at base period prices.

Electric Power.- The annual costs of this input were not recorded until 1941 and its price index did not become available until 1949. Since this input would be excluded from the entire aggregate quantity index as long as price index numbers were missing for the weight period employed, the index was extended with unpublished estimates till 1941 and it was assumed that no price changes took place between 1935 and 1941. Although the price index numbers for the 1935-49 period are decidedly rough, it was felt that the resulting error would be less than the errors resulting from the deletion of electricity from the aggregate input indexes based on the 1935-39, 1940-44 and 1945-49 weight periods.

The annual electricity costs were divided by the price index numbers of electricity to get estimates of the electricity input at base period prices.

Miscellaneous.- The annual estimates of the categories "Fruit and Vegetable Supplies" (pesticides, containers and nursery stock) and "Miscellaneous" (veterinary expenses, binder twine, irrigation charges, fence repairs, rope, salt, hardware, artificial insemination charges, purebred livestock registration fees and livestock purchases) were added and the totals divided by the price index numbers of hardware used by farmers to get estimates of this mixed category at base period prices.

Farm Outputs

Farm price index numbers, the appropriate deflators for the values of farm products, are available for most farm products, but only since 1935. For the years 1926 to 1935 wholesale price index numbers of "field products" and "animal products" are published.

For the purpose of obtaining continuous farm output index numbers for the years 1926 to 1957, two series of aggregate output values at constant prices were determined: one for the years 1926 to 1957, using wholesale price indexes; and another for the years 1935 to 1957, using farm price indexes wherever possible.

One may wonder to what extent the quantity index numbers for the years 1926 to 1934 (i.e. the one based on wholesale prices) would differ from quantity index numbers based on farm prices, had it been possible to determine them for those years. The comparability would, of course, depend on the manner in which both the wholesale prices and farm prices of agricultural products change. If they change in the same proportion from year to year their index numbers (using the same base period) would be equal, and it would be immaterial whether the wholesale price index or the farm price index were used. Farm prices are commonly more subject to changes in the market conditions than wholesale prices, however, and particularly for the 1926-1935 period, during which a serious economic depression occurred, one would expect the two price indexes to deviate. A comparison with figures for the United States may serve as an illustration.

Table 5 shows that for the years 1927 to 1930 the relationship

between farm and wholesale prices of agricultural products remained about constant. In 1931 prices dropped more on the farm than on the wholesale level. Both indexes changed in the same proportion between 1931 and 1932, but from then on farm prices climbed faster. By 1936 and 1937 the relationship prevailing in 1930 was reached again.

Table 5.- Indexes (1910-1914 = 100) of Prices Received by Farmers and Wholesale Prices of Farm Products; and Prices Received by Farmers as a Percentage of Wholesale Prices of Farm Products, U.S.A., 1926-1939.

Year	Prices Received by Farmers (a)	Wholesale Prices of Farm Products (b)	Prices Received as a Percentage of Wholesale Prices
1926	145	140	103.6
1927	140	139	100.7
1928	148	148	100.0
1929	148	147	100.7
1930	125	124	100.8
1931	87	91	95.6
1932	65	68	95.6
1933	70	72	97.2
1934	90	92	97.8
1935	109	111	98.2
1936	114	113	100.9
1937	122	121	100.8
1938	97	96	101.0
1939	95	92	103.3

SOURCES: United States Department of Agriculture, Washington, Govt. Printing Office:
(a) Agricultural Statistics, 1954, p. 428;
(b) Agricultural Statistics, 1952, p. 683.

These discrepancies between the changes in farm and wholesale prices of agricultural products appear moderate, which may be ascribed to price stabilizing policies. In Canada, where such policies were notably lacking and the prices of some major agricultural products

there depended so much on conditions in foreign markets, the discrepancies were probably much more pronounced. But without more information concerning the movements of farm and wholesale prices in Canada, there is no basis for adjusting the quantity index numbers for the years 1926 to 1934 (based on wholesale prices) to bring them in line with the quantity index numbers based on farm prices. The two indexes in this study were simply linked to provide a continuous series from 1926 to 1957.

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It should be noted that in this study the intermediate products which entered commercial channels (i.e. handled by a third party) to become inputs in another sector of the industry were not deducted from the cash sales -- although deduction is customarily made to avoid "double counting". Important in this respect are (1) cattle and calves raised in the Prairie Provinces and sold as feeder cattle to farmers elsewhere in the country, and (2) feed grains produced by one sector and used as an input by another.

Apart from the fact that estimates of the values of these intermediate products are missing for the years before 1935, the effects of including them on the output side is offset in the productivity ratio by their inclusion also on the input side. The output index by itself, however, shows discrepancies with an index for which "double counting" has been avoided. [14]

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14 Cf. Canada, Department of Trade and Commerce, D.B.S., Index of Farm Production, 1958.

Should the productivity study of one industry be part of a productivity study pertaining to the whole economy, the elimination of these intra-industry intermediate products is a condition to make the productivity for the whole economy equal the sum of the weighted industrial productivities. [15] In such studies it would also be necessary to eliminate from the output of each industry the value of the inter-industry intermediate products, i.e. the cost of materials and services imported from outside the industry and used in its production process. The resulting output value is called "gross added value". [16]

As for the present study, it is more likely that the productivity analyses for Canadian agriculture will be followed by similar studies pertaining to regional sections of the industry. As long as the intra-industry intermediate products are intermediate also for the region they can be eliminated on both the national and regional levels. But a substantial part of the intermediate products for the industry as a whole are end-products for the regions. The feed grains and feeder cattle mentioned above are examples of this kind. It certainly would be wrong to delete these items from the outputs in regional productivity analyses. It is necessary then to include the same items in the calculation of the national productivity estimates to make them equal to

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15 Cf. Ruttan, V. W., "Agricultural and Nonagricultural Growth in Output per Unit of Input", Journal of Farm Economics, Vol. 39, No. 5, Dec. 1957, p. 1567; Kendrick, J. W., Productivity Trends: Capital and Labor, Occasional Paper 53, National Bureau of Economic Research, Inc., New York, 1956, pp. 3 and 4.

16 For a discussion of terms, see: United Nations, Agricultural Sector Accounts and Tables, a Handbook of Definitions and Methods, E.C.E.-F.A.O. Agriculture Division, Agri-113, Geneva, Dec. 1956.

the sum of the weighted regional estimates.

The gross added value approach must be followed, of course, if the objective is to determine the returns to capital invested, the entrepreneur and labor.[17] The net added value of output is used if one wants to know the returns to the entrepreneur and labor only.[18] In this study the objective is to determine the changes in the returns to all inputs, and the values of the inter-industry intermediate products and depreciation of the capital stock, therefore, are also not deducted from the output value.

Farm Outputs at Wholesale Prices, 1926-1957

Field Products.- Annual total income from field crops includes the cash income from wheat, oats, barley, rye, flaxseed, potatoes, vegetables and other crops as well as Canadian Wheat Board payments, plus income in kind from fruits, vegetables, wool and cereal products (valued at the market price the farmer would have received), plus or minus inventory changes of grains. The annual totals were divided by the Canadian wholesale price index numbers of field products to get estimates of this class at base period prices.

Animal Products.- Total income from livestock consists of the cash income from cattle, calves, hogs, sheep, lambs, dairy products, poultry,

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17 Cf. Gutman, G. O., "Investment and Production in Australian Agriculture"; Review of Marketing and Agricultural Economics, Department of Agriculture, N.S.W., Australia, Dec. 1955, p. 237.

18 In addition to the intra and inter-industry intermediate products the cost of depreciation is also deducted from the output value.

eggs and other livestock and products, plus income in kind from dairy products, poultry, eggs and meat (valued at farm prices), plus or minus changes in the livestock inventory. The yearly totals were divided by the Canadian wholesale price index numbers of animal products to get estimates of this class at base period prices.

Forest Products.- For each year the cash income from the sale of forest and maple products plus the income in kind from forest products, honey and maple products (the last two items are published in one figure) was divided by the Canadian wholesale price index numbers of lumber and timber to get estimates of this class at base period prices.

House Rent.- Annual house rents were divided by an equally weighted combination of the price indexes of building materials and of tax and interest rates to get this class at base period prices.

Farm Outputs at Farm Prices,[19] 1935-1957

Field Products.- The total output of field crops is made up of the income at constant farm prices from the following products:

Grains.- This group includes the cash income from wheat, oats, barley, rye, flaxseed, corn and Canadian Wheat Board payments, as well as income in kind[20] from cereal products, plus or minus inventory changes of grains. Current total annual figures were divided by the farm price index of grains.

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19 Farm prices are not available for (1) miscellaneous (field products), (2) wool, (3) forest products, and (4) house rent.

20 All incomes in kind are valued at the market prices the farmer would have received had he sold the products.

Potatoes.- Annual totals of cash income and income in kind from potatoes were divided by the farm price index numbers of potatoes.

Fruits.- Annual totals of cash income and income in kind from home used fruits and greenhouse products were divided by the farm price index numbers of fruits.

Vegetables.- Annual totals of cash income and income in kind from vegetables were divided by the farm price index numbers of vegetables.

Tobacco.- Annual tobacco cash sales were divided by the farm price index numbers of tobacco.

Sugar Beets.- Annual cash sales of sugar beets were divided by the farm price index numbers of sugar beets.

Clover and Grass Seed.- Annual cash sales of these products were divided by the price index numbers of forage seed.

Hay and Clover.- Annual cash sales of hay and clover were divided by the farm price index numbers of tame hay.

Miscellaneous.- Annual totals of the cash income from the sale of fibre flax and the "Miscellaneous" estimates of the Dominion Bureau of Statistics were divided by the Canadian general wholesale price index numbers.

Animal Products.- Total output of livestock includes the income at constant farm prices from the following commodities:

Cattle, Hogs and Sheep.- Annual totals of cash sales of cattle and calves, hogs, sheep and lambs, and horses, plus income in

kind from meat, plus or minus changes in the livestock inventory were divided by the farm price index numbers of livestock.

Dairy Products.- Annual totals of cash sales of milk, cream and butter, plus income in kind from fluid milk, butter and cheese were divided by the farm price index numbers of dairy products.

Poultry.- Annual totals of the cash sales of and incomes in kind from poultry and eggs were divided by the combined farm price index numbers of poultry and eggs.

Wool.- Annual totals of the cash sales of and income in kind from wool were divided by the Canadian wholesale price index of domestic wool.

Fur.- Annual fur cash sales were divided by the index numbers of prices paid to producers.

Forest Products.- For each year totals of cash income and income in kind from firewood, fence rails, fence posts and logs for lumber were divided by wholesale price index numbers of lumber and timber.

Honey and Maple Products.- For each year cash value of sales and perquisites of maple products and honey were divided by the index numbers of prices paid to producers.

House Rent.- As under d, previous section.

Discussion

It is not the purpose of this study to describe and interpret fully the relative changes over time in the input and output structure of Canadian agriculture. Important as these changes may be the discussion must be restricted, for the sake of brevity, to the deviations

between the six indexes and the differences between the input and output indexes. The total input and total output indexes have been depicted graphically to facilitate the discussion.[21]

Chart 3 (see also Table 27), which depicts the total input indexes, shows that for the first 15 years the six series correspond fairly closely. The widest divergence occurred in the years 1930, 1931 and 1932, when the Paasche index numbers were between two and three points above the index numbers of the constant weight formula with the 1945-49 weight period. During this 15-year period no particular index consistently displays the highest or the lowest index numbers. In a few instances, indeed, the same index has for some years the lowest and for other years the highest index numbers of the group.

After 1941 the pattern becomes more regular. The numbers of the constant weight index with the 1935-39 weight period are for the last 17 years consistently the highest, and the index with the 1945-49 weight period gives for most of these years the lowest index numbers. It should be noted that neither the index numbers based on the most recent (i.e. 1950-54) weight period, nor the true Paasche index numbers form unequivocally the low limit of the array of computed index numbers.

It is also after 1941 that the indexes begin to diverge. The range increases gradually from 2.5 points in 1941 to 23.8 points in 1957. The cluster of index numbers based on the 1945-49 and 1950-54 weight periods, and the Paasche index numbers form the low limit. The

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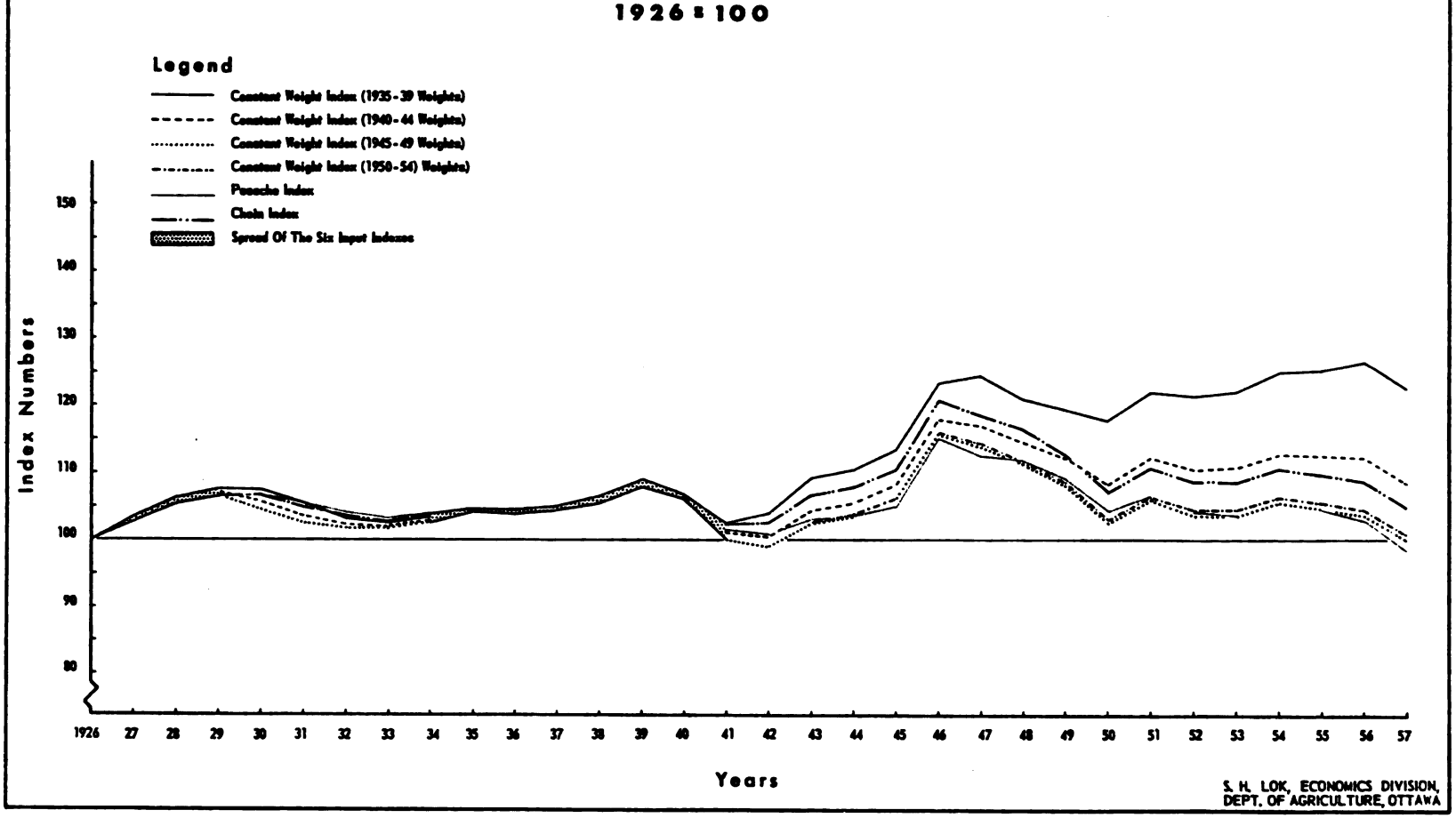
21 For the construction of these indexes see Tables 16 to 33, Appendix III.

Chart 3– Total Input Indexes For Canadian Agriculture, Based On (1) Constant Weight (Weight Periods: 1935-39, 1940-44, 1945-49, And 1950-54), (2) Paasche, And (3) Chain Index Formulas, 1926-1957



index with the 1940-44 weight period and the chain index occupy an intermediate position, although they stay closer to the low limit after 1946. At that time the index with the 1935-39 weight period begins to depart noticeably from the others. It even shows a slight upward trend in contrast to the downward trend of the other indexes determined.

The divergence of the input indexes clearly shows the limitation of aggregate index numbers for a long period, say 20 or 30 years, when prices and quantities change considerably. [22]

. . .

For the purpose of determining productivity ratios the divergence between the various indexes would have been of little concern if the output indexes were to show the same relationship among each other as happens to be the case among the input indexes. Although some aspects are shared by both sets of indexes, there are also significant differences.

For the first 10 years all six output indexes (see Chart 4 and Table 38) fall within a range which on the average is just over two points, and at most 3.9 points. As with the input indexes the low

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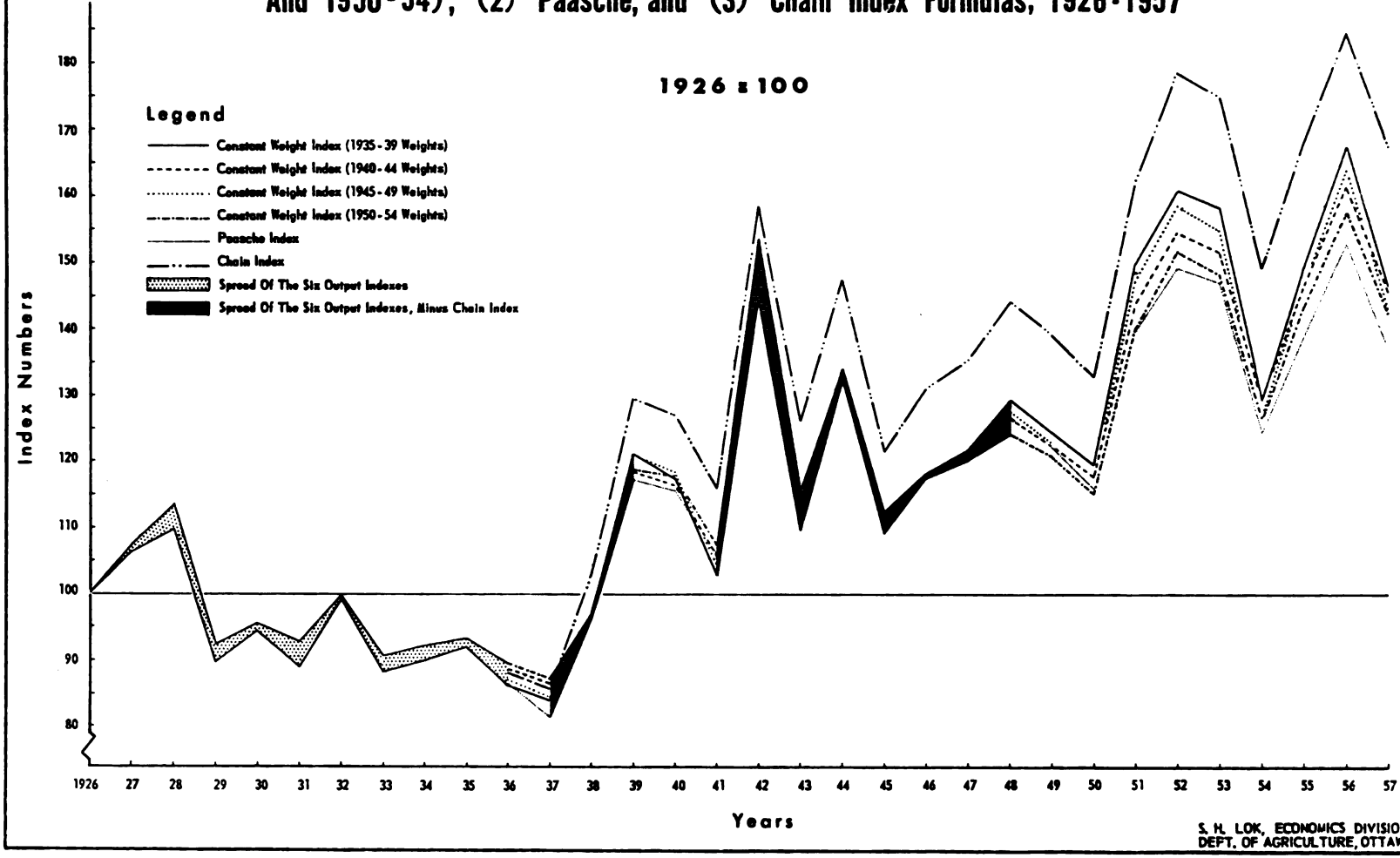
22 Since a similar divergence can be expected for aggregate price indexes, the shift of weight period for the D.B.S. price index "Commodities and Services Used by Farmers" from 1938 (the present weight period, although modifications have been made in 1948 to approach the post-war combination of inputs) to a more recent period is likely to produce an index which shows less of a rise over the last 20 years than does the present one.

Chart 4. Total Output Indexes (Including Intermediate Products) For Canadian Agriculture, Based On (1) Constant Weight (Weight Periods: 1935-39, 1940-44, 1945-49, And 1950-54), (2) Paasche, and (3) Chain Index Formulas, 1926-1957



values over the last 10 years of the series include the index numbers based on the Paasche and the 1950-54 weight period formulas.

The high limit marks the essential difference between the patterns of the two sets of index numbers, and this will greatly affect the range of productivity ratios. For the outputs the chain index gives the highest values in the series, and not the 1935-39 constant weight period index as with the inputs. It is only since 1947 that the latter gives the highest value of the constant weight indexes. The index based on 1950-54 weights is the lowest of the four.

Although in some years during the 1950's the values of the constant weight indexes are as much as 10 points apart, they correspond throughout the time series much more closely than is the case with the inputs.

V. INDEXES OF OVER-ALL PRODUCTIVITY, REAL NET RETURN PER FARM, AND ESTIMATES OF REAL REALIZED AND TOTAL GROSS RETURNS

Indexes of Over-all Productivity

The ratio of the index numbers of total output to total input gives — within the limitations of the unavoidable assumptions discussed in chapter II — an index which indicates the changes in over-all productive capacity of inputs (including weather and other extraneous but relevant factors).

For each productivity index the output and input indexes based on the same index number formula were used, because each formula conveys its own particular meaning to the index numbers. The constant weight formulas aggregate outputs in terms of consumers' satisfaction of the weight period and inputs in terms of productive capacity of the weight period. The ratio of the two indexes for a given year thus indicates the difference in over-all productivity, had tastes of the weight period prevailed in the given year. In other words, the input-output relationship of the weight period is extended to other years in the series. Unnecessary confusion would arise if one were to use an input-output relationship whose inputs referred to techniques of one period, but whose outputs referred to consumers' satisfaction of another period.

The incongruity of mixing fixed weight, Paasche, and chain output and input indexes to obtain productivity indexes is even more pronounced. Each of these indexes has its own limitations and usefulness. Ratios of which one component, for instance, were chain index numbers (which reflect year to year changes) and the other Paasche index numbers (which reflect changes between given and base year), would have little meaning.

The productivity indexes based on the six sets of output and input indexes determined in the previous chapter are presented in Table 6, and are graphically depicted in Chart 5. The discrepancies between the output and between the input indexes are not offset in the productivity ratios, because the discrepancies between the indexes and even their ordering in each set are different.

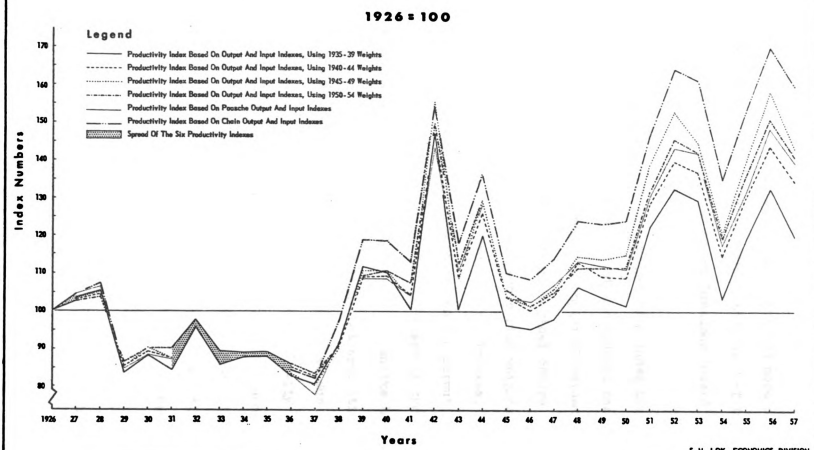
The productivity index based on the chain index formula, which since 1937 gave the highest output index numbers and intermediate input index values (the values were in the bottom half of the range during the last 10 years), forms the high limit for the years 1937 to 1957. From 1941 on the productivity index based on the 1935-39 weight period provides the low limit, which is partly explained by (1) the upward divergence and marked departure of its input index from the other input indexes determined since that date, and (2) the closer concurrence of its output index with other fixed weight output indexes and the Paasche output index.

The spread between the productivity indexes is relatively small until 1939, but the difference of 10 points in that year gradually

Table 6.- Indexes of Over-all Productivity (1926 = 100), Based on (1) Constant Weight (Weight Periods: 1935-39, 1940-44, 1945-49, and 1950-54), (2) Paasche and (3) Chain Output and Input Indexes, Canadian Agriculture, 1926-1957

Year	Constant Weight: Weight Period				Paasche	Chain
	1935-39	1940-44	1945-49	1950-54		
1926	100.0	100.0	100.0	100.0	100.0	100.0
1927	103.7	103.1	103.3	102.8	104.8	104.7
1928	105.6	104.6	105.1	103.8	106.6	107.6
1929	83.8	85.4	85.1	86.7	84.4	85.3
1930	88.3	89.4	90.5	90.3	88.6	89.8
1931	84.4	87.8	87.9	90.3	87.6	87.6
1932	96.3	97.3	97.6	97.9	95.9	96.0
1933	86.0	88.1	87.6	89.3	85.9	87.1
1934	88.0	89.0	88.8	89.4	87.9	88.8
1935	88.1	88.9	88.5	89.2	88.3	89.1
1936	83.0	85.2	83.4	86.2	83.2	84.6
1937	80.4	82.8	80.3	83.4	77.9	82.2
1938	91.6	91.0	90.4	90.8	91.9	97.3
1939	111.8	109.0	111.0	109.4	108.6	119.0
1940	110.2	109.3	111.0	111.0	108.6	118.8
1941	100.3	104.7	104.1	107.5	104.3	113.1
1942	147.5	147.3	155.3	149.8	143.3	154.2
1943	100.5	109.1	108.9	112.7	110.9	118.1
1944	120.2	126.2	129.4	129.4	128.6	136.4
1945	96.6	103.8	103.9	105.8	103.8	110.1
1946	95.5	100.2	101.6	101.6	102.5	108.4
1947	98.2	104.1	106.0	105.1	107.1	114.0
1948	106.8	110.3	114.7	111.3	113.2	124.0
1949	104.0	109.2	113.8	111.5	112.1	123.2
1950	101.5	108.9	114.8	111.7	111.2	124.0
1951	122.8	128.4	138.9	131.6	130.3	146.5
1952	132.6	139.8	152.7	145.3	143.1	164.0
1953	129.5	136.8	149.7	142.0	141.9	161.0
1954	103.4	114.6	120.5	119.2	117.6	134.9
1955	119.4	130.1	139.9	135.9	131.7	153.1
1956	132.5	143.8	158.0	150.6	148.2	169.6
1957	119.8	134.2	143.0	140.9	139.1	159.1

Chart 5-- Over-all Productivity Indexes For Canadian Agriculture, Based On (1) Constant Weight (Weight Periods: 1935-39, 1940-44, 1945-49, And 1950-54), (2) Paasche, And (3) Chain Output And Input Indexes, 1926-1957



S. H. LOK, ECONOMICS DIVISION, DEPT. OF AGRICULTURE, OTTAWA

increases to 39.3 points in 1957. The values based on the Paasche and 1940-44, 1945-49, and 1950-54 constant weight index numbers more or less cluster in between the outer limits over the latter half of the series. Yet among these indexes also, the spread broadens toward the end of the series.

It should be noted that since 1946 the productivity index based on 1945-49 weighting has higher values than any of the indexes based on the other fixed weights used. This phenomenon is empirical evidence for the fallacy of Ruttan's contention that "technological change can be bracketed by using both beginning-period and end-period weights." [1]

In spite of the erratic pattern of the productivity indexes, which largely reflect the effects of weather fluctuations on the output indexes, each shows an upward long-term trend. In some respects the changes in over-all productivity for Canadian agriculture are not unlike those for United States agriculture, but Cochrane's contention that productivity progresses in "spurts" is hardly supported.[2] It is true that due to unfavourable weather and depressed economic conditions productivity changed little during the 1930's and that it rose sharply between 1937 and 1939, but for the last 20 years an upward trend is discernable. The interruption during the years 1945 to 1949 is explained by weather conditions adverse to growth and a pronounced increase in total inputs at the end of the war which slowly tapered off over the following years.

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1 Ruttan, V. W., "Agricultural and Nonagricultural Growth in Output per Unit of Input", Journal of Farm Economics, Vol. 39, No. 5, Dec. 1957, p. 1568.

2 Cochrane, W. W., "Conceptualizing the Supply Relation in Agriculture". Journal of Farm Economics, Vol. 37, No. 5, Dec. 1955, p. 1169.

Indexes of Real Net Return Per Farm

In computing an index reflecting changes in income, the purpose for which it will be used must be kept in mind. It will be recalled that this study is an attempt to test the popular thesis that in agriculture rising productivity is detrimental to the welfare of farmers. If income is to serve in this context as an indicator of welfare it must be (1) derived from the productive effort only, i.e. excluding subsidies or transfer payments, (2) net of expenses, (3) in dollars of equal purchasing power, and (4) on a per capita or per farm basis. Whether the value of the changes in inventories should be included in the net income for each year or not is less obvious. It may be argued that the presence of unsold output does not add any money in the farmer's pocket, and hence does not add to the farmer's welfare. This reasoning does not appear valid as far as livestock is concerned. The farmer might have sold the addition to the livestock inventory and if he does not do so it means he has invested some of his income in his own farm. Also, if the sales exceed the amount produced during the year the difference should not be considered as accruing from that year's production and must be deducted from the cash income. The case is somewhat different for the additions to grain surpluses, because they usually arise from lack of acceptable markets. But even here, surpluses are sold soon or later and the revenue obtained can only be accredited to the year in which the surplus was formed.

Since government supplementary payments under the Prairie Farm Assistance Act, Prairie Farm Income Plan, and the wheat acreage

reduction payments are considered transfer payments,[3] they were excluded from the cash income.[4] The resulting value was adjusted for changes in the value of farm inventories, and operating and depreciation charges were deducted.

Elimination of changes in the general purchasing power of the dollar was accomplished by inflating (or deflating) the annual net values by an index of farm family living costs. The deflated values were then augmented by the incomes in kind, deflated by the wholesale price index of farm products,[5] to get annual net returns in dollars of constant purchasing power.[6] For the purpose of obtaining a matching

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3 For a description of these government programs, see: Shefrin, F., and Marjorie R. Cameron, Agricultural Assistance, War and Post-War, Department of Agriculture, Ottawa, 1949, pp. 17-20.

4 These payments are treated as subsidies, and not attributable to the production process, in national accounting (Canada, Department of Trade and Commerce, D.B.S., National Accounts Income and Expenditure, 1926-1956, p. 116). This viewpoint, however, does not prevail in all government circles. When acreage payments to western grain producers were announced in 1960 the Prime Minister said that the payments (between $41 and $42 million) were "... not a hand-out in any sense of the word.", but "... an amount roughly equal to the average of what the western farmer would get if a two-price system for wheat were put into effect." (House of Commons Debates, Vol. 104, No. 144, Aug. 8, 1960, Queen's Printer, Ottawa, p. 7743).

5 Income in kind was deflated separately by the wholesale price index of farm products, because its cash value is determined by farm prices and the wholesale price index of farm products is the only series that covers the years 1926 to 1957. A similar procedure was followed in the Report of the Royal Commission on Price Spreads of Food Products, Vol. II, Queen's Printer, Ottawa, 1959, p. 14.

6 The term "net return" is used in this study to distinguish it from "net income" as defined by D.B.S., which includes government supplementary payments.

set of net return indexes the index number formulas applied were the same as those used in computing total output and input indexes.

. . .

Data on number of farms are available for census years. Some adjustments needed to be made, however, in view of the changes in the census definition which occurred twice during the years from 1926 to 1957. In 1931 and 1941 (and also in 1921) tracts of land one acre or more in size producing $50 worth of agricultural products were counted as farms. For the census of 1951 and 1956, however, a farm had to be three acres or more in size, or if from one to three acres the value of its agricultural production had to be $250 or more. It was estimated that of the decline in farms between 1941 and 1951 about 55,000 resulted from the change in definition.[7] To improve comparability the census figures for 1921, 1931 and 1941 were therefore reduced by this amount. Farms in Newfoundland, Yukon and Northwest Territories were not included, because these areas were also excluded from the income estimates. The figures for the inter-census years were obtained by interpolation and extrapolation.

Since 1946 the labor force surveys of the Dominion Bureau of Statistics provide estimates of "own account workers" and "employers" in agriculture. The totals of the annual averages of these two categories, which can be assumed to consist of farm operators, decline

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7 Canada, Department of Trade and Commerce, D.B.S., Ninth Census of Canada, 1951, Vol. X (General Review), Ottawa, 1956, p. 455.

at a faster rate than the number of farms based on census data. Only for the years 1946 to 1949 are the labor force figures higher than the figures based on the census; in 1956 the former is almost 60,000 less.

The discrepancy must be ascribed, of course, to the difference in methods and criteria used by the census and the survey. The census figures include small holdings whose operators remain outside the agricultural labor force, because most of the year they work in industries other than agriculture. The chances are much smaller that the labor force survey would count a farm operator whose farm was not included in the census.

As long as the proportion of "farms" from which the operator derives only a minor part of his total net income is about the same for all census years, the matter of definition is no cause for concern. In this study the changes in net return per farm are required, and not the actual net returns per farm.

. . .

The computation of the index of real net return per farm based on 1935-39 dollars is shown in Table 7. Since 1946 the index of real net return per farm operator has also been determined for comparison. Indexes of real net return per farm in terms of 1940-44, 1945-49, and 1950-54 dollars, and using the Paasche and chain index formulas, are set forth in Table 8. All six indexes of real net return per farm are depicted graphically in Chart 6.

Table 7.- Computation of Indexes of Net Return from Agricultural Production, Per Farm (1926-1957) and Per Farm Operator (1946-1957), Based on 1935-39 Dollars, Canada

Year	Total Net Cash Income minus Supplementary Payments (a)	Index of Farm Family Living Costs (1935-39 = 100) (b)	Income in Kind (a)	Wholesale Price Index of Farm Products (1935-39 = 100) (c)
	'000		'000	
1926	378484	121.1	239574	144.4
1927	391510	119.8	240410	138.6
1928	400398	118.5	241128	136.3
1929	171029	117.3	246069	140.8
1930	134987	113.7	226074	119.5
1931	- 46451	103.9	182360	78.9
1932	- 19135	97.8	149327	65.5
1933	- 44686	95.8	153633	69.3
1934	42311	97.9	160656	83.5
1935	71527	97.9	166109	89.2
1936	70140	98.3	174397	97.9
1937	129801	102.9	177223	117.4
1938	189832	101.9	174369	102.9
1939	252126	99.5	176992	92.6
1940	284490	108.5	175715	96.1
1941	267383	114.0	191871	106.6
1942	750380	119.0	223767	127.1
1943	513266	121.6	243174	145.4
1944	877432	122.8	247687	155.3
1945	602544	123.2	259191	166.4
1946	791052	127.1	269978	179.5
1947	833679	138.3	285037	192.2
1948	1217425	162.8	315907	232.1
1949	1098980	173.2	299179	228.7
1950	910031	177.6	295920	236.7
1951	1592067	198.6	334567	268.6
1952	1568420	210.0	345888	250.2
1953	1308066	203.6	334744	221.6
1954	698276	204.5	324569	213.6
1955	928191	203.8	328435	212.6
1956	1122929	204.5	329271	214.2
1957	724483	212.7	327435	213.6

- continued /90

Table 7.- Continued

Year	Total Net Cash Income minus Supplementary Payments in 1935-39 Dollars	Income in Kind in 1935-39 Dollars	Total Net Income minus Supplementary Payments in 1935-39 Dollars	Number of farms* (d)	Number of farm Operators (e)
	'000	'000	'000		'000
1921				656090	
1926	312538	165910	478448	664857	
1927	326803	173456	500259	666610	
1928	337889	176910	514799	668363	
1929	145805	174765	320570	670116	
1930	118722	189183	307905	671870	
1931	- 44707	231128	186421	673623	
1932	- 19565	227980	208415	674044	
1933	- 46645	221693	175048	674465	
1934	43218	192402	235620	674886	
1935	73061	186221	259282	675307	
1936	71353	178649	250002	675728	
1937	126143	150957	277100	676148	
1938	186292	169455	355747	676569	
1939	253393	191136	444529	676990	
1940	262203	182846	445049	677411	
1941	234551	179992	414543	677832	
1942	630571	176056	806627	671995	
1943	426206	167245	593451	666158	
1944	714562	159489	874051	660321	
1945	489078	155764	644842	654484	
1946	622386	150406	772792	648647	679
1947	602805	148302	751107	642809	664
1948	747804	136108	883912	636972	669
1949	634515	130817	765332	631135	663
1950	512405	125019	637424	625298	614
1951	801645	124560	926205	619461	597
1952	746867	138245	885112	610090	548
1953	642468	151058	793526	600719	552
1954	341455	151952	493407	591348	572
1955	455442	154485	609927	581977	542
1956	549110	153721	702831	572606	513
1957	340612	153294	493906	563235	497

- continued /91

Table 7.- Continued

Year	Net Return (i.e. Total Net Income minus Supplementary Payments) in 1935-39 Dollars		Index of Net Return (i.e. Total Net Income minus Supplementary Payments) in 1935-39 Dollars	
	Per Farm	Per Farm Operator	Per Farm	Per Farm Operator
1926	720		100.0	
1927	750		104.2	
1928	770		106.9	
1929	478		66.4	
1930	458		63.6	
1931	277		38.5	
1932	309		42.9	
1933	260		36.1	
1934	349		48.5	
1935	384		53.3	
1936	370		51.4	
1937	410		56.9	
1938	526		73.1	
1939	657		91.2	
1940	657		91.2	
1941	612		85.0	
1942	1200		166.7	
1943	891		123.7	
1944	1324		183.9	
1945	985		136.8	
1946	1191	1138	165.4	165.4
1947	1168	1131	162.2	164.4
1948	1388	1321	192.8	192.0
1949	1213	1154	168.5	167.7
1950	1019	1038	141.5	150.9
1951	1495	1551	207.6	225.4
1952	1451	1615	201.5	234.7
1953	1321	1438	183.5	209.0
1954	834	863	115.8	125.4
1955	1048	1125	145.6	163.5
1956	1227	1370	170.4	199.1
1957	877	994	121.8	144.5

- continued 92

Table 7.- Continued.

SOURCES: Canada, Department of Trade and Commerce, D.B.S., Ottawa;
(a) 1926-1957: Handbook of Agricultural Statistics, Part II (Farm Income, 1926-57), Ref. Paper No. 25, rev. ed., 1958, p. 26;

(b) 1926-1952: Prices and Price Indexes, 1949-1952, p. 93, 1953-1957: Price Index Numbers of Commodities and Services Used by Farmers (3 times a year), Vol. 11, No. 1, and Vol. 14, No. 1;

(c) 1926-1951: Ibid., p. 104,
1952-1957: Prices and Price Indexes, January 1960;

(d) 1951: Ninth Census of Canada, 1951, Vol. VI (Agriculture), Part 1, p. 15, other census years: Census of Canada, 1956, Vol. II (Agriculture), pp. 1 and 8 (see text for revisions), intercensus years: interpolated (1957 extrapolated);

(e) 1946-1957: annual average of "Own account workers" and "Employers", The Labour Force, November 1945-July 1958, Ref. Paper No. 58, rev. ed., 1958, pp. 58 and 59.

* Excludes data for Newfoundland, Yukon and Northwest Territories.

From 1934 on the chain index diverges upward from the other five indexes. The largest discrepancy is in 1952 when the chain index number lies 44.6 points above the index number based on 1935-39 constant weights, which in that year is the second highest.

The indexes based on the constant weight and Paasche formulas remain on the whole relatively close throughout the time series. Comparison of the index numbers based on constant weights indicates that until 1941 the lowest index numbers resulted from the 1935-39 and the highest from the 1945-49 constant weight formulas. After 1941 the order is reversed, constant 1935-39 prices give the highest and constant 1945-49 prices give the lowest of the four sets of constant

Table 8.- Indexes of Real Net Return Per Farm, Based on (1) Constant Weight (Weight Periods: 1940-44, 1945-49, and 1950-54), (2) Paasche and (3) Chain Index Formulas, Canada, 1926-1957

Year	Constant Weight			Paasche	Chain
	1940-44	1945-49	1950-54		
1926	100.0	100.0	100.0	100.0	100.0
1927	104.3	104.2	104.3	104.3	104.2
1928	107.0	106.9	107.0	107.0	106.9
1929	67.5	70.8	68.9	68.9	68.3
1930	64.9	69.4	66.8	64.5	66.3
1931	41.0	49.9	44.8	29.4	41.4
1932	45.3	53.7	48.9	31.0	48.6
1933	38.5	47.1	42.2	25.9	37.3
1934	50.2	56.1	52.7	45.0	59.6
1935	54.8	60.0	57.0	51.5	66.5
1936	52.8	57.7	54.9	51.3	64.0
1937	57.8	60.7	59.1	58.5	70.8
1938	73.8	76.2	74.8	73.2	90.0
1939	91.8	93.7	92.7	90.7	112.4
1940	91.7	93.2	92.4	90.6	112.6
1941	85.5	87.5	86.3	84.5	104.6
1942	165.2	159.6	162.9	165.4	208.2
1943	123.2	121.1	122.3	122.3	155.1
1944	182.9	174.9	179.5	176.6	227.7
1945	135.9	132.0	134.3	132.4	171.9
1946	163.7	157.1	160.9	156.5	204.7
1947	160.6	154.2	157.9	154.1	201.0
1948	190.1	180.3	185.9	179.0	235.0
1949	166.3	158.6	163.0	160.0	206.8
1950	140.1	134.5	137.7	135.3	175.2
1951	204.5	193.0	199.6	193.9	251.9
1952	198.8	188.7	194.5	194.7	246.1
1953	181.4	173.9	178.3	181.1	225.4
1954	115.6	114.4	115.1	115.8	143.8
1955	144.6	141.0	143.1	145.1	180.2
1956	168.9	163.2	166.5	169.5	210.8
1957	121.5	120.3	121.1	121.8	151.4

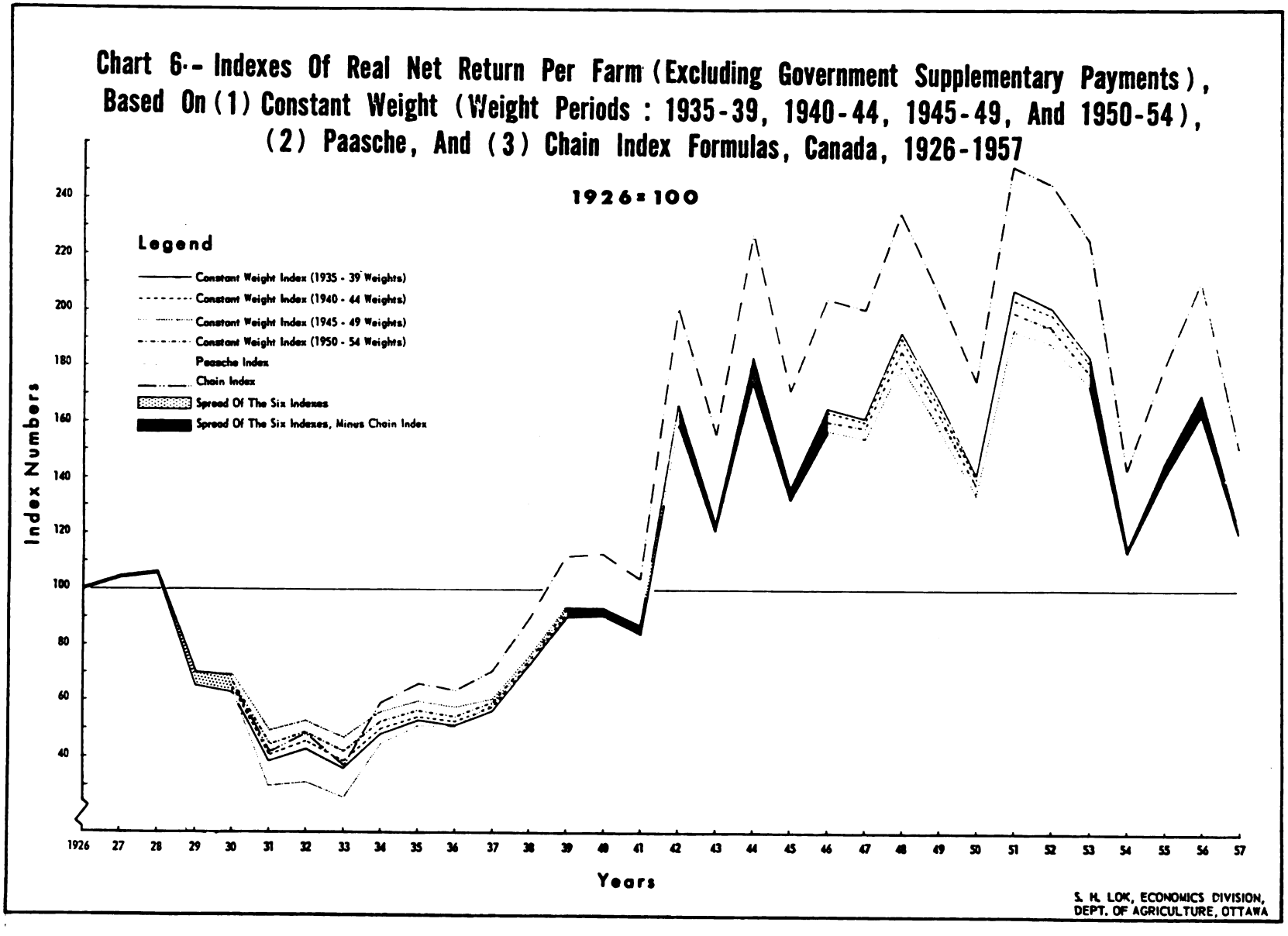
Chart 6.- Indexes Of Real Net Return Per Farm (Excluding Government Supplementary Payments), Based On (1) Constant Weight (Weight Periods : 1935-39, 1940-44, 1945-49, And 1950-54), (2) Paasche, And (3) Chain Index Formulas, Canada, 1926-1957
1926=100
Legend
Constant Weight Index (1935 - 39 Weights)
Constant Weight Index (1940 - 44 Weights)
Constant Weight Index (1945 - 49 Weights)
Constant Weight Index (1950 - 54 Weights)
Paasche Index
Chain Index
Spread Of The Six Indexes
Spread Of The Six Indexes, Minus Chain Index
Index Numbers
240
220
200
180
160
140
120
100
80
60
40
1926 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57
Years
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weight index numbers.

The annual changes of all six indexes are in the same direction. Real net return per farm dropped sharply from 1928 till it reached the lowest level in 1933. After 1933 the income situation improved, but it was not until 1942 that it passed the base year value. In spite of the annual fluctuations, a slight upward trend is discernible between 1942 and 1953. Over the last four years a decline in real net income per farm seems to have set in.

Real Realized and Total Gross Returns

The question of income adjustments for supplementary government payments and inventory changes which arose in the preceding section is even more relevant in the estimation of aggregate real gross returns. The latter are used to test the elasticity of demand; and it is, therefore, essential to get changes in gross returns based on production and market prices only. Supplementary government payments again must be deducted from the gross income.

As far as the inventory changes are concerned the changes in their values were included in the estimates of real net return per farm partly because a decline in the inventory value could not be attributed to the productive services of the year in which the decline took place, and partly because an increase in the inventory value could be looked upon as a saving or an investment under the first hypothesis, where the income estimates served as indicators of welfare.

The first reason is also valid for including the inventory

changes in the gross return estimates under the second hypothesis but the second reason only insofar as the savings or investments are voluntary. It is safe to assume that increases in grain inventories are involuntary in that the grain could not be sold at acceptable prices. The extent to which increaes in the livestock inventory indicate poor current market conditions or good future market conditions is not so easy to establish. In view of this uncertainty two sets of gross return were determined: one in which the changes in inventory values are excluded, and another in which these changes are included. The second hypothesis will, therefore, be extended to test the relationship between total output and real realized gross return (i.e. no adjustments are made for changes in inventory values), as well as the relationship between total output and real total gross return (i.e. plus or minus changes in inventory values).

As in the estimation of real net returns per farm, cash income from the sale of farm products and current values of incomes in kind were deflated (or inflated) separately. The price index used to express the income in kind in constant dollars was again the wholesale price index for farm products. But the index of farm family living costs would be inappropriate for calculating gross income estimates in constant dollars. A more suitable index is the composite price index of goods and services used by farmers in their business as well as in their households.

The annual realized and total gross returns were determined on the basis of (1) 1935-39 dollars, (2) 1940-44 dollars, (3) 1945-49

Table 9.- Computation of Realized and Total Gross Returns in 1935-39 Dollars, Canadian Agriculture, 1926-1957

Year	Cash Income from Farm Products: No Adjustment for Inventory Changes (a)	Cash Income from Farm Products: Plus or Minus Inventory Changes (a)	Composite Index Inclusive of Living Costs 1935-39 = 100 (b)	Cash Income from Farm Products in 1935-39 Dollars: No Adjustment for Inventory Changes	Cash Income from Farm Products in 1935-39 Dollars: Plus or Minus Inventory Changes
	'000	'000		'000	'000
1926	961194	963326	126.8	758039	759721
1927	940399	1003405	126.7	742225	791953
1928	1064246	1040134	125.0	851397	832107
1929	931765	804062	123.7	753246	650010
1930	641925	725753	115.7	554813	627271
1931	471913	452463	102.1	462207	443157
1932	409045	429404	95.1	430121	451529
1933	419643	386226	92.2	455144	418900
1934	503234	495930	96.5	521486	513917
1935	532583	536309	96.4	552472	556337
1936	587282	544760	98.2	598047	554745
1937	638456	627636	104.3	612134	601760
1938	649658	684705	101.8	638171	672598
1939	712076	765674	99.4	716374	770296
1940	735381	813034	107.5	684075	756311
1941	880849	828260	115.2	764626	718976
1942	1107615	1434868	126.6	874893	1133387
1943	1400243	1283463	134.7	1039527	952831
1944	1814596	1656213	137.9	1315878	1222780
1945	1664309	1425518	140.6	1184075	1013882
1946	1692543	1706045	145.0	1167271	1176583
1947	1936744	1885967	157.5	1229679	1197439
1948	2394673	2382055	183.7	1303578	1296709
1949	2412709	2314636	191.7	1258586	1207426
1950	2143786	2241731	197.3	1086562	1136204
1951	2782750	3074161	217.5	1279425	1413407
1952	2859143	3149220	229.8	1244188	1370418
1953	2786223	2870758	225.3	1236672	1274194
1954	2375427	2277451	224.2	1059512	1015812
1955	2350198	2562051	224.5	1046859	1141225
1956	2663520	2883562	230.3	1156544	1252089
1957	2591861	2453194	238.7	1085824	1027731

- continued /98

Table 9.- Continued

Year	Income in Kind in 1935-39 Dollars (c)	Realized Gross Return in 1935-39 Dollars	Total Gross Return in 1935-39 Dollars
		'000	'000
1926	165910	923949	925631
1927	173456	915681	965409
1928	176910	1028307	1009017
1929	174765	928011	824775
1930	189183	744001	816454
1931	231128	693335	674285
1932	227980	658101	679509
1933	221693	676837	640593
1934	192402	713888	706319
1935	186221	738693	742558
1936	178649	776696	733394
1937	150957	763091	752717
1938	169455	807626	842053
1939	191136	907510	961432
1940	182846	866921	939157
1941	179992	944618	898968
1942	176056	1050949	1309443
1943	167245	1206772	1120076
1944	159489	1475367	1382269
1945	155764	1339839	1169646
1946	150406	1317677	1326989
1947	148302	1377981	1345741
1948	136108	1439686	1432817
1949	130817	1389403	1338243
1950	125019	1211581	1261223
1951	124560	1403985	1537967
1952	138245	1382433	1508663
1953	151058	1387730	1425252
1954	151952	1211464	1167764
1955	154485	1201344	1295710
1956	153721	1310265	1405810
1957	153294	1239118	1181025

SOURCES: Canada, Department of Trade and Commerce, D.B.S., Ottawa
(a) 1926-1957: Handbook of Agricultural Statistics, Part II (Farm Income, 1926-57), Ref. Paper No. 25, rev. ed., 1958, p. 26;

- continued /99

Table 9.- continued

SOURCES: continued
(b) 1926-1952: Prices and Price Indexes, 1949-1952, p. 93
1953-1957: Price Index Numbers of Commodities and Services Used by Farmers (three times a year), Vol. 11, No. 1, and Vol. 14, No. 1;
(c) 1926-1957: Table 7.

dollars, and (4) 1950-54 dollars. Since the choice of weight period made little difference in the annual estimates, only the computations based on 1935-39 dollars are shown (see Table 9).

VI. TESTING OF HYPOTHESES

As will be remembered from Chapter I the following two hypotheses were to be tested for Canadian agriculture:

(1) the relationship between annual percentage changes in over-all productivity and real net return per farm is negative or zero between 1926 and 1957, and

(2) the relationship between annual percentage changes in aggregate output and real gross return is negative or zero between 1926 and 1957.

It was also pointed out in Chapter I that the relationship between the index numbers of these two sets of variables is irrelevant for the purpose of this study, and that instead the first differences or the percentage changes of successive annual values must be related to learn about possible causal connections between the two variables of each set.

First Hypothesis

The annual percentage changes in over-all productivity and real net return per farm are given in Tables 10 and 11. The changes based on 1935-39 weights are graphically depicted in Chart 7. The close correspondence of these changes already indicates lack of support for the first hypothesis advanced in this study.

The percentage changes were plotted also in a productivity-return per farm diagram, and a simple linear regression equation of the per

Table 10.- Annual Per Cent Changes in Over-all Productivity, Based on (1) Constant Weight (Weight Periods: 1935-39, 1940-44, 1945-49, and 1950-54), (2) Paasche and (3) Chain Quantity Index Numbers, Canadian Agriculture, 1926-1957

Year	Constant Weight				Paasche	Chain
	1935-39	1940-44	1945-49	1950-54		
	-		per	cent		-
1926						
1927	3.7	3.1	3.3	2.8	4.8	4.7
1928	1.8	1.5	1.7	1.0	1.7	2.8
1929	- 20.7	- 18.4	- 19.0	- 16.5	- 20.8	- 20.7
1930	5.3	4.7	6.3	4.2	5.0	5.3
1931	- 4.5	- 1.8	- 2.9	0.0	- 1.1	- 2.4
1932	14.1	10.8	11.0	8.4	9.5	9.6
1933	- 10.7	- 9.5	- 10.2	- 8.8	- 10.4	- 9.3
1934	2.3	1.0	1.4	0.1	2.3	2.0
1935	0.1	- 0.1	- 0.3	- 0.2	0.5	0.3
1936	- 5.8	- 4.2	- 5.8	- 3.4	- 5.8	- 5.1
1937	- 3.1	- 2.8	- 3.7	- 3.2	- 6.4	- 2.8
1938	13.9	9.9	12.6	8.9	18.0	18.4
1939	22.1	19.8	22.8	20.5	18.2	22.3
1940	- 1.4	0.3	0.0	1.5	0.0	- 0.2
1941	- 9.0	- 4.2	- 6.2	- 3.2	- 4.0	- 4.8
1942	47.1	40.7	49.2	39.3	37.4	36.3
1943	- 31.9	- 25.9	- 29.9	- 24.8	- 22.6	- 23.4
1944	19.6	15.7	18.8	14.8	16.0	15.5
1945	- 19.6	- 17.7	- 19.7	- 18.2	- 19.3	- 19.3
1946	- 1.1	- 3.5	- 2.2	- 4.0	- 1.3	- 1.5
1947	2.8	3.9	4.3	3.4	- 4.5	5.2
1948	8.8	6.0	8.2	5.9	5.7	8.8
1949	- 2.6	- 1.0	- 0.8	0.2	- 1.0	- 0.6
1950	- 2.4	- 0.3	0.9	0.2	- 0.8	0.6
1951	21.0	17.9	21.0	17.8	17.2	18.1
1952	8.0	8.9	9.9	10.4	9.8	11.9
1953	- 2.3	- 2.1	- 2.0	- 2.3	0.8	- 1.8
1954	- 20.2	- 16.2	- 19.5	- 16.1	- 17.1	- 16.2
1955	15.5	13.5	16.1	14.0	12.0	13.5
1956	11.0	10.5	12.9	10.8	12.5	10.8
1957	- 9.6	- 6.7	- 9.5	- 6.4	- 6.1	- 6.2

Table 11.- Annual Per Cent Changes in Real Net Return Per Farm, Based on (1) Constant Weight (Weight Periods: 1935-39, 1940-44, 1945-49, and 1950-54), (2) Paasche, and (3) Chain Index Number Formulas, Canada, 1926-1957

Year	Constant Weight*				Paasche	Chain
	1935-39	1940-44	1945-49	1950-54		
	- per cent -					
1926						
1927	4.2	4.3	4.2	4.3	4.3	4.2
1928	2.7	2.5	2.5	2.6	2.6	2.6
1929	- 37.9	- 36.9	- 33.7	- 35.6	- 35.6	- 36.1
1930	- 4.2	- 3.8	- 2.0	- 3.0	- 6.4	- 2.9
1931	- 39.5	- 36.8	- 28.1	- 33.0	- 54.4	- 37.6
1932	11.6	10.7	7.6	9.2	5.4	17.4
1933	- 15.9	- 15.3	- 12.3	- 13.8	- 16.5	- 23.3
1934	34.2	30.6	19.1	25.0	73.7	59.8
1935	10.0	9.2	6.9	8.2	14.4	11.6
1936	- 3.6	- 3.8	- 3.8	- 3.7	- 0.4	- 3.8
1937	10.8	9.4	5.1	7.5	14.0	10.6
1938	28.3	27.8	25.6	26.7	25.1	27.1
1939	24.9	24.4	23.0	23.9	23.9	24.9
1940	0.0	- 0.1	- 0.5	- 0.3	- 0.1	0.2
1941	- 6.8	- 6.8	- 6.2	- 6.6	- 6.7	- 7.1
1942	96.1	93.2	82.5	88.6	95.7	99.0
1943	- 25.7	- 25.5	- 24.1	- 24.9	- 26.1	- 25.5
1944	48.6	47.6	43.5	45.8	44.4	45.8
1945	- 25.6	- 25.2	- 24.0	- 24.7	- 25.0	- 24.0
1946	20.9	20.5	19.0	19.8	18.2	19.1
1947	- 1.9	- 1.9	- 1.8	- 1.9	- 1.5	- 1.8
1948	18.8	18.3	16.9	17.8	16.2	16.9
1949	- 12.6	- 12.5	- 12.1	- 12.3	- 10.6	- 12.0
1950	- 16.0	- 15.8	- 15.2	- 15.5	- 15.4	- 15.3
1951	46.7	46.0	43.5	44.9	43.3	43.8
1952	- 2.9	- 2.8	- 2.2	- 2.6	0.4	- 2.3
1953	- 9.0	- 8.7	- 7.9	- 8.3	- 7.0	- 8.4
1954	- 36.9	- 36.2	- 34.2	- 35.4	- 36.1	- 36.2
1955	25.7	25.1	23.3	24.3	25.3	25.3
1956	17.1	16.8	15.7	16.4	16.8	17.0
1957	- 28.5	- 28.0	- 26.3	- 27.3	- 28.1	- 28.2

* The per cent changes are not based on the index numbers but on the absolute figures.

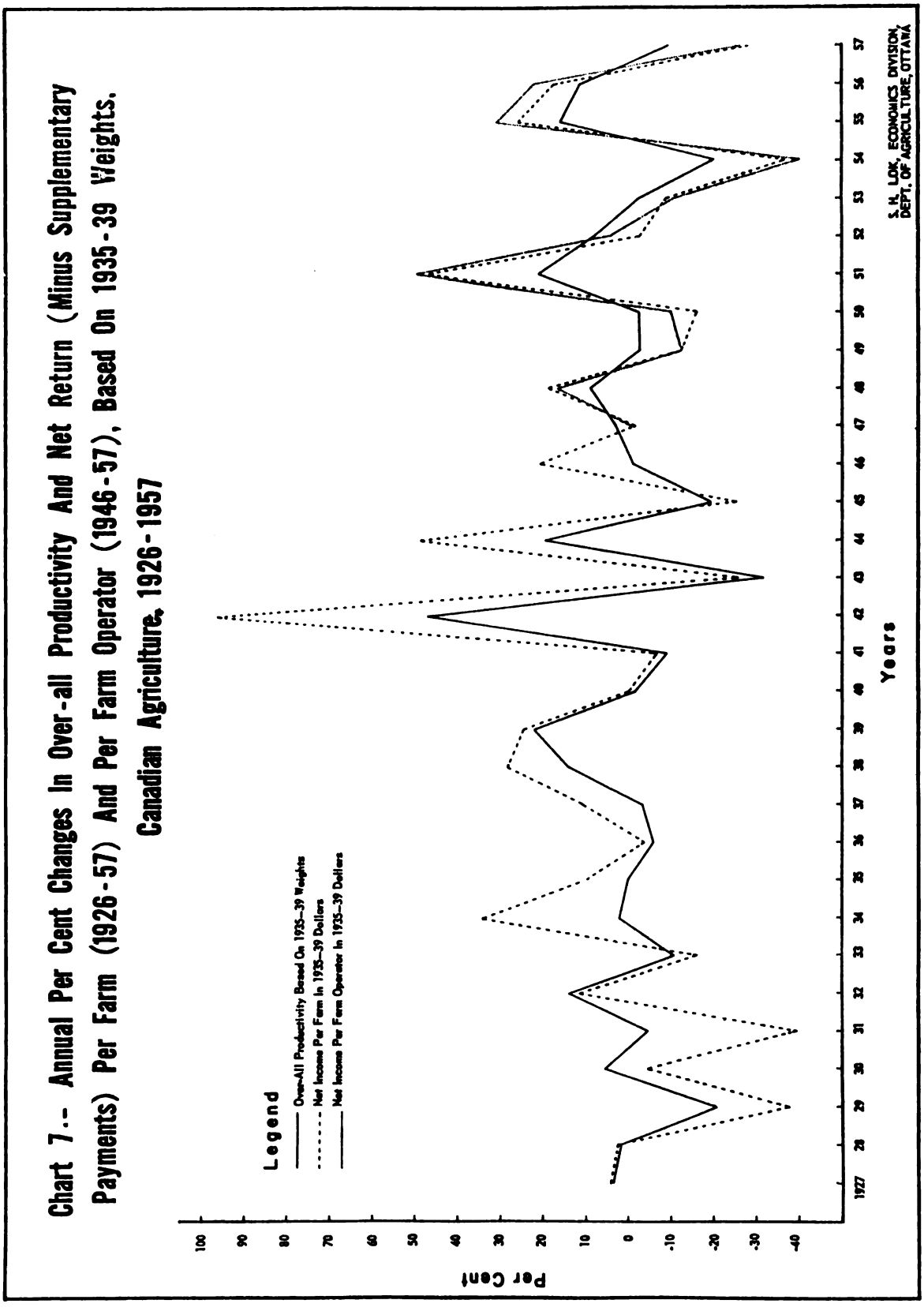


Chart 7.- Annual Per Cent Changes In Over-all Productivity And Net Return (Minus Supplementary Payments) Per Farm (1926-57) And Per Farm Operator (1946-57), Based On 1935-39 Weights. Canadian Agriculture, 1926-1957
Legend
Over-All Productivity Based On 1935–39 Weights
Net Income Per Farm In 1935–39 Dollars
Net Income Per Farm Operator In 1935–39 Dollars
Per Cent
Years
S. H. LOK, ECONOMICS DIVISION, DEPT. OF AGRICULTURE, OTTAWA

cent changes in net return per farm on the per cent changes in over-all productivity was calculated (see Chart 8). The regression equations pertaining to the six index number formulas used in this study, together with the associated standard errors of estimate and correlation coefficients are given in Table 12.

Table 12.- Linear Regression Equations of Annual Per Cent Changes in Real Net Return Per Farm and Over-all Productivity, Based on Selected Index Number Formulas, and Associated Standard Errors of Estimate (S_{yx}) and Coefficients of Correlation (r), Canadian Agriculture, 1926-1957

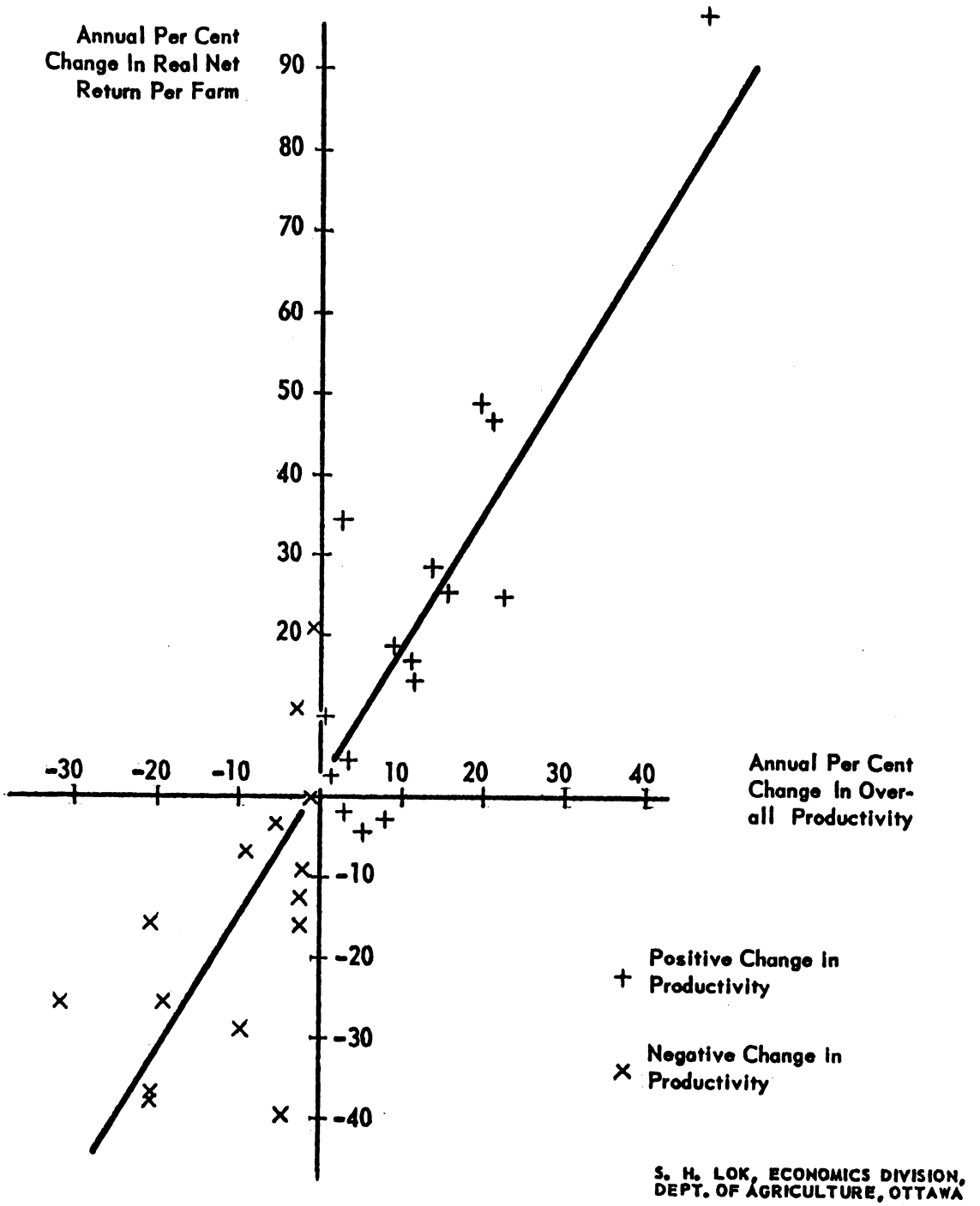
Index Number Formula	Regression Equation *	S_{yx}	r
Constant 1935-39 weights	$Y_c = 1.49 + 1.67\ X$	13.88%	0.88
Constant 1940-44 weights	$Y_c = 0.14 + 2.27\ X$	9.13%	0.95
Constant 1945-49 weights	$Y_c = 0.06 + 1.49\ X$	11.54%	0.89
Constant 1950-54 weights	$Y_c = 0.37 + 1.83\ X$	14.10%	0.86
Paasche	$Y_c = 1.42 + 2.19\ X$	17.55%	0.83
Chain	$Y_c = 0.79 + 1.90\ X$	17.59%	0.82

* Y_c is the calculated annual per cent change in net return (minus supplementary payments) per farm; X is the annual per cent change in over-all productivity.

In all six cases the regression coefficients have positive values and the coefficients of correlation are well above the value required to be significantly different from zero at the one per cent level.[1] On the basis of the data and methods used in this study the first hypothesis is not substantiated, and no evidence is provided for the belief

1 With 29 degrees of freedom the coefficient of correlation must be at least 0.456 to be significantly different from zero at the one per cent level (Cf. Snedecor, G. W., Statistical Methods, Iowa State College Press, Ames, 1959, p. 174).

Chart 8. – Relationship Between Annual Per Cent Changes in Over-all Productivity (1935-39 Weights) and Real Net Return Per Farm (1935-39 Dollars), Canadian Agriculture, 1926-1957



that in Canadian agriculture productivity and real net return per farm are inversely related. Instead, as far as Canadian agriculture is concerned, the regression equations suggest that with every per cent increase (decrease) in over-all productivity, net return per farm has increased (decreased) by about 1½ to 2 per cent.

Second Hypothesis

With the lack of support for the hypothesis that over-all productivity and real net return per farm are inversely related, the hypothesis that the aggregate demand for agricultural products is relatively inelastic also becomes questionable.

It may be true that the demand for certain farm products is inelastic, but here the question is raised whether the aggregate demand curve for all Canadian farm products is inelastic. Should the generalization be correct, it would follow that output and real gross income would be inversely related. Only through an offsetting reduction in costs and in number of farms could the relationship between the changes in over-all productivity, which appeared to follow closely the changes in aggregate output (cf. Charts 4 and 5), and real net return per farm become positive.

The annual per cent changes in real realized and real gross returns based on the four constant weight periods used in this study are presented in Table 13. The variations caused by the different weight periods are only slight.

The annual per cent changes in total output for each of the four

Table 13.- Annual Per Cent Changes in Real Realized and Real Total Gross Returns Based on the Constant Weight Periods: 1935-39, 1940-45, 1945-49 and 1950-54, Canadian Agriculture, 1926-1957

Year	Real Realized Gross Return — Weight Period				Real Total Gross Return — Weight Period			
	1935-39	1940-44	1945-49	1950-54	1935-39	1940-44	1945-49	1950-54
	- per cent -				- per cent -			
1926								
1927	- 0.9	- 0.9	- 0.7	- 0.8	4.3	4.3	4.3	4.3
1928	12.3	12.3	11.9	12.1	4.5	4.5	4.4	4.5
1929	- 9.8	- 9.7	- 9.4	- 9.6	-18.3	-18.2	-17.6	-18.0
1930	-19.8	-19.8	-18.7	-19.4	- 1.0	- 1.0	- 0.6	- 0.8
1931	- 6.8	- 6.7	- 5.3	- 6.2	-17.4	-17.3	-15.5	-16.6
1932	- 5.1	- 5.1	- 4.8	- 5.0	0.8	0.8	0.6	0.7
1933	2.8	2.8	2.4	2.7	- 5.7	- 5.7	- 5.5	- 5.6
1934	5.5	5.4	4.2	4.9	10.3	10.1	8.6	9.6
1935	3.5	3.4	3.1	3.3	5.1	5.1	4.7	4.9
1936	5.1	5.1	4.7	4.9	- 1.2	- 1.2	- 1.4	- 1.3
1937	- 1.8	- 1.8	- 2.4	- 2.0	2.6	2.6	1.7	2.3
1938	5.8	5.9	6.1	5.9	11.9	11.9	11.9	11.9
1939	12.4	12.4	12.4	12.4	14.2	14.2	14.1	14.2
1940	- 4.5	- 4.5	- 4.5	- 4.5	- 2.3	- 2.3	- 2.4	- 2.4
1941	9.0	8.9	8.5	8.8	- 4.3	- 4.3	- 4.2	- 4.2
1942	11.3	11.2	10.7	11.0	45.7	45.5	43.6	44.8
1943	14.8	14.8	14.1	14.5	-14.5	-14.4	-14.2	-14.4
1944	22.3	22.2	21.5	21.9	23.4	23.4	22.5	23.0
1945	- 9.2	- 9.2	- 9.0	- 9.1	-15.4	-15.4	-15.1	-15.3
1946	- 1.7	- 1.7	- 1.7	- 1.7	13.5	13.4	13.0	13.3
1947	4.6	4.6	4.4	4.5	1.4	1.4	1.3	1.4
1948	4.5	4.5	4.2	4.4	6.5	6.4	6.1	6.3
1949	- 3.5	- 3.5	- 3.5	- 3.5	- 6.6	- 6.6	- 6.5	- 6.6
1950	-12.8	-12.8	-12.6	-12.7	- 5.8	- 5.8	- 5.7	- 5.7
1951	15.9	15.9	15.5	15.7	21.9	21.9	21.5	21.7
1952	- 1.5	- 1.5	- 1.3	- 1.4	- 1.9	- 1.9	- 1.7	- 1.8
1953	0.4	0.4	0.6	0.5	- 5.5	- 5.5	- 5.2	- 5.4
1954	-12.7	-12.7	-12.4	-12.6	-18.1	-18.0	-17.6	-17.9
1955	- 0.8	- 0.8	- 0.8	- 0.8	11.0	10.9	10.7	10.9
1956	9.1	9.0	8.8	9.0	8.5	8.5	8.3	8.4
1957	- 5.4	- 5.4	- 5.3	- 5.4	-16.0	-16.0	-15.6	-15.8

Table 14.- Annual Per Cent Changes in Total Output, Based on the Constant Weight Periods: 1935-39, 1940-44, 1945-49 and 1950-54, Canadian Agriculture, 1926-1957

Year	Weight Period			
	1935-39	1940-44	1945-49	1950-54
	-	per	cent	-
1926				
1927	7.3	6.8	6.8	6.4
1928	4.7	3.9	4.1	3.2
1929	-20.2	-17.6	-18.4	-15.9
1930	5.1	3.2	4.3	2.4
1931	- 6.1	- 3.6	- 4.5	- 1.7
1932	11.7	9.3	10.1	7.4
1933	-11.3	- 9.6	-10.3	- 8.9
1934	3.2	1.9	2.2	0.9
1935	1.1	1.1	1.1	1.3
1936	- 6.3	- 4.2	- 5.5	- 3.4
1937	- 2.7	- 2.4	- 3.2	- 2.8
1938	15.1	11.4	14.2	10.3
1939	25.4	22.6	25.6	23.3
1940	- 3.1	- 1.7	- 2.2	- 0.8
1941	-12.4	- 8.9	-11.7	- 8.6
1942	49.1	39.8	47.1	37.8
1943	-28.4	-23.1	-27.5	-22.0
1944	20.9	17.0	20.1	16.0
1945	-17.3	-15.6	-18.0	-16.3
1946	7.2	5.3	7.1	5.0
1947	3.7	3.1	2.6	2.0
1948	5.8	3.7	5.8	3.2
1949	- 3.8	- 3.1	- 3.7	- 2.7
1950	- 3.7	- 3.8	- 4.3	- 4.7
1951	25.2	22.2	25.1	21.6
1952	7.3	7.2	7.6	8.4
1953	- 1.7	- 1.7	- 2.1	- 2.4
1954	-18.2	-14.7	-18.1	-14.5
1955	15.6	13.2	15.4	13.3
1956	12.0	10.2	11.8	10.0
1957	-12.5	- 9.8	-12.7	- 9.8

SOURCE: Table 38.

constant weight periods are derived from the total output estimates computed in Chapter IV. These four sets of figures, which are in Table 14, also compare closely.

Because in these particular cases the choice of weight period made little difference, the averages of the percentage changes of the four weight periods were used in the regression and correlation analyses. The results of these analyses are as follows:

(1) $Y_1 = -0.27 + 0.90\ X$; $r = 0.92$; and

(2) $Y_2 = 0.74 + 0.30\ X$; $r = 0.45$; where

Y_1 is the annual per cent change in real total gross return, Y_2 is the annual per cent change in real realized gross return, and X is the annual per cent change in total output.

For both real gross return measures the regression coefficients turned out positive. With the high degree of correlation under equation (1) it seems that a one per cent change in total output is associated with a change in the same direction of almost one per cent in real total gross return. Although the coefficient of correlation under equation (2) is about half as large as that under equation (1) it still is significantly different from zero at almost the one per cent level. The data and methods used in this study fail to support the second hypothesis also.

Discussion

The conclusions reached must be viewed in the light of the shortcomings of the methods and of the data used. The assumptions justifying the constant dollar method for determining changes in over-all

productivity have been discussed. They obviously put severe restrictions on the applicability of the method, and the unsolved problem of weight period choice adds an arbitrary element to the estimates of the over-all productivity index. The discrepancies between the productivity indexes based on different weight periods did not result in contradictory conclusions for this study because the annual changes in the index numbers (i.e. increases or decreases) were in the same direction for the different weight periods used. Consequently the signs of the regression coefficients were the same for each case.

All statistics used came either directly from official sources or were derived from official estimates. How reliable these estimates are is an open question. It is obvious, however, that many difficulties are involved in their compilation. Particularly in the assembly of the input data the problems are pronounced, and it would not have been possible for officials of the Dominion Bureau of Statistics to provide such a complete picture of various costs in agriculture since 1926 without a good deal of judgment and rules of thumb.

The effects on the total input index of some input estimates used in this study, about which a good deal of uncertainty exists, are no doubt considerable in view of their relative importance. Labour, for instance, is the largest single input and its annual estimates are among the least reliable. Another important input item is the wear and tear on buildings and machinery. The problems of estimating depreciation even under the simplest circumstances are well known; for the whole agricultural industry any elaborate procedure would be out of

the question. The estimates of the Dominion Bureau of Statistics are simply a certain percentage of the annual value of the capital assets involved. The estimates of inventory values themselves are, of course, subject to many errors and arbitrary guesses.

In estimating the annual incomes there is uncertainty about the cash value of incomes in kind. The estimates of the Dominion Bureau of Statistics are based on market prices the farmer would have received had he sold the products. But when income is used as a measure of welfare it might have been more appropriate to value at prices the farmer would have had to pay had he bought the products.

The need to eliminate income-stabilizing supplements from government funds has been treated in this study by excluding the supplementary payments reported by the Dominion Bureau of Statistics in its Handbook of Agricultural Statistics, Part II. The various forms of support, however, make a more complicated picture than is indicated by this procedure.

All such shortcomings must be considered in interpreting the conclusions of this study. The emphasis should not be on the relationships found but on the lack of support for the relationships stated in the hypotheses.

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Lack of evidence of a negative relationship between over-all productivity and real net return per farm should be interpreted with

caution as far as the results of research on the latter are concerned. It was pointed out that research is only one of the factors affecting over-all productivity and that variations in weather and other exogeneous factors affecting growth are largely responsible for the annual fluctuations in over-all productivity. It would be incorrect to apply the findings pertaining to over-all productivity to agricultural research simply because the latter usually contributes to it.

To separate the effects of research from the changes in over-all productivity will be a difficult, if not impossible, task. Some estimate might have been made if the effects of research were to assert themselves gradually over time by establishing a secular trend in over-all productivity. However, this approach is open to a number of objections. First, since the over-all productivity indexes based on different weight periods diverge considerably towards the end of the time series an arbitrary decision is involved in selecting the particular index or combination of indexes on which the secular trend should be based. Second, even without the two preceding problems there may be factors other than research that affect over-all productivity gradually over time. The various forms of specialization on farms and in regions, or the emigration of a certain class of farm managers out of agriculture could also fall in this category. It would be necessary, then, to separate the effects of research from the effects of other factors contributing to a rising secular trend. Third, there is the belief that technical

innovations are not adopted gradually but more likely spasmodically.[2] Fourth, it is not certain even that the adoption of technical innovations will always raise the over-all productivity ratio. If the production manager is forced through labor shortages to adopt labor saving machinery the smallest available size of which is larger than needed for the size of his farm, the ratio may well decline. And finally, if meaningful measures of changes in productivity as a result of research alone could be established, the testing of the first hypothesis would subsequently make it necessary to isolate from the changes in income the part that can be ascribed to the changes in productivity induced by research.

The inescapable conclusion is that the composite parts of the changes in over-all productivity and real net income are inextricable. Under such circumstances it is well-nigh impossible to determine the extent to which research has contributed to over-all productivity, and to what extent it has affected real net income per farm. The long-run upward trend of both over-all productivity and real net income per farm is inconsistent, however, with the belief that agricultural research is detrimental to farmers' welfare.

Lack of evidence of an inverse relationship between changes in total output and either of the gross return measures suggests an elastic aggregate demand for Canadian farm products as a whole.[3] As

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2 Cf. Schumpeter, J.A., Business Cycles, Vol. I, McGraw-Hill, New York, 1939; and Cochrane, W. W., "Conceptualizing the Supply Relation in Agriculture", Journal of Farm Economics, Vol. 37, No. 5, Dec. 1955, p. 1169.

3 This inference is supported by other research. Cf. "Contrary to Canadian beliefs in general, the evidence at hand indicates that the demand for this wheat is not highly inelastic if inelastic at all." (Gislason, C., "How Much Has the Canadian Wheat Board Cost the Canadian Farmers?", Journal of Farm Economics, Vol. 41, Aug. 1959, No. 3, p. 592).

long as this relationship holds true a high degree of productivity, regardless of the cause, would be beneficial to farmers. Actually such elasticity is not surprising since a large proportion of Canadian farm products is sold in foreign markets.[4] Weather and other conditions affecting growth are not universally good or bad, and the amount traded in the world market tends to fluctuate less than the year to year supplies in a country with such variable conditions for growth as Canada. The quantity available for export will have less effect on the farm price than if this quantity were to be sold in the home market.

One should not forget, however, that the price of wheat, the major export item of Canadian farm products, is set annually by the Canadian Wheat Board. It is possible that through the Board's policy the price of wheat has been kept within an elastic section of the total demand curve. At a time when surpluses are accumulating (see Table 15) the floor price might approximate the dividing point between an elastic and an inelastic range of the demand curve.

The presence of unsold stocks of agricultural commodities seems to add weight to the argument against technical research and rising productivity. No doubt the presence of substantial surpluses will have a depressing effect on farm prices. But the increasing productive

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4 In 1957 about 35 per cent of cash income from Canadian farm products was derived from export (Canada, Department of Trade and Commerce, D.B.S., Ottawa, Handbook of Agricultural Statistics, Part II, Farm Income, 1926-57 , Ref. Paper No. 25, rev. ed., 1958, p. 26; Department of Agriculture, Economics Division, Ottawa, Canada Trade in Agricultural Products with the United Kingdom, the United States and All Countries, 1956 and 1957, p. 13).

capacity of Canadian agriculture is not the sole reason. Much is due to the tendency of traditional foreign customers to become increasingly self-sufficient and to shift to cheaper sources of supply.

Table 15.- Carry-over at Beginning of Crop Year of Wheat, Oats, Barley, and Rye, Canadian Agriculture, 1945-1957

Crop Year	Wheat	Oats	Barley	Rye
	- thousand bushels -			
1946-47	73,600	77,492	29,937	768
1947-48	86,141	69,484	28,764	755
1948-49	77,710	47,891	31,449	904
1949-50	102,411	60,507	29,669	11,918
1950-51	112,200	44,905	20,355	6,431
1951-52	189,203	95,177	53,496	3,299
1952-53	217,178	108,358	79,504	8,774
1953-54	383,185	144,409	111,667	17,541
1954-55	618,675	125,769	145,910	22,235
1955-56	536,748	83,967	91,488	19,935
1956-57	579,574	119,106	110,948	15,713
1957-58	733,546	226,215	142,779	14,160

SOURCE: Canada, Department of Trade and Commerce, D.B.S., Ottawa, Handbook of Agricultural Statistics, Part I (Field Crops, 1908-1958), 1959, pp. 169-172.

Instead of using the so-called surpluses as evidence of too high a level of productivity and a gratuitous amount of research, it can also be argued that productivity in Canadian agriculture is too low. The word surplus is not used in the dictionary sense of "that which remains when use or need is satisfied.",[5] but in an economic sense of "that which remains at a price".[6] In a world where "... many millions

5 Webster's New Collegiate Dictionary, Thomas Allen, Toronto, 1953, p. 354.

6 Blau, G., Disposal of Agricultural Surpluses, Commodity Policy Studies, No. 5, Food and Agriculture Organization of the United Nations, Rome, June 1954, p. 3.

still go hungry, at least part of the time" [7] a surplus problem is obviously one of under-consumption, and not one of over-production. The demand is there, but it is ineffective. With increasing productivity the unit cost might be reduced far enough to cause agricultural staples to be sold in countries where food shortages exist.

It would be unrealistic indeed to seek the solution of the farm income problem in lowering agricultural productivity through the curtailment of technical innovations in the country. Such a move would not help the Canadian farmer, but his competitor.[8]

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7 United Nations, The State of Food and Agriculture, 1959, Food and Agriculture Organization, p.106.

8 Cf. "... Our ability to maintain markets in a period of increasing competition will depend to a considerable extent upon our ability to increase our efficiency of production (and marketing) and thereby to increase our competitive position in the market place." (Heisig, C. P., "Long Range Production Prospects and Problems", Journal of Farm Economics, Vol. 35, No. 5, Dec. 1953, p. 750); and "This slow response to /technical/ change is doubtless a significant reason why agricultural prosperity has lagged behind that of the rest of our economy", Pond, G. E., "Discussion", Agricultural Adjustment Problems in a Growing Economy (Heady, E. O., et al, eds.), The Iowa State College Press, Ames, 1958, p. 19.

VII. SUMMARIZING PROPOSITIONS

In this study an attempt has been made to examine the relationships between (a) the annual percentage changes in over-all productivity and real net return per farm, and (b) the annual percentage changes in total output and real gross return to farmers for Canadian agriculture for for the 1926 to 1957 period.

The principal task in testing the first relationship was to determine the changes in over-all productivity. Six indexes of over-all productivity were constructed: four using as constant weights the appropriate prices of the periods (1) 1935-39, (2) 1940-44, (3) 1945-49, and (4) 1950-54; one based on the Paasche and one based on the chain index number formula. The same weight periods and formulas were used to construct six indexes of real net return per farm.

For the second relationship changes in total output and in aggregate realized and total real gross returns were determined on the basis of the four constant weight periods only.

. . .

The following propositions contain definitions, agreements and disagreements with statements from the literature, and conclusions arising from this study. The propositions are arranged in logical order and not always in the order in which they are discussed in the text. They furnish a concise summary of the study.

1. A productivity ratio that is designed to take into account the want-satisfying capacity of all outputs resulting from a production

process and the productive capacity of all economic inputs necessary for that production process is called over-all productivity.

2. The weight period is the period whose commodity prices (in the construction of quantity indexes) or whose commodity quantities (in the construction of price indexes) are used as weights. The base period is the period in a time series whose index number has been made equal to 100.

3. Over-all productivity is an ordinal concept, and is operationally defined by the constant dollar method as the ratio of all useful outputs aggregated in weight period dollars to all economic inputs aggregated in weight period dollars.

4. In this study the annual index numbers of total useful output were divided by the corresponding index numbers of total economic input to give an index of over-all productivity with the same weight and base periods.

5. With the assumptions of competitive equilibrium in the industry and linearity between all output/input relationships, the annual changes in the over-all productivity ratios (as defined by the constant dollar method) of a production process reflect changes from the over-all productive capacity of the weight period inputs if the tastes of that period remained unchanged.

6. Weighting the inputs and the outputs with constant prices throughout a time series is necessary because for different periods a (current) dollar's worth of output represents different amounts of consumers' satisfaction, and a (current) dollar's worth of input repre-

sents different amounts of productive capacity.

7. Annual changes in the over-all productivity of an industry are caused by a variety of reasons, such as technical innovations, economies of size, enterprise and regional specialization, decline in the proportion of inefficient or efficient producers. In agriculture the changes in environmental conditions are largely responsible for the annual fluctuations in over-all productivity.

8. The constant dollar method is essentially a linear case of the theoretical production function method.

9. In terms of index number construction the use of constant prices as weights to aggregate inputs and outputs measured in different units, corresponds to the Laspeyres' method of determining quantity indexes.

10. The expression weight period bias refers to discrepancies between indexes as a result of using different weight periods.

11. For a comparison between two periods only, the use of first period weights (Laspeyres' method) will give the same results as the use of second period weights (Paasche's method) if (a) regardless of the quantity changes, the prices of the items change in the same proportion, or (b) if, regardless of the price changes, the quantities of the items change in the same proportion.

12. Mudgett's contention that the difference between the Laspeyres and Paasche index numbers "will equal zero only when $q_1 = q_0$ for all commodities involved" is incorrect; the word "only" should be deleted.

13. Mill's contention that the Laspeyres price index has a downward bias and the Paasche index an upward bias, if quantities remain

constant, is incorrect. With no change in quantities both index numbers will be the same and will equal unity.

14. Some authors incorrectly base their argument that the Laspeyres price index has an upward bias and the Paasche price index a downward bias on price-quantity relationships indicated by the demand curve.

15. The relevant price-quantity relationships to be considered in explaining weight period bias are those established over time by the points of intersection of prices and quantities pertaining to the items included in the aggregate index.

16. For two items and two periods it can be shown diagrammatically that the Laspeyres formula will result in a larger percentage change than the Paasche formula if the price-quantity relationships of the items is inverse between the two periods; if this relationship is positive the Laspeyres formula will result in a smaller percentage change than the Paasche formula.

17. The price-quantity relationship over time of an input or output does not only depend upon the item but also on the periods between which the comparison takes place.

18. L. von Bortkiewicz formally demonstrated that the unequivocal criterion determining the direction of the weight period bias is the sign of the weighted coefficient of correlation between price and quantity relatives — weighted by the beginning-period values of the items comprising the aggregate index.

19. In a time series of more than two periods weighting with beginning-period weights is an application of, but is not synonymous with the Laspeyres formula; and weighting with end-period weights is not

synonymous with the Paasche formula.

20. Some authors inadvertently apply the term Paasche to end-period weighting in time series with more than two periods.

21. Ruttan's fallacious conclusion that "the 'true' measure of technological change can be bracketed by using both beginning-period and end-period weights" is based on inappropriate use of static models, and unwarranted extension of his conclusions pertaining to a comparison between two periods to time series of several periods.

22. The aggregate index numbers of total input for Canadian agriculture based on 1935-39 constant prices are over the last 17 years of the 1926-1957 period consistently higher than those based on the weight periods 1940-44, 1945-49, and 1950-54, and on the Paasche and chain index number formulas.

23. For 1957, the year with the widest divergence in the six indexes, the aggregate index number based on 1935-39 constant prices is 13.9 points above the second highest index number (based on 1940-44 constant prices) and 23.8 points above the lowest of the six index numbers (based on the Paasche formula).

24. The aggregate index numbers of total output for Canadian agriculture from 1926 to 1957 based on the chain index number formula are since 1938 higher than those of the five other indexes determined.

25. The widest divergence between the six total output indexes is in 1956 when the chain index number is 31.9 points above the Paasche index number.

26. The index numbers based on the four constant weight periods correspond much closer for total output than for total input.

27. Over the last 11 years of the 1926-1957 period the index numbers of total output based on 1935-39 constant prices are higher than those based on the weight periods 1940-44, 1945-49, and 1950-54, and the Paasche index number formula.

28. The index numbers of over-all productivity follow closely the pattern of the index numbers of total output.

29. The index numbers of over-all productivity for Canadian agriculture from 1926-1957, based on the chain index number formula are since 1937 higher than those based on the four constant weight periods and on the Paasche formula.

30. From 1941 on the index numbers of over-all productivity based on constant 1935-39 prices are the lowest of the six indexes, which is explained partly by (1) the upward divergence and marked departure of its total input index from the other total input indexes determined since that date, and (2) the closer concurrence of its output index with other fixed weight output indexes and the Paasche output index.

31. The spread between the six indexes of over-all productivity is 10 points in 1939; it gradually increases to 39.3 points in 1957. The spread between the four constant weight index numbers in 1957 is 23.2 points.

32. The index numbers of real net return per farm based on the four constant weight periods and on the Paasche formula correspond closely.

33. The chain index of real net return per farm begins to diverge upward from the other five indexes in 1934; the widest divergence between the chain and the next highest index is in 1951 with 47.4 points.

34. The discrepancies caused by different weight periods and different index number formulas are much less marked in the year to year per cent changes than in the indexes.

35. The hypothesis that the relationship between annual percentage changes in over-all productivity and real net return per farm is negative or zero for Canadian agriculture is not supported for the years 1926-to 1957.

36. The hypothesis that the relationship between annual percentage changes in aggregate output and real gross return is negative or zero for Canadian agriculture is not supported for the years 1926 to 1957.

37. The belief that the aggregate demand for Canadian farm products is relatively inelastic is not supported for the years 1926 to 1957.

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APPENDIX 1

L. von Bortkiewicz demonstrated formally that the L index number will be higher than the P index number if the weighted coefficient of correlation between the price and quantity relatives is negative; the L index number will be lower than the P index number if this coefficient is positive.

If the diagrams customarily used in production economics depict the direction of the changes in prices and quantities as they actually occur between two periods, the von Bortkiewicz conclusion can be reached also diagrammatically. The following two illustrations deal with:

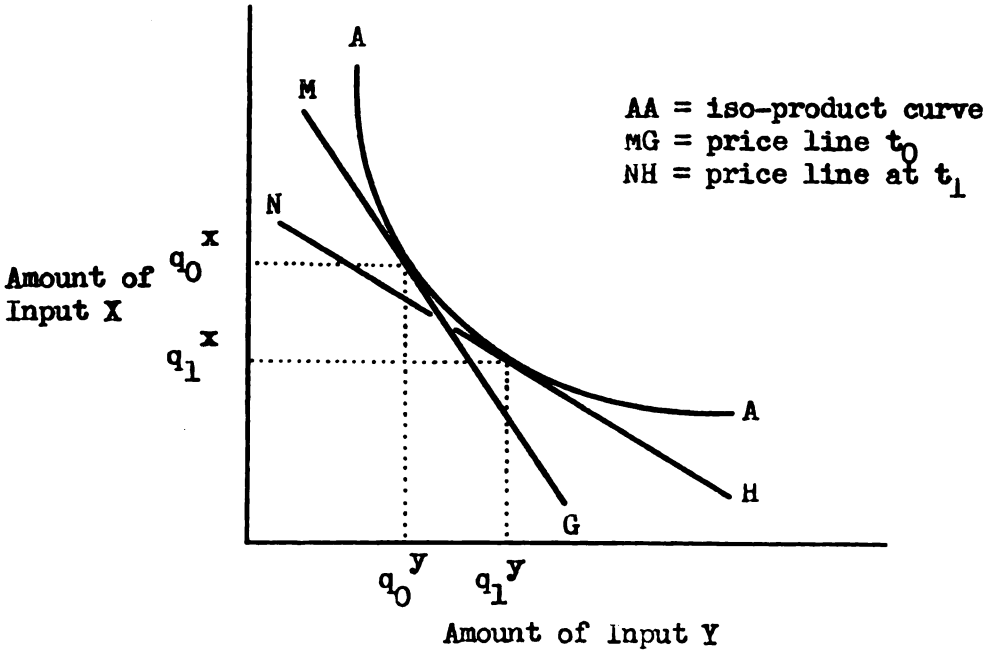
1. aggregate quantity indexes of factors of production and consumers' goods, both as inputs;
2. aggregate quantity indexes of consumers' goods and factors of production, both as outputs.

(1) Aggregate Quantity Index of Factors of Production and Consumers' Goods, Both as Inputs

With the assumption of a negative price-quantity relationship between periods t_0 and t_1 for the factors of production X and Y, it must be shown that the L index number (i.e. $\leq q_1p_0 / \leq q_0p_0$) is greater than the P index number (i.e. $\leq q_1p_1 / \leq q_0p_1$). It is assumed also, to simplify the exposition, that the techniques available for producing A from X and Y have not changed between the two periods.

In terms of productive capacity the combinations $q_0^x + q_0^y$ and $q_1^x + q_1^y$ (both combinations produce the same amount of output A) are equal and the aggregate quantity index of the inputs should be the same in both periods, i.e. the ratio $(q_1^x + q_1^y)/(q_0^x + q_0^y)$ should be unity. It can be shown, however, that weighting the quantities with t_0 prices will give a ratio greater than unity, and weighting with t_1 prices will give a ratio smaller than unity.

When prices of t_0 are used as weights the numerator and denominator of the index ratio are $(q_1^x p_0^x + q_1^y p_0^y)$ and $(q_0^x p_0^x + q_0^y p_0^y)$, respectively. To establish that the numerator is greater than the denominator it must be shown that the weighted amount by which q_1^x is smaller than q_0^x, i.e. $(q_0^x - q_1^x)p_0^x$, is smaller than the weighted amount by which q_1^y is greater than q_0^y, i. e. $(q_1^y - q_0^y)p_0^y$.



It follows from the diagram that the ratio $(q_0^x - q_1^x)/(q_1^y - q_0^y)$ is smaller than the price ratio p_0^y / p_0^x. Therefore, the cross-product $(q_0^x - q_1^x)p_0^x$ is smaller than the cross-product $(q_1^y - q_0^y)p_0^y$. Thus the numerator of the L index number for t_1 is greater than its denominator, and the L index has an upward bias.

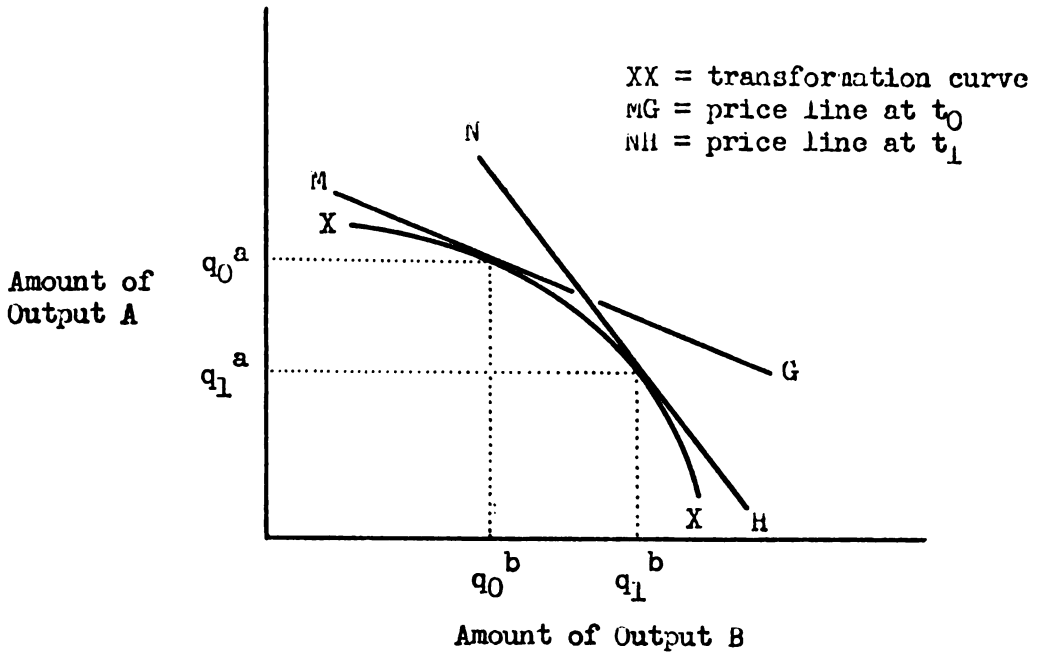
The diagram also shows that the ratio $(q_0^x - q_1^x)/(q_1^y - q_0^y)$ is greater than the price ratio p_1^y / p_1^x. Hence $(q_0^x - q_1^x)p_1^x$ is greater than $(q_1^y - q_0^y)p_1^y$, and the weighted combination $q_1^x p_1^x + q_1^y p_1^y)$ is smaller than the weighted combination $(q_0^x p_1^x + q_0^y p_1^y)$. Weighting with t_1 prices, or the P index, thus gives a ratio smaller than unity and under-emphasizes the aggregate input value.

The same conclusions will be reached for consumers' goods used as inputs by making AA in the diagram an indifference curve and assuming that tastes between t_0 and t_1 have not changed.

(2) Aggregate Quantity Indexes of Consumers' Goods and Factors of Production, Both as Outputs

With the assumption of a positive price-quantity relationship between periods t_0 and t_1 for the outputs A and B, it must be shown that the L index number (i. e. $\leq q_1 p_0 / \leq q_0 p_0$) is smaller than the P index number (i. e. $\leq q_1 p_1 / \leq q_0 p_1$). It is assumed also, to simplify the exposition, that the same production function and input prices apply to both periods t_0 and t_1.

Along much the same line of reasoning as used in the previous illustration the conclusion can be reached that beginning-period weight-



ing will make the amount by which output A declines between t_0 and t_1 greater than the amount by which output B increases. This conclusion follows from the diagram which shows that $(q_0^a - q_1^a)/(q_1^b - q_0^b)$ is greater than p_0^b/p_0^a; consequently $(q_0^a - q_1^a)p_0^a$ is greater than $(q_1^b - q_0^b)p_0^b$, which makes $(q_0^a p_0^a + q_0^b p_0^b)$ greater than $(q_1^a p_0^a + q_1^b p_0^b)$. Hence the L index number gives a value smaller than unity.

In terms of costs, however, and under conditions of competitive equilibrium also in terms of the combined productive capacity of the inputs, the quantity $q_0^a + q_0^b$ is equal to the quantity $q_1^a + q_1^b$. From the producer's point of view the L index number has, therefore, a downward bias.

It also follows from the diagram that the ratio $(q_0^a - q_1^a)/(q_1^b - q_0^b)$ is smaller than the price ratio p_1^b/p_1^a. The cross-

product $(q_0^a - q_1^a)p_1^a$ is, therefore, smaller than the cross-product $(q_1^b - q_0^b)p_1^b$, and the weighted combination $(q_1^a p_1^a + q_1^b p_1^b)$ is greater than the weighted combination $(q_0^a p_1^a + q_0^b p_1^b)$. The P index number would thus result in a ratio greater than unity which would be an overstatement of the output combination from the producer's point of view.

APPENDIX II

Computer Programs

A. Listing of Items

		Item Number	Item
1.	Inputs:	01	real estate
		02	machinery
		03	livestock
		04	labor
		05	real estate: repairs and depreciation
		06	real estate: taxes
		07	machinery: repairs and depreciation
		08	machinery: other
		09	feed
		10	fertilizer
		11	electricity
		12	miscellaneous
2.	Outputs:	13	field crops
	(1926-1957)	14	animal products
		15	forest products
		16	house rent
3.	Outputs:	17	grains
	(1935-1957)	18	potatoes
		19	fruits
		20	vegetables
		21	tobacco
		22	sugar beets
		23	clover and grass seed
		24	hay and clover
		25	miscellaneous
		26	cattle, hogs, and sheep
		27	dairy products
		28	poultry and eggs
		29	wool
		30	fur
		31	forest products
		32	maple and honey products
		33	house rent
4.	Interest rate	34	

B. Listing of Program for Computing Quantity Indexes with Fixed Weight Periods (i.e. (1) 1935-39, (2) 1940-44, (3) 1945-49, and (4) 1950-54) on Datatron (Burroughs-205)*

	35 3020	0000 13 0002	0000 02 7000	0000 14 0002	0000 75 7000	3000 00 0001
	2 7001	0000 12 7002	0000 64 7018	0000 14 0004	0000 02 7018	3005 00 0002
	20 5020	0000 72 7001	0000 33 0000	0000 64 4000	0000 19 1000	3010 00 0003
	80 7002	0000 12 7002	0000 22 7012	0000 00 0030	-0000 00 0011	3015 00 0004
	64 6000	0000 75 5036	0000 60 5037	0000 14 0002	0000 74 5038	3020 00 0005
	74 7000	0000 12 7009	0000 74 5039	0000 12 7010	0000 65 7009	3025 00 0006
	63 7019	0000 75 7013	0000 12 7013	0000 75 7014	0000 12 7014	3030 00 0007
	20 7009	0000 00 1926	4000 00 0000	0000 34 0020	0000 01 1280	3035 00 0008
	34 3060	0000 20 4003	0010 00 0005	0000 10 0000	0000 64 4011	3040 00 0009
	52 0000	0000 64 5012	0000 74 4002	0000 28 3153	0000 12 5012	3045 00 0010
	74 4003	0000 12 5000	0000 63 4004	0000 02 4004	0000 65 4004	3050 00 0011
	12 5001	0000 74 4005	0000 02 5010	0000 72 5005	0000 20 5000	3055 00 0012
	12 4019	0000 63 5010	0000 20 4989	0000 35 3080	0000 64 4012	3060 00 0013
	14 0004	0000 12 4012	0000 74 4018	0000 12 4018	0000 75 5015	3065 00 0014
	2 3048	0000 72 4005	0000 00 0064	0000 13 0010	0000 14 0018	3070 00 0015
	1 0002	-0000 02 5015	0000 22 4014	0000 00 0001	0000 34 3043	3075 00 0016
			33 0000	0000 15 5010	0000 02 5000	3080 00 0017
	17 0004	-0000 74 5015	0000 13 0010	0000 64 5000	0000 14 0018	3085 00 0018
1111	24 1111	0000 22 5001	0000 00 0000	00 34 3040	0000 20 4006	3090 00 0019
0 -	35 9999	0000 00				3095 00 0020
9990	44 8000	0000 30 3102	0000 33 0000	0000 64 4000	0000 13 0008	3100 00 0021
	2 4002	0000 14 0002	0000 74 7019	0000 60 7018	0000 14 0010	3105 00 0022
0 0	74 7017	0000 12 3129	0000 74 7016	0000 12 3132	0000 30 3120	3110 00 0023
-	34	-0000 00 1280	-0000 12 0020	-0000 00 0040	-0000 00 0026	3115 00 0024
0	74 3115	0000 63 7039	0000 12 7035	0000 72 4002	0000 64 4001	3120 00 0025
	13 0010	0000 64 4000	0000 14 0002	0000 63 7039	-0000 12 0020	3125 00 0026

* The location of the data on the memory drum can be determined by the following formulas:
(1) 40 (year-1926) + 20 + item number, for current dollar values;
(2) 40 (year-1926) + 1300 + item number, for index numbers;
(3) 40 (year-1926) + 1334, for interest rate.

(continued)

B. Continued

	14	0004	0000	63	7038	-0000	12	1300	0000	64	4001	0000	63	7038	3130	00	0027
				30	3100	-0000	00	0090	0000	00	1111	0011	11	1111	3135	00	0028
8720	64	1301	0000	04	7045	0000	72	7040	0000	64	7055	-0000	12	0000	3140	00	0029
	64	7040	0000	74	7054	0000	28	3150	0000	12	7040	0000	20	7040	3145	00	0030
0 0	21	3040	5757	57	5757	4880	34	0020	0000	08	6666	0001	00	0001	3150	00	0031
		1	0000	64	7074	0000	12	6009	0007	72	7073	0000	20	3160	3155	00	0032
0001	31	3330	0001	12	6010	0000	64	7072	0000	12	6000	0000	64	7071	3160	00	0033
	20	3166	0000	31	3000	0001	12	6001	0000	64	7070	0000	20	3175	3165	00	0034
		202	0000	00	0101	0000	00	1926	0000	00	0033	0000	00	1935	3170	00	0035
0	31	3000	0001	12	6002	0000	64	7089	0000	20	3179	0000	31	3000	3175	00	0036
0 01	12	6003	0000	80	6001	0000	80	6002	0001	12	6004	0000	82	6010	3180	00	0037
0 01	12	6005	0000	64	7088	0000	20	3190	0000	00	0412	0000	00	0303	3185	00	0038
0 01	31	3000	0000	80	6005	0001	12	6005	0000	64	7003	0000	20	3195	3190	00	0039
	31	3000	0001	12	6006	0000	64	7002	0000	12	6000	0000	64	7001	3195	00	0040
	20	3204	0000	00	1733	0000	00	1935	0000	00	1316	0000	31	3000	3200	00	0041
0 01	12	6007	0000	64	3172	0000	12	6000	0000	12	3980	0000	64	3227	3205	00	0042
	20	3211	0000	31	3000	0001	12	3988	0000	33	0000	0000	83	6001	3210	00	0043
0003	12	3981	0000	64	7026	0000	20	3218	0000	31	3000	0001	12	3989	3215	00	0044
- -	33	0000	0000	83	6002	0000	12	3982	0000	64	7025	0000	20	3228	3220	00	0045
		303	0000	00	0202	0000	00	0101	0000	31	3000	0001	12	3990	3225	00	0046
0 0	33	0000	0000	83	6003	0003	12	3983	0000	64	7046	0000	20	3235	3230	00	0047
0 -	31	3000	0001	12	3991	0000	33	0000	0000	83	6004	0003	12	3984	3235	00	0048
0 0	64	3991	0000	82	6010	0000	12	3992	0000	64	7045	0000	20	3247	3240	00	0049
		412	0000	00	0103	0000	31	3000	0001	12	3993	0000	80	3992	3245	00	0050
0001	12	3994	0000	33	0000	0000	83	6005	0000	12	3985	0000	64	7064	3250	00	0051
	20	3256	0000	31	3000	0001	12	3995	0000	33	0000	0000	83	6006	3255	00	0052
0003	12	3986	0000	64	7063	0000	20	3265	0000	00	1733	0000	00	1316	3260	00	0053
0	31	3000	0001	12	3996	0000	33	0000	0000	83	6007	0003	12	3987	3265	00	0054
9990	54	3980	0120	50	3980	0000	30	3273	0000	64	6000	0000	74	7091	3270	00	0055
	12	6000	0000	75	7090	0000	15	7080	0000	64	6000	0000	30	3208	3275	00	0056

(continued)

B. Concluded

0		64	6009		0000	74	7089		0000	12	6009		0000	75	7088		0000	15	7086		3280	00	0057
		30	3292		0000	08	7777		0000	30	3315		0000	00	1955		0000	00	0005		3285	00	0058
			1958		0000	00	0001		0000	72	3312		0000	20	3294		0001	31	3330		3290	00	0059
		12	6008		-9680	64	1301		0000	33	0000		0000	83	6008		-0000	12	1301		3295	00	0060
		64	7096		0000	75	7011		0000	28	7007		0000	12	7096		0000	74	7010		3300	00	0061
0		12	7099		0000	20	7096		0000	37	3292		0000	22	7093		0000	30	3158		3305	00	0062
		52	0000		0010	00	0040		0000	00	0032		0020	42	0000		0000	30	3156		3310	00	0063
0020		42	0000		0120	40	8000		0000	28	7016		9680	64	4000		0000	02	4007		3315	00	0064
		12	4001		0000	12	4002		9980	54	8007		0000	64	7018		0000	74	3328		3320	00	0065
		28	3329		0000	12	7018		0000	20	7016		0010	00	0000		0000	08	7667		3325	00	0066
0		34	3339		0000	11	0000		0000	12	7038		0000	72	4054		0000	64	7037		3330	00	0067
		14	0004		0000	20	4039		0000	00	0030		0000	00	0000		0000	12	4057		3335	00	0068
0		64	6009		0000	75	4055		0000	60	4051		0000	14	0010		0000	74	4053		3340	00	0069
		33	0000		-0000	12	4052		0000	74	4051		0000	22	4046		0000	72	7038		3345	00	0070
		2	4051		-0000	00	0040		0000	00	0003		-0000	80	1301		0000	00	0003		3350	00	0071
			1926		0000	83	4358		0000	00	0000		5150	00	0000		0000	0			3355	00	0072

C. Listing of Source Program ("For Transit") for Computing Paasche and Chain Quantity Indexes on I.B.M. 650 Data Processing System

```
                FN.  RNDF   = I                                    +0000001500 +0079756466 +9550926572
0  0000 0       DIMENSION A(33),B(          101  QIPC
0  0000 1       33),S(33),DIV(33),          102  QIPC
0  0000 1       X(33),Y(33),Z(33),          103  QIPC
0  0000 1       C(7),IO(7),IOC(7),          104  QIPC
0  0000 1       IOP(7),ITAB(7)              105  QIPC
C  0000 0                                   106  QIPC
0  0000 0       READ , ITAB                 107  QIPC
C  0000 0                                   108  QIPC
0  0000 0       IOP ( 7 ) = 0               109  QIPC
0  0000 0       IOC ( 7 ) = 0               110  QIPC
0  0000 0       READ, NY1 ,NY2              111  QIPC
0  0999 0       LYR = NY1                   113  QIPC
0  0000 0       LYT = LYR * 100             114  QIPC
0  0000 0       IFST = 1                    115  QIPC
0  0000 0       ILST = 16                   116  QIPC
0  0000 0       IS = 1                      117  QIPC
0  0000 0       GO TO 200                   118  QIPC
C  0000 0                                   119  QIPC
C  0000 0       READ CARDS CALCULATE  DIV   120  QIPC
C  0000 0       I IS 1,16                   121  QIPC
C  0000 0                                   122  QIPC
0  0001 0       LYR = LYR + 1               123  QIPC
0  0000 0       LYT = LYR * 100             124  QIPC
0  0000 0       DO 2  I = 1, 7              125  QIPC
0  0002 0       C ( I ) = 100.              126  QIPC
0  0100 0       SPN = 0.0                   127  QIPC
0  0000 0       SPD = 0.0                   128  QIPC
0  0000 0       SCN = 0.0                   129  QIPC
0  0000 0       SCD = 0.0                   130  QIPC
```

(continued)

C. Continued

```
0  0003 0     DO 5  I = 1 , 3                 131  QIPC
0  0000 0     IS = 1                          132  QIPC
0  0000 0     GO TO 300                       133  QIPC
C  0000 0                                     134  QIPC
C  0000 0     READ CARD CHECK DATA TO xyz     135  QIPC
C  0000 0                                     136  QIPC
0  0004 0     PN = X ( I )                    137  QIPC
0  0000 0     SPN = SPN + PN                  138  QIPC
0  0000 0     PD = DIV ( I ) *                139  QIPC
0  0000 1     Y ( I )                         140  QIPC
0  0000 0     SPD = SPD + PD                  141  QIPC
0  0000 0     CN = ( PN * B ( I )             142  QIPC
0  0000 1     ) / Y ( I )                     143  QIPC
0  0000 0     SCN = SCN + CN                  201  QIPC
0  0000 0     CD = A ( I )                    202  QIPC
0  0000 0     SCD = SCD + CD                  203  QIPC
0  0000 0     ITEM = I                        204  QIPC
0  0000 0     GO TO 500                       205  QIPC
C  0000 0                                     206  QIPC
C  0000 0     OUTPUT ROUTINE                  207  QIPC
C  0000 0                                     208  QIPC
0  0005 0     CONTINUE                        209  QIPC
0  0000 0     PN = SPN * Z ( 1 )              210  QIPC
0  0000 0     PD = SPD * Z ( 1 )              211  QIPC
0  0000 0     CN = SCN * S ( 1 )              212  QIPC
0  0000 0     CD = SCD * S ( 1 )              213  QIPC
0  0000 0     ITEM = 4                        214  QIPC
0  0000 0     GO TO 500                       215  QIPC
C  0000 0                                     216  QIPC
C  0000 0     OUTPUT                          217  QIPC
C  0000 0                                     218  QIPC
0  0006 0     DO 21 I = 4,12                  219  QIPC
```

(continued)

C. Continued

```
0  0000 0     IS = 2                                220  QIPC
0  0000 0     GO TO 300                             221  QIPC
C  0000 0                                           222  QIPC
C  0000 0     READ CARD                             223  QIPC
C  0000 0                                           224  QIPC
0  0007 0     PN = PN + X ( I )                     225  QIPC
0  0000 0     PD = PD +                             226  QIPC
0  0000 1     DIV ( I ) * Y ( I )                   227  QIPC
0  0000 0     CN = CN +                             228  QIPC
0  0000 1     ( X ( I ) * B ( I )                   229  QIPC
0  0000 2     ) / Y ( I )                           230  QIPC
0  0021 0     CD = CD + A ( I )                     231  QIPC
0  0000 0     ITEM = 5                              232  QIPC
0  0000 0     GO TO 500                             233  QIPC
C  0000 0                                           234  QIPC
C  0000 0     OUTPUT                                235  QIPC
C  0000 0                                           236  QIPC
0  0027 0     PN = 0.0                              237  QIPC
0  0000 0     PD = 0.0                              238  QIPC
0  0000 0     CN = 0.0                              239  QIPC
0  0000 0     CD = 0.0                              240  QIPC
0  0000 0     DO 9  I = 13 , 16                     301  QIPC
0  0000 0     IS = 3                                302  QIPC
0  0000 0     GO TO 300                             303  QIPC
C  0000 0                                           304  QIPC
C  0000 0     READ CARD                             305  QIPC
C  0000 0                                           306  QIPC
0  0008 0     PN = PN + X ( I )                     307  QIPC
0  0000 0     PD = PD +                             308  QIPC
0  0000 1     DIV ( I ) * Y ( I )                   309  QIPC
0  0000 0     CN = CN + ( X ( I )                   310  QIPC
0  0000 1     * B ( I ) ) / Y (I)                   311  QIPC
```

(continued)

C. Continued

```
0  0009 0     CD = CD + A ( I )                312  QIPC
C  0000 0     ITEM = 6                         313  QIPC
0  0000 0     GO TO 500                        314  QIPC
C  0000 0                                      315  QIPC
C  0000 0     OUTPUT                           316  QIPC
C  0000 0                                      317  QIPC
0  0010 0     IF ( LYR - NY2 )                 318  QIPC
0  0010 1     12, 11 , 14                      319  QIPC
0  0011 0     IFST = 17                        320  QIPC
0  0000 0     ILST = 33                        321  QIPC
0  0000 0     IS = 2                           322  QIPC
0  0000 0     GO TO 200                        323  QIPC
C  0000 0                                      324  QIPC
C  0000 0     READ CARDS CALC DIV              325  QIPC
C  0000 0                                      326  QIPC
0  0012 0     DO 13 I = 1 , 16                 327  QIPC
0  0000 0     A ( I ) = X ( I )                328  QIPC
0  0000 0     B ( I ) = Y ( I )                329  QIPC
0  0013 0     S ( I ) = Z ( I )                330  QIPC
0  0000 0     PUNCH , LYR , A ,                331  QIPC
0  0000 1     B , S                            332  QIPC
C  0000 0                                      401  QIPC
0  0000 0     LABEL = 1                        402  QIPC
0  0000 1     LYR * 100                        403  QIPC
0  0000 0     IOP ( 1 ) = IOP (1)              404  QIPC
0  0000 1     + LABEL                          405  QIPC
0  0502 0     PUNCH, IOP                       406  QIPC
0  0000 0     IOC ( 1 ) = IOC (1)              407  QIPC
0  0000 1     + LABEL + 10000000               408  QIPC
0  0503 0     PUNCH , IOC                      409  QIPC
0  0000 0     LYR = LYR + 1                    410  QIPC
0  0000 0     LYT = LYR * 100                  411  QIPC
```

(continued)

C. Continued

```
0  0000 0     GO TO 100                          412  QIPC
C  0000 0                                        413  QIPC
C  0000 0                                        501  QIPC
0  0014 0     PN = 0.0                           502  QIPC
0  0000 0     PD = 0.0                           503  QIPC
0  0000 0     CN = 0.0                           504  QIPC
0  0000 0     CD = 0.0                           505  QIPC
0  0015 0     DO 17 I = 17 , 33                  506  QIPC
0  0000 0     IS = 4                             507  QIPC
0  0000 0     GO TO 300                          508  QIPC
C  0000 0                                        509  QIPC
C  0000 0     READ CARD                          510  QIPC
C  0000 0                                        511  QIPC
0  0016 0     PN = PN + X ( I )                  512  QIPC
0  0000 0     PD = PD + DIV ( I )                513  QIPC
0  0000 1     * Y ( I )                          514  QIPC
0  0000 0     CN = CN + (X( I ) *                515  QIPC
0  0000 1     B ( I ) ) / Y ( I )                516  QIPC
0  0017 0     CD = CD + A ( I )                  517  QIPC
0  0000 0     ITEM = 7                           518  QIPC
0  0000 0     GO TO 500                          519  QIPC
C  0000 0                                        520  QIPC
C  0000 0     OUTPUT                             521  QIPC
C  0000 0                                        522  QIPC
0  0018 0     DO 19 I=17 , 33                    523  QIPC
0  0000 0     A ( I ) = X ( I )                  524  QIPC
0  0000 0     B ( I ) = Y ( I )                  525  QIPC
0  0019 0     S ( I ) = Z ( I )                  526  QIPC
0  0000 0     GO TO 12                           527  QIPC
C  0000 0     SUBROUTINE TO READ, CALC DIV       601  QIPC    *
C  0000 0                                        602  QIPC
```

(continued)

C. Continued

```
0  0200 0     DO 204 I= IFST,ILST          603  QIPC
0  0201 0     READ , IT,LX,LY,LZ           604  QIPC
0  0000 0     IF ( LYT + I - IT )          605  QIPC
0  0000 1     202 , 203 , 202              606  QIPC
0  0202 0     PAUSE                        607  QIPC
0  0000 0     GO TO 201                    608  QIPC
0  0203 0     A ( I ) = LX                 609  QIPC
0  0000 0     B ( I ) = LY                 610  QIPC
0  0000 0     S ( I ) = LZ * .001          611  QIPC
0  0204 0     DIV ( I ) =                  612  QIPC
0  0204 1     A ( I ) / B ( I )            613  QIPC
0  0000 0     GO TO ( 1 ,12) , IS          614  QIPC
C  0000 0                                  615  QIPC
C  0000 0     SUBROUTINE TO READ X,Y,Z     616  QIPC
C  0000 0                                  617  QIPC
0  0300 0     READ , IT,LX,LY,LZ           618  QIPC
0  0000 0     IF ( LYT + I - IT )          619  QIPC
0  0000 1     301, 302, 301                620  QIPC
0  0301 0     PAUSE                        621  QIPC
0  0000 0     GO TO 300                    622  QIPC
0  0302 0     X ( I ) = LX                 623  QIPC
0  0000 0     Y ( I ) = LY                 624  QIPC
0  0000 0     Z ( I ) = LZ * .001          625  QIPC
0  0000 0     GO TO ( 4, 7, 8, 16          626  QIPC
0  0000 1     ) , IS                       627  QIPC
C  0000 0                                  628  QIPC
C  0000 0     SUBROUTINE OUTPUT            629  QIPC
C  0000 0                                  630  QIPC
0  0500 0     IO ( 1 ) = LYR *             631  QIPC
0  0000 1     100000000 + ITAB (           632  QIPC
0  0000 1     ITEM ) + ITEM                633  QIPC
```

(continued)

C. Concluded

```
0  0000 0    IO ( 2 ) = RNDF (          634  QIPC
0  0000 1    PN )                       635  QIPC
0  0000 0    IO ( 3 ) = RNDF (          636  QIPC
0  0000 1    PD )                       637  QIPC
0  0000 0    IO ( 4 ) = RNDF ( (        638  QIPC
0  0000 1    PN * 1000. ) / PD )        639  QIPC
0  0000 0    IO ( 5 ) = RNDF (          640  QIPC
0  0000 1    CN )                       701  QIPC
0  0000 0    IO ( 6 ) = RNDF (          702  QIPC
0  0000 1    CD )                       703  QIPC
0  0000 0    C ( ITEM ) = ( CN /        704  QIPC
0  0000 1    CD ) * C ( ITEM )          705  QIPC
0  0000 0    IO ( 7 ) = RNDF (          706  QIPC
0  0000 1    C ( ITEM ) * 10. )         707  QIPC
0  0501 0    PUNCH , IO                 708  QIPC
0  0000 0    IOP ( ITEM ) =             709  QIPC
0  0000 1    IO ( 4 )                   710  QIPC
0  0000 0    IOC ( ITEM ) =             711  QIPC
0  0000 1    IO ( 7 )                   712  QIPC
0  0000 0    GO TO ( 5, 5, 5, 6,        713  QIPC
0  0000 1    27, 10, 18 ) , ITEM        714  QIPC
C  0000 0                               715  QIPC
C  0000 0    RESTARTS                   716  QIPC
C  0000 0                               717  QIPC
0  0990 0    PUNCH, LYR, LYT, A,        718  QIPC
0  0990 1    B, S, DIV, C               719  QIPC
0  0000 0    PAUSE                      720  QIPC
0  0991 0    READ, LYR, LYT, A,         721  QIPC
0  0991 1    B, S, DIV, C               722  QIPC
0  0000 0    GO TO 100                  723  QIPC
0  0000 0    END                        724  QIPC
```

APPENDIX III

Tables Showing Computation of Total Input and Total Output Indexes for Canadian Agriculture

Table 16.- Current Dollar Values of (1) Real Estate, (2) Machinery and (3) Livestock, Canadian Agriculture, 1926-1957

Year	Real Estate (a)	Machinery (a)	Livestock (a)
	- thousands of dollars -		
1926	4698745	665172	785626
1927	4698745	665172	859353
1928	4698745	665172	933080
1929	4698745	665172	947498
1930	4440476	650664	758224
1931	4053282	650664	516714
1932	3489400	610658	415886
1933	3425200	573867	444092
1934	3467808	538685	457654
1935	3449255	533546	540507
1936	3292258	524429	573632
1937	3253346	526876	603672
1938	3083056	543781	587077
1939	3106885	547393	644485
1940	2963226	568349	682522
1941	3029846	596046	621285
1942	3238024	660492	782648
1943	3454480	722277	1097966
1944	3649477	758083	1081967
1945	3711473	826632	1042301
1946	3897005	905491	1075332
1947	4214119	1026573	1148853
1948	4665126	1194947	1244981
1949	4716823	1415546	1370793
1950	5022642	1681075	1467581
1951	5512519	1931880	2014153
1952	5622186	2037947	1790874
1953	6034349	2152463	1556502
1954	5983724	2240868	1424076
1955	6236094	2210000	1462663
1956	6456456	2193297	1422720
1957	6527584	2197775	1516391

SOURCES.- Canada, Department of Trade and Commerce, D.B.S., Ottawa;
(a) 1926-1934: Monthly Bulletin of Agricultural Statistics (under heading "Gross Agricultural Wealth of Canada by Provinces"),
1935-1957: revised estimates from Agriculture Division, Farm Finance Section.

Table 17.- Interest Rate on Farm Mortgages, and Price Indexes (1935-39 = 100) of (1) Farm Real Estate, (2) Farm Machinery, and (3) Animal Products, Canada, 1926-1957

Year	Interest Rate (%) on Farm Mortgages (a)	Farm Real Estate		Farm Machinery Index (c)	Animal Products Index (d)
		Dollars Per Acre (b)	Index		
1926	7.5	37	152.9	97.6	130.2
1927	7.1	38	157.0	97.5	127.8
1928	7.2	38	157.0	97.6	138.2
1929	7.3	37	152.9	97.5	144.4
1930	7.3	32	132.2	97.0	133.3
1931	7.3	28	115.7	94.9	92.7
1932	7.4	24	99.1	94.1	70.5
1933	7.1	24	99.1	92.1	69.2
1934	7.0	23	95.0	94.6	86.5
1935	6.8	24	99.1	95.5	94.1
1936	6.4	24	99.1	97.8	93.7
1937	6.0	24	99.1	97.2	106.0
1938	5.9	24	99.1	104.1	104.8
1939	5.9	25	103.3	103.6	101.5
1940	5.8	24	99.1	105.8	106.7
1941	5.6	25	103.3	109.1	124.4
1942	5.6	26	107.4	114.4	144.6
1943	5.6	28	115.7	117.1	161.8
1944	5.4	30	124.0	118.2	166.1
1945	5.3	30	124.0	115.1	170.2
1946	5.2	32	132.2	118.8	181.2
1947	5.2	35	144.6	126.3	200.2
1948	5.2	39	161.2	141.6	263.7
1949	5.1	40	165.3	158.3	265.4
1950	5.2	43	177.7	165.1	281.4
1951	5.3	47	194.2	186.8	336.9
1952	5.3	48	198.3	195.4	277.5
1953	5.4	51	210.7	196.7	263.8
1954	5.5	50	206.6	197.9	256.2
1955	5.4	52	214.9	198.8	245.1
1956	5.6	55	227.3	209.4	246.9
1957	5.7	56	231.4	223.8	258.0

SOURCES.- Canada, Department of Trade and Commerce, D.B.S., Ottawa;
(a) 1926-1957: Agriculture Division, Farm Finance Section (the values of "Mortgages and Agreements for Sale" were divided by "Interest on Mortgages and Agreements for Sale");
(b) 1926-1957: Quarterly Bulletin of Agricultural Statistics, Vol. 40, p. 31, Vol. 49, p. 22;
(c) 1926-1952: Prices and Price Indexes, 1949-1952, p. 96,
1953-1957: Prices and Price Indexes (monthlies);
(d) 1926-1952: Prices and Price Indexes, 1949-1952, p. 104,
1953-1957: Prices Division.

Table 18.- Real Estate, Machinery and Livestock at 1935-39 Prices, Canadian Agriculture, 1926-1957

Year	Real Estate	Machinery	Livestock
	- thousands of dollars -		
1926	3073084	681529	603399
1927	2992831	682228	672420
1928	2992831	681529	675166
1929	3073084	682228	656162
1930	3358908	670788	568810
1931	3503269	685631	557404
1932	3521090	648946	589909
1933	3456307	623091	641751
1934	3650324	569434	529080
1935	3480580	558687	574396
1936	3322157	536226	612201
1937	3282892	542053	569502
1938	3111055	522364	560188
1939	3007633	528372	634960
1940	2990137	537192	639664
1941	2933055	546330	499425
1942	3014920	577353	541250
1943	2985722	616804	678594
1944	2943127	641356	651395
1945	2993123	718186	612398
1946	2947810	762198	593450
1947	2914328	812805	573853
1948	2893999	843889	472120
1949	2853492	894217	516501
1950	2826473	1018216	521528
1951	2838578	1034197	597849
1952	2835192	1042962	645360
1953	2863953	1094287	590031
1954	2896285	1132323	555845
1955	2901859	1111670	596762
1956	2840500	1047420	576233
1957	2820909	982026	587748

Table 19.- Annual Interest Inputs at 1935-39 Prices for (1) Real Estate, (2) Machinery, (3) Livestock, and (4) Total Investment, Canadian Agriculture, 1926-1957

Year	Real Estate	Machinery	Livestock	Total Investment
		- thousands of dollars -		
1926	190531	42255	37411	270197
1927	185556	42298	41690	269544
1928	185556	42255	41860	269671
1929	190531	42298	40682	273511
1930	208252	41589	35266	285107
1931	217203	42509	34559	294271
1932	218308	40235	36574	295117
1933	214291	38632	39788	292711
1934	226320	35305	32803	294428
1935	215796	34638	35612	286046
1936	205974	33246	37956	277176
1937	203539	33607	35309	272455
1938	192885	32386	34732	260003
1939	186473	32759	39368	258600
1940	185388	33306	39659	258353
1941	181849	33872	30964	246685
1942	186925	35796	33558	256279
1943	185115	38242	42073	265430
1944	182474	39764	40386	262624
1945	185574	44528	37969	268071
1946	182764	47256	36794	266814
1947	180688	50394	35579	266661
1948	179428	52321	29271	261020
1949	176916	55441	32023	264380
1950	175241	63129	32335	270705
1951	175992	64120	37067	277179
1952	175782	64664	40012	280458
1953	177565	67846	36582	281993
1954	179570	70204	34462	284236
1955	179915	68924	36999	285838
1956	176111	64940	35726	276777
1957	174896	60886	36440	272222

Table 20.- Current Dollar Values of Supplementary (1) Real Estate and (2) Machinery Inputs, Canadian Agriculture, 1926-1957

Year	Real Estate *			
	Repairs (a)	Depreciation (b)	Repairs and Depreciation	Taxes (c)
	- thousands of dollars -			
1926	20771	61550	82321	61005
1927	22693	67237	89930	61587
1928	23202	68751	91953	64493
1929	24025	71178	95203	67949
1930	21914	64932	86846	69819
1931	20075	59480	79555	65384
1932	17174	50904	68078	60046
1933	16726	49562	66288	54774
1934	16878	50007	66885	54048
1935	17752	52590	70342	55331
1936	17373	51470	68843	56387
1937	17558	52036	69594	55723
1938	16994	50355	67349	56713
1939	17521	51918	69439	57165
1940	16708	50189	66897	56304
1941	17031	50458	67489	58863
1942	20464	54443	74907	59704
1943	22211	59242	81453	62539
1944	25675	62485	88160	65228
1945	29152	63151	92303	67776
1946	43670	66062	109732	75722
1947	46343	71015	117358	83423
1948	55141	77191	132332	94562
1949	56818	77689	134507	104813
1950	59673	83148	142821	110429
1951	88114	92235	180349	123592
1952	111481	94569	206050	137060
1953	117950	101556	219506	149031
1954	119269	102246	221515	160764
1955	114990	106957	221947	165264
1956	133618	111023	244641	176350
1957	122928	112780	235708	184139

* The published estimates were expanded to include all farms (see text p. 64).

(continued)

Table 20.- Concluded

Year	Machinery			
	Repairs (a)	Depreciation (b)	Repairs and Depreciation	Other * (c)
	- thousands of dollars -			
1926	17094	55431	72525	53370
1927	17803	60642	78445	58338
1928	17876	67046	84992	66267
1929	16697	72860	89557	74422
1930	16395	69426	85821	73899
1931	11795	59813	71608	65145
1932	12818	56252	69070	58951
1933	12512	53182	65694	55279
1934	13831	50126	63957	58746
1935	16302	48101	64403	58637
1936	15353	47167	62520	59397
1937	15728	47391	63119	61751
1938	17846	49022	66868	65746
1939	19177	49390	68567	73326
1940	19917	51662	71579	79669
1941	20416	54434	74850	89998
1942	27891	60215	88106	97033
1943	31478	65820	97298	99244
1944	36000	69004	105004	104381
1945	39060	75341	114401	108422
1946	42952	82630	125582	119725
1947	47386	94089	141475	132276
1948	54062	110236	164298	166387
1949	55999	131416	187415	192154
1950	60638	157129	217767	235726
1951	57890	181129	239019	265850
1952	62515	190389	252904	277308
1953	63611	201006	264617	292015
1954	56076	209447	265523	304511
1955	58357	205448	263805	316775
1956	64127	202481	266608	342833
1957	65340	201869	267209	352247

* Sum total of fuel, oil, grease, tires, tubes and insurance.

SOURCES.- Canada, Department of Trade and Commerce, D.B.S., Ottawa;
(a) 1926-1957: Handbook of Agricultural Statistics, Part II (Farm Income, 1926-57), Ref. Paper No. 25, rev. ed., 1958, p. 69;
(b) 1926-1957: Agriculture Division, Farm Finance Section;
(c) 1926-1957: as under (a), p. 68.

Table 21.- Price Indexes (1935-39 = 100) of Supplementary Farm Real Estate and Machinery Inputs, Canada, 1926-1957

Year	Building Material (a)	Property Taxes (b)	Farm Machinery (a)	Gasoline, Oil and Grease (a)
1926	114.0	144.7	97.6	127.7
1927	108.3	146.9	97.5	118.1
1928	114.7	139.5	97.6	112.8
1929	117.2	138.0	97.5	113.5
1930	101.8	134.9	97.0	113.6
1931	88.3	119.8	94.9	105.1
1932	80.1	109.1	94.1	108.7
1933	84.9	95.0	92.1	105.5
1934	87.5	95.6	94.6	108.2
1935	87.1	95.5	95.5	105.1
1936	97.3	96.9	97.8	101.7
1937	108.7	98.8	97.2	99.7
1938	98.7	104.1	104.1	97.4
1939	108.1	104.8	103.6	96.2
1940	116.0	107.0	105.8	97.6
1941	128.1	108.2	109.1	105.0
1942	148.5	110.6	114.4	114.4
1943	155.0	114.6	117.1	114.7
1944	173.0	123.7	118.2	114.7
1945	174.8	128.0	115.1	114.2
1946	175.2	135.7	118.8	116.4
1947	186.7	148.2	126.3	121.2
1948	224.8	158.8	141.6	136.9
1949	237.1	170.2	158.3	139.3
1950	255.0	179.8	165.1	145.1
1951	296.1	191.2	186.8	147.1
1952	303.3	205.6	195.4	149.9
1953	307.8	215.8	196.7	150.4
1954	307.0	226.0	197.9	153.0
1955	308.8	230.7	198.8	151.7
1956	316.6	241.2	209.4	152.5
1957	322.9	252.0	223.8	155.0

SOURCES.- Canada, Department of Trade and Commerce, D.B.S., Ottawa:
(a) 1926-1952: Prices and Price Indexes, 1949-1952, p. 96,
1953-1957: Price Index Numbers of Commodities and Services Used by Farmers (3 times a year), Vol. 11, No. 1, and Vol. 14, No. 1;
(b) 1926-1957: Prices Division.

Table 22.- Supplementary Real Estate and Machinery Inputs at 1935-39 Prices, Canadian Agriculture, 1926-1957

Year	Real Estate		Machinery	
	Repairs and Depreciation	Taxes	Repairs and Depreciation	Other
	- thousands of dollars -			
1926	72211	42160	74308	41793
1927	83038	41924	80456	49397
1928	80168	46232	87082	58747
1929	81231	49238	91853	65570
1930	85310	51756	88475	65052
1931	90097	54578	75456	61984
1932	84991	55038	73401	54233
1933	78079	57657	71329	52397
1934	76440	56536	67608	54294
1935	80760	57938	67438	55792
1936	70753	58191	63926	58404
1937	64024	56400	64937	61937
1938	68236	54479	64234	67501
1939	64236	54547	66184	76222
1940	57670	52620	67655	81628
1941	52685	54402	68607	85712
1942	50442	53982	77016	84819
1943	52550	54572	83090	86525
1944	50960	52731	88836	91003
1945	52805	52950	99393	94940
1946	62632	55801	105709	102856
1947	62859	56291	112015	109139
1948	58866	59548	116030	121539
1949	56730	61582	118392	137942
1950	56016	61418	131900	162458
1951	60908	64640	127954	180727
1952	67936	66663	129429	184995
1953	71314	69060	134528	194159
1954	72155	71134	134170	199027
1955	71874	71636	132699	208817
1956	77271	73114	127320	224808
1957	72997	73071	119396	227256

Table 23.- Current Dollar Values of (1) Labor, (2) Feed and Seed, (3) Fertilizer, (4) Electric Power, and (5) Miscellaneous, Canadian Agriculture, 1926-1957 (1941-1957 for Electric Power)

Year	Labor (a)		Feed and Seed * (b)	Fertilizer (b)	Electric Power (b)	Miscellaneous ** (b)
	1000 persons	-	thousands of dollars			-
1926	1251	799389	62611	6182		46838
1927	1284	807636	64952	5798		48882
1928	1305	827370	69861	6849		49893
1929	1307	819489	63696	8878		43849
1930	1238	692042	55467	12050		43723
1931	1216	533824	37757	9936		32529
1932	1237	421817	30992	5657		25803
1933	1257	404754	27992	5309		24230
1934	1277	431626	36673	6410		27547
1935	1298	464684	39128	6989		28112
1936	1319	493306	45584	7695		28516
1937	1339	535600	60783	10157		32386
1938	1359	550395	55412	11189		35192
1939	1379	584696	55467	11141		37213
1940	1344	623616	57677	12574		40792
1941	1224	664632	68440	12921	1770	48208
1942	1139	799578	109118	17041	1914	58354
1943	1118	987194	163977	18486	1914	62337
1944	1136	1116688	164096	19629	1954	69562
1945	1144	1224080	174163	22757	2152	71711
1946	1271	1418436	205581	24966	2616	75218
1947	1172	1416948	264065	29631	3194	88938
1948	1186	1564334	281844	32924	3636	99246
1949	1114	1484962	267877	39432	4463	102128
1950	965	1285380	271620	41903	6305	107720
1951	991	1474608	276579	46951	7919	126842
1952	927	1464660	285682	50905	9126	130560
1953	911	1457600	240155	58044	10967	129261
1954	906	1427856	274527	56021	12692	129084
1955	880	1365760	280197	54079	13914	138694
1956	808	1338048	321167	55644	15186	153697
1957	773	1360480	300695	56979	15914	148086

* Bought through commercial channels only.
** Sum total of (1) "Fruit and Vegetable Supplies, and (2) "Miscellaneous".
SOURCES.- Canada, Department of Trade and Commerce, D.B.S., Ottawa;
(a) 1926-1945: Canadian Labour Force Estimates, 1931-1945, Ref. Paper No. 23, rev. ed., 1957, pp. 20 and 15,
1946-1957: The Labour Force, November 1945-July 1958, Ref. Paper No. 58, rev. ed., 1958, pp. 58-59;
(b) 1926-1957: as under (a), Table 12, p. 96.

Table 24.- Price Indexes (1935-39 = 100; for Electric Power 1949 = 100) of (1) Labor, (2) Feed, (3) Fertilizer, (4) Electric Power, and (5) Hardware, Canadian Agriculture, 1926-1957 (1941-1957 for Electric Power)

Year	Average Annual Wage Rate Per Hired Help		Feed	Fertilizer	Electric Power	Hardware
	Dollars (a)	Index	(b)	(b)	(c)	(b)
1926	639	162.9	136.4	129.4		104.0
1927	629	160.4	145.6	129.4		102.4
1928	634	161.6	143.5	120.7		105.0
1929	627	159.9	140.0	119.8		101.7
1930	559	142.5	105.8	114.1		100.0
1931	439	111.9	74.6	106.9		99.8
1932	341	86.9	73.5	93.5		99.8
1933	322	82.1	73.5	95.5		93.9
1934	338	86.2	95.0	98.2		94.9
1935	358	91.3	93.5	97.0		96.4
1936	374	95.4	97.6	98.2		96.7
1937	400	102.0	127.6	101.4		101.0
1938	405	103.3	100.8	103.3		104.3
1939	424	108.1	80.5	100.2		101.6
1940	464	118.3	90.8	106.3		109.1
1941	543	138.4	95.6	114.0	128.8	113.5
1942	702	179.0	113.3	121.9	128.8	120.0
1943	883	225.1	120.0	112.9	128.0	120.7
1944	983	250.6	125.1	112.9	115.6	120.5
1945	1070	272.8	127.6	112.9	102.6	119.7
1946	1116	284.5	128.3	113.9	103.0	120.8
1947	1209	308.3	139.8	120.5	104.8	129.7
1948	1319	336.3	204.0	131.5	99.6	152.6
1949	1333	339.9	209.5	141.3	100.0	164.8
1950	1332	339.6	225.3	147.0	103.7	168.2
1951	1488	379.4	228.2	159.6	108.5	187.5
1952	1580	402.9	233.3	181.3	110.8	204.1
1953	1600	408.0	215.7	182.1	114.6	202.7
1954	1576	401.8	205.3	182.8	115.9	201.7
1955	1552	395.7	214.7	181.2	116.0	200.2
1956	1656	422.2	206.4	180.8	115.6	209.9
1957	1760	448.8	204.5	183.4	115.2	224.1

SOURCES.- Canada, Department of Trade and Commerce, D.B.S., Ottawa;
(a) 1926-1957: Quarterly Bulletin of Agricultural Statistics, preceded by Monthly Bulletin of Agricultural Statistics (for the period 1940-1957 the average of January, May and August wages was multiplied by 12);
(b) 1926-1957: as under (a), Table 13, p. 97);
(c) 1941-1957: Prices Division, Retail Section.

Table 25.- Labor, Feed, Fertilizer, Electric Power and Miscellaneous Inputs at 1935-39 Prices, Canadian Agriculture, 1926-1957

Year	Labor	Feed	Fertilizer	Electric Power	Miscellaneous
			- thousands of dollars -		
1926	490724	45902	4777		45036
1927	503514	44610	4481		47736
1928	511986	48684	5674		47517
1929	512501	45497	7411		43116
1930	485644	52426	10561		43723
1931	477055	50613	9295		32594
1932	485405	42166	6050		25855
1933	493001	38084	5559		25804
1934	500726	38603	6527		29027
1935	508964	41848	7205		29162
1936	517092	46705	7836		29489
1937	525098	47636	10017		32065
1938	532812	54972	10832		33741
1939	540884	68903	11119		36627
1940	527148	63521	11829		37390
1941	480225	71590	11334	1770	42474
1942	446692	96309	13979	1914	48628
1943	438558	136648	16374	1927	51646
1944	445606	131172	17386	2178	57728
1945	448710	136491	20157	2704	59909
1946	498572	160235	21919	3274	62266
1947	459600	188888	24590	3924	68572
1948	465160	138159	25037	4704	65037
1949	436882	127865	27906	5751	61971
1950	378498	120559	28505	7832	64043
1951	388668	121200	29418	9405	67649
1952	363529	122453	28078	10612	63969
1953	357255	111338	31875	12336	63770
1954	355365	133720	30646	14118	63998
1955	345150	130506	29845	15460	69278
1956	316931	155604	30776	16930	73224
1957	303137	147039	31068	17801	66080

Table 26.- Total Inputs at Average Prices of 1935-39, 1940-44, 1945-49 and 1950-54, Canadian Agriculture, 1926-1957

Year	Weight Period			
	1935-39	1940-44	1945-49	1950-54
	- thousands of dollars -			
1926	1087110	1563511	2359681	3076813
1927	1124700	1619365	2441049	3184357
1928	1155690	1658862	2496256	3254702
1929	1169929	1674496	2514310	3278309
1930	1168055	1651700	2465232	3222207
1931	1145941	1620587	2422291	3167089
1932	1121255	1598759	2401599	3135717
1933	1114621	1594650	2401922	3131872
1934	1124190	1608074	2423082	3157484
1935	1135154	1629250	2458640	3203246
1936	1129573	1627020	2462556	3202258
1937	1134569	1635982	2477305	3217675
1938	1146812	1657556	2512512	3262280
1939	1177322	1697095	2570907	3336449
1940	1157814	1663673	2514341	3261503
1941	1115486	1580417	2370108	3079139
1942	1130060	1571667	2336468	3045999
1943	1187319	1630997	2414982	3156901
1944	1200224	1650175	2440384	3188611
1945	1236128	1691829	2492981	3260502
1946	1340079	1845565	2730638	3568955
1947	1352539	1831241	2685471	3520658
1948	1315100	1791947	2623715	3430912
1949	1299404	1753886	2547877	3333012
1950	1281927	1692027	2415199	3167923
1951	1327749	1752029	2497857	3273763
1952	1318122	1725760	2446623	3212690
1953	1327627	1731980	2443108	3209304
1954	1358569	1763705	2485312	3266813
1955	1361103	1759610	2470081	3246916
1956	1372748	1753998	2445998	3220472
1957	1330069	1695466	2360191	3104880

Table 27.- Aggregate Quantity Indexes (1926 = 100) of Total Input Based on (1) Constant Weight (Weight Periods: 1935-39, 1940-44, 1945-49, and 1950-54), (2) Paasche, and (3) Chain Index Formulas, Canadian Agriculture, 1926-1957

Year	Constant Weight: Weight Period: 1935-39	1940-44	1945-49	1950-54	Paasche	Chain
1926	100.0	100.0	100.0	100.0	100.0	100.0
1927	103.5	103.6	103.4	103.5	102.8	102.8
1928	106.3	106.1	105.8	105.8	105.3	105.4
1929	107.6	107.1	106.6	106.5	106.5	106.6
1930	107.4	105.6	104.5	104.7	106.5	106.4
1931	105.4	103.7	102.7	102.9	105.5	105.0
1932	103.2	102.3	101.8	101.9	104.0	103.4
1933	102.5	102.0	101.8	101.8	103.2	102.7
1934	103.4	102.9	102.7	102.6	103.9	103.8
1935	104.4	104.2	104.2	104.1	104.6	104.6
1936	103.9	104.1	104.4	104.1	104.0	104.1
1937	104.3	104.6	105.0	104.6	104.3	104.5
1938	105.5	106.0	106.5	106.0	105.5	105.9
1939	108.3	108.5	109.0	108.4	107.9	108.8
1940	106.5	106.4	106.6	106.0	106.2	106.9
1941	102.6	101.1	100.4	100.1	101.6	102.5
1942	104.0	100.5	99.0	99.0	100.9	102.7
1943	109.2	104.3	102.3	102.6	103.1	106.8
1944	110.4	105.5	103.4	103.6	103.5	108.0
1945	113.7	108.2	105.6	106.0	105.1	110.4
1946	123.3	118.0	115.7	116.0	114.8	120.9
1947	124.4	117.1	113.8	114.4	112.4	118.6
1948	121.0	114.6	111.2	111.5	111.8	116.3
1949	119.5	112.2	108.0	108.3	109.1	112.9
1950	117.9	108.2	102.4	103.0	104.3	107.2
1951	122.1	112.1	105.9	106.4	106.5	110.9
1952	121.3	110.4	103.7	104.4	104.2	108.9
1953	122.1	110.8	103.5	104.3	103.6	108.7
1954	125.0	112.8	105.3	106.2	105.7	110.6
1955	125.2	112.5	104.7	105.5	105.5	109.9
1956	126.3	112.2	103.7	104.7	103.1	108.9
1957	122.3	108.4	100.0	100.9	98.5	105.0

Table 28.- Current Dollar Values of Farm Outputs: (1) Field Products, (2) Animal Products, (3) Forest Products, and (4) House Rent, Canadian Agriculture, 1926-1957

Year	Field Products			
	Cash income * (a)	Income in Kind ** (c)	Inventory changes (d)	Total
	- thousands of dollars -			
1926	555731	42502	3375	601608
1927	523798	37224	59229	630251
1928	618412	32917	- 18127	633202
1929	484178	36067	- 135435	384810
1930	271119	39409	82985	393513
1931	177720	23330	- 36142	164908
1932	186115	20330	13986	220431
1933	190696	27336	- 33829	184203
1934	231658	27752	- 5747	253663
1935	234482	26946	7458	268886
1936	255832	33052	- 42047	246837
1937	262431	30897	2459	295787
1938	296540	28665	39525	364730
1939	343931	30889	32662	407482
1940	303205	31761	54011	388977
1941	326591	33266	- 65754	294103
1942	364358	41357	316361	722076
1943	535388	50321	- 164508	421201
1944	851738	50327	- 118908	783157
1945	688834	53748	- 161310	581272
1946	729234	56554	50138	835926
1947	863775	58147	- 38212	883710
1948	1033623	62686	90306	1186615
1949	1087582	57292	- 100855	1044019
1950	778582	54295	154474	987351
1951	1164131	59658	231520	1455309
1952	1390522	81618	133561	1605701
1953	1321866	63778	49683	1435327
1954	889588	62568	- 133059	819097
1955	817505	62778	180553	1060836
1956	1067345	63515	213784	1344644
1957	952848	62365	- 152213	863000

* Sum total of cash income from the sale of wheat, oats, barley, and rye, plus Wheat Board payments.

** Sum total of farm income in kind of (1) fruit and vegetables, and (2) other field products.

(continued)

Table 28.- (Continued)

Year	Animal Products			
	Cash income * (b)	Income in Kind ** (c)	Inventory changes (d)	Total
	- thousands of dollars -			
1926	383529	85159	- 1243	467445
1927	394367	86279	- 6223	474423
1928	422196	90519	- 5985	506730
1929	423693	90910	7732	522335
1930	348897	75292	843	425032
1931	277582	54594	16692	348868
1932	210063	40140	6373	256576
1933	216766	42007	412	259185
1934	257251	49191	- 1557	304885
1935	282633	52343	- 3732	331244
1936	314869	56232	- 475	370626
1937	358699	60784	- 13279	406204
1938	336301	61735	- 4478	393558
1939	350694	60875	20936	432505
1940	411269	61426	23642	496337
1941	530972	74582	13165	618719
1942	716460	90192	10892	817544
1943	837354	94526	47728	979608
1944	931971	93429	- 9475	1015925
1945	946422	103106	- 77981	971547
1946	927853	106423	- 36636	997640
1947	1027334	112383	- 12565	1127152
1948	1317312	133600	- 102924	1347988
1949	1283206	121370	2782	1407358
1950	1321341	115321	- 56529	1380133
1951	1563608	133229	59891	1756728
1952	1412284	122851	156516	1691651
1953	1413309	120096	34852	1568257
1954	1435564	112656	35083	1583303
1955	1480827	112770	31300	1624897
1956	1534633	106065	6258	1646956
1957	1585872	103196	13546	1702614

* Sum total of cash income from the sale of cattle and calves, hogs, sheep, and lambs, dairy products, poultry, eggs and other livestock and products.

** Sum total of farm income in kind of dairy products, poultry and eggs, and meat.

(continued)

Table 28.- Concluded

Year	Forest Products			House Rent (c)
	Cash Income * (b)	Income in Kind (c)	Total	
	- thousands of dollars -			
1926	21934	34650	56584	77263
1927	22234	33401	55635	83506
1928	23638	32421	56059	85271
1929	23894	31386	55280	87706
1930	21909	30886	52795	80487
1931	16611	30694	47305	73742
1932	12867	25511	38378	63346
1933	12181	23061	35242	61229
1934	14325	22298	36623	61415
1935	15468	22846	38314	63974
1936	16581	23112	39693	62501
1937	17326	22797	40123	62745
1938	16817	23477	40294	60492
1939	17451	23527	40978	61701
1940	20907	22995	43902	59533
1941	23286	24553	47839	59470
1942	26797	28689	55486	63529
1943	27501	29702	57203	68625
1944	30887	31558	62445	72373
1945	29553	30049	59602	73288
1946	35456	29793	65249	77208
1947	45635	31021	76656	83486
1948	43738	28220	71958	91401
1949	41921	27213	69134	93304
1950	43863	26843	70706	99461
1951	55011	30805	85816	110875
1952	56337	27125	83462	114294
1953	51048	28452	79500	122418
1954	50275	27837	78112	121508
1955	51866	26166	78032	126721
1956	61542	27792	89334	131899
1957	53141	27306	80447	134568

* Sum total of cash income from the sale of forest and maple products.

** Sum total of farm income in kind of (1) honey and maple products, and (2) forest products.

SOURCES:- Canada, Department of Trade and Commerce, Ottawa;

(a) 1926-1957: Handbook of Agricultural Statistics, Part II (Farm Income, 1926-57), Ref. Paper No. 25, rev. ed., 1958, p. 38;

(b) 1926-1957: Ibid., p. 39;

(c) 1926-1957: Ibid., p. 58;

(d) 1926-1957: Agriculture Division, Farm Finance Section.

Table 29.- Price Indexes (1935-39 = 100) of (1) Field Products, (2) Animal Products, (3) Lumber and Timber, and (4) Building Materials, Tax and Interest Rates, Canada, 1926-1957

Year	Field Products * (a)	Animal Products * (a)	Lumber and Timber * (b)	Building Materials, Tax and Interest Rates ** (c)
1926	158.5	130.2	111.6	124.8
1927	149.4	127.8	108.6	121.5
1928	134.3	138.2	115.5	122.8
1929	137.2	144.4	118.3	111.2
1930	105.8	133.3	100.3	126.1
1931	65.0	92.7	84.5	103.9
1932	60.4	70.5	75.3	96.6
1933	69.3	69.2	78.1	93.9
1934	80.5	86.5	87.2	94.9
1935	84.4	94.1	86.4	94.0
1936	102.2	93.7	97.0	98.2
1937	128.9	106.0	109.7	103.4
1938	100.9	104.8	99.2	99.6
1939	83.7	101.5	106.4	104.6
1940	85.4	106.7	118.5	109.0
1941	88.9	124.4	137.1	115.5
1942	109.7	144.6	152.8	126.4
1943	129.0	161.8	170.2	130.6
1944	144.5	166.1	183.9	142.1
1945	162.5	170.2	185.2	144.1
1946	177.9	181.2	197.7	146.2
1947	184.1	200.2	262.7	155.8
1948	200.6	263.7	330.1	178.0
1949	191.9	265.4	349.2	187.9
1950	191.9	281.4	388.2	199.6
1951	200.4	336.9	457.3	224.0
1952	223.0	277.5	437.8	232.4
1953	179.4	263.8	419.2	238.0
1954	170.9	256.2	419.0	240.8
1955	180.1	245.1	441.3	243.0
1956	181.6	246.9	450.6	250.6
1957	163.6	258.0	433.3	257.4

* Wholesale price index numbers.

** Arithmetic average of (1) building materials, and (2) tax and interest rates.

SOURCES:- Canada, Department of Trade and Commerce, Ottawa;

(a) 1926-1951: Prices and Price Indexes, 1949-1952, p. 104,
1952-1957: Prices and Price Indexes (monthlies);

(b) 1926-1951: as under (a), p. 32,
1952-1957: as under (a);

(c) 1926-1952: as under (a), pp. 93 and 96,
1953-1957: Price Index Numbers of Commodities and Services Used by Farmers (3 times a year).

Table 30.- Field Products, Animal Products, Forest Products, and House Rent at 1935-39 Wholesale Prices, Canadian Agriculture, 1926-1957

Year	Field Products	Animal Products	Forest Products	House Rent
		- thousands of dollars -		
1926	379563	359021	50702	61909
1927	421855	371223	51229	68729
1928	471483	366664	48536	69439
1929	280474	361728	46729	78872
1930	371940	318854	52637	63828
1931	253705	376341	55982	70974
1932	364952	363938	50967	65576
1933	265805	374545	45124	65207
1934	315109	352468	41999	64715
1935	318585	352013	44345	68057
1936	241523	395545	40921	63647
1937	229470	383211	36575	60682
1938	361477	375532	40619	60735
1939	486836	426113	38513	58988
1940	455476	465170	37048	54617
1941	330824	497362	34894	51489
1942	658228	565383	36313	50260
1943	326512	605444	33609	52546
1944	541977	611634	33956	50931
1945	357706	570827	32182	50859
1946	469885	550574	33004	52810
1947	480016	563013	29180	53585
1948	591533	511182	21799	51349
1949	544043	530278	19798	49656
1950	514513	490452	18214	49830
1951	736202	521439	18766	49498
1952	720045	609604	19064	49180
1953	800071	594487	18965	51436
1954	479284	617995	18642	50460
1955	589026	662953	17682	52148
1956	740443	667054	19826	52633
1957	527506	659928	18566	52280

Table 31.- Total Farm Outputs at (mainly) Average Wholesale Prices of 1935-39, 1940-44, 1945-49 and 1950-54, Canada, 1926-1957

Year	Weight Period			
	1935-39	1940-44	1945-49	1950-54
	- thousands of dollars -			
1926	851196	1082962	1706999	2105256
1927	913036	1156597	1823407	2239194
1928	956122	1202295	1898588	2312311
1929	767803	991382	1548137	1943197
1930	807259	1023282	1614443	1989360
1931	757002	986359	1542321	1954216
1932	845432	1078565	1697483	2100403
1933	750681	973572	1522493	1913339
1934	774292	992102	1556122	1931667
1935	783000	1003082	1573156	1954630
1936	741636	967694	1509679	1904535
1937	709938	926574	1444585	1821166
1938	838363	1069188	1680890	2071632
1939	1010450	1274751	2011707	2444050
1940	1012313	1287062	2027632	2477948
1941	914570	1186188	1857811	2312133
1942	1310184	1647593	2607053	3140254
1943	1018111	1332831	2081822	2606798
1944	1238499	1580301	2488661	3038239
1945	1011574	1314619	2057690	2559134
1946	1106273	1414885	2224997	2726341
1947	1125795	1438821	2261590	2766631
1948	1175863	1476181	2330894	2798866
1949	1143775	1444938	2277020	2748894
1950	1073010	1353771	2132868	2572769
1951	1315905	1633836	2589003	3070911
1952	1397893	1751095	2768545	3309213
1953	1464959	1821714	2886039	3425653
1954	1166382	1495408	2346088	2869132
1955	1321810	1681676	2644724	3208126
1956	1479955	1860150	2937752	3522349
1957	1258280	1610336	2527913	3084802

Table 32.- Aggregate Quantity Indexes (1926 = 100) of Total Outputs Based on (1) Constant Weight (Weight Periods: 1935-39, 1940-44, 1945-49, and 1950-54), (2) Paasche, and (3) Chain Index Formulas, Using Primarily Wholesale Prices as Weights, Canadian Agriculture, 1926-1957

Year	Constant Weight; Weight Period: 1935-39	1940-44	1945-49	1950-54	Paasche	Chain
1926	100.0	100.0	100.0	100.0	100.0	100.0
1927	107.3	106.8	106.8	106.4	107.6	107.6
1928	112.3	111.0	111.2	109.8	112.3	113.4
1929	90.2	91.5	90.7	92.3	89.9	90.9
1930	94.8	94.5	94.6	94.5	94.3	95.6
1931	88.9	91.1	90.4	92.8	92.4	92.0
1932	99.3	99.6	99.4	99.8	99.7	99.3
1933	88.2	89.9	89.2	90.9	88.6	89.5
1934	91.0	91.6	91.2	91.8	91.3	92.2
1935	92.0	92.6	92.2	92.8	92.4	93.2
1936	87.1	89.4	88.4	90.5	86.3	89.1
1937	83.4	85.6	84.6	86.5	81.3	85.3
1938	98.5	98.7	98.5	98.4	98.6	102.9
1939	118.7	117.7	117.9	116.1	117.7	124.0
1940	118.9	118.8	118.8	117.7	118.4	124.9
1941	107.4	109.5	108.8	109.8	110.3	115.0
1942	153.9	152.1	152.7	149.2	152.0	157.5
1943	119.6	123.1	122.0	123.8	123.3	128.3
1944	145.5	145.9	145.8	144.3	145.8	152.4
1945	118.8	121.4	120.5	121.6	119.5	125.8
1946	130.0	130.6	130.3	129.5	130.3	137.2
1947	132.3	132.9	132.5	131.4	131.8	139.5
1948	138.1	136.3	136.5	132.9	135.9	144.6
1949	134.4	133.4	133.4	130.6	132.4	141.7
1950	126.1	125.0	124.9	122.2	123.2	132.6
1951	154.6	150.8	151.7	145.9	145.6	158.4
1952	164.2	161.7	162.2	157.2	158.3	171.7
1953	172.1	168.2	169.1	162.7	161.2	178.6
1954	137.0	138.1	137.4	136.3	134.8	149.8
1955	155.3	155.3	154.9	152.4	149.2	167.2
1956	173.9	171.8	172.1	167.3	164.0	184.2
1957	147.8	148.7	148.1	146.5	144.4	160.7

Table 33.- Current Dollar Values of Seventeen Farm Output Categories, Canada, 1935-1957

Year	Grains (a)	Potatoes (b)	Fruits (c)	Vegetables (d)	Tobacco (e)	Sugar Beets (f)	Clover and Grass Seed (f)	Hay and Clover (f)
				- thousands of dollars -				
1935	175913	16046	26929	23220	10760	2881	844	3730
1936	143181	28239	24766	24849	9418	3511	1181	2291
1937	181149	21611	29166	26930	16802	2825	2345	4604
1938	249349	17756	28897	27616	20269	3404	2996	3397
1939	281332	28984	23182	32603	19444	4417	2827	1567
1940	272114	18364	22263	34496	9220	4960	2202	1577
1941	152333	27679	26597	46119	12445	5077	4114	1669
1942	543354	38217	35076	49051	22442	6131	3950	1869
1943	209434	49045	40023	59172	21374	5099	6798	4570
1944	545442	45017	49745	67445	23528	5506	8083	8108
1945	335996	50494	43202	67600	32186	6681	8962	5578
1946	565564	53290	53751	74142	36584	7540	10491	5632
1947	598435	49402	51599	79843	48560	8833	8826	5493
1948	868181	58273	52561	89725	41909	9286	20872	5800
1949	748620	48991	46673	77253	54416	10507	14317	4126
1950	701297	43738	44529	72976	56759	13479	13820	4274
1951	1142870	87190	46345	87927	57442	16439	11696	3323
1952	1206913	98076	55706	105259	66672	14792	10994	1377
1953	1104198	47103	61350	93096	59976	13621	9599	1848
1954	488822	44906	63433	88067	66888	11973	12774	1802
1955	725452	51367	53554	91047	75837	12875	8955	1232
1956	1008691	60954	49915	92108	64129	12397	10720	1478
1957	525429	53077	52211	92028	73063	16192	6203	1076

(continued)

Table 33.- Continued

Year	Miscellaneous (g)	Cattle, hogs and Sheep (h)	Dairy Products (i)	Poultry and Eggs (j)	Wool (k)	Fur (f)	Forest Products (l)	Honey and Maple Products (m)	House Rent (n)
				- thousands of dollars -					
1935	8364	141439	121517	58896	1188	5514	34730	6473	63974
1936	9185	162984	132477	64134	1502	6532	35918	6988	62501
1937	10146	188545	140277	66079	2086	6802	37810	4937	62745
1938	10831	168840	148793	64944	1410	6476	36385	7219	60492
1939	12892	216061	139028	67347	1369	5793	37462	6657	61701
1940	13804	267726	142896	75137	2212	6148	39617	6771	59533
1941	17735	332406	187899	91612	2564	4796	44188	6634	59470
1942	21596	419150	255100	127459	3132	6732	48663	10135	63529
1943	25373	521921	282238	157741	3369	8957	51320	11578	68625
1944	29957	527376	304513	166793	3482	8242	53226	15064	72373
1945	29200	453023	308574	190950	3409	10276	54922	10368	73288
1946	28586	468996	329522	185226	3089	6785	58769	10948	77208
1947	32401	525488	372974	205635	2779	11718	62274	22378	83486
1948	39726	659544	445200	224217	2268	7970	62791	18238	91401
1949	38848	765091	406634	220099	2037	8797	59670	14432	93304
1950	36142	778806	381068	202184	3433	10835	59759	15091	99461
1951	45456	1011171	430549	293938	4230	11418	76984	14613	110875
1952	45668	946316	437420	290396	2387	10262	71067	17509	114294
1953	44244	784021	452206	315348	2450	10195	72003	11786	122418
1954	40172	800656	461884	302156	2451	12974	66849	14705	121508
1955	40285	806162	473511	323286	2277	15678	66919	15328	126721
1956	44020	809771	467295	348183	2328	15198	79230	14517	131899
1957	43481	841817	494060	342826	2507	16118	69912	16061	134568

(continued)

Table 33.- Concluded

SOURCES: Canada, Department of Trade and Commerce, D.B.S., Ottawa:

(a) sum of cash income from the sale of wheat, oats, barley, rye, flaxseed, (Handbook of Agricultural Statistics, Part II, Farm Income, 1926-57, Ref. Paper No. 25, rev. ed., 1958, p. 38) and corn (Agriculture Division, Farm Finance Section), plus Wheat Board Payments (Handbook of Agricultural Statistics, Part II, p. 38), plus income in kind from cereal products (Agriculture Division, Farm Finance Section), plus or minus inventory changes of field products (ibid);
(b) sum of cash income from the sale of potatoes (Handbook of Agricultural Statistics, Part II, p. 38), plus income in kind from potatoes (Agriculture Division, Farm Finance Section);
(c) sum of cash income from the sale of fruits (Handbook of Agricultural Statistics, Part II, p. 38), plus income in kind from fruits and greenhouse products (Agriculture Division, Farm Finance Section);
(d) sum of cash income from the sale of vegetables (Handbook of Agricultural Statistics, Part II, p. 38), plus income in kind from vegetables (Agriculture Division, Farm Finance Section);
(e) Handbook of Agricultural Statistics, Part II, p. 38;
(f) Agriculture Division, Farm Finance Section;
(g) sum of cash income from sale of D.B.S. miscellaneous and fibre flax (Agriculture Division, Farm Finance Section);
(h) sum of cash income from the sale of cattle and calves, hogs, sheep and lambs (Handbook of Agricultural Statistics, Part II, p. 39), and horses (Agriculture Division, Farm Finance Section), plus income in kind from meat (Handbook of Agricultural Statistics, Part II, p. 59), plus or minus inventory changes of animal products (Agriculture Division, Farm Finance Section);
(i) sum of cash income from the sale of dairy products (Handbook of Agricultural Statistics, Part II, p. 39), plus income in kind from dairy products (ibid., p. 58);
(j) sum of cash income from the sale of poultry and eggs (Handbook of Agricultural Statistics, Part II, p. 39), plus income in kind from poultry and eggs (ibid., p. 58);
(k) sum of cash income from the sale of wool (Agriculture Division, Farm Finance Section), plus income in kind from wool (ibid.);
(l) sum of cash income from the sale of forest products (Agriculture Division, Farm Finance Section), plus income in kind from forest products (Handbook of Agricultural Statistics, Part II, p. 58);
(m) sum of cash income from the sale of maple products and honey (Agriculture Division, Farm Finance Section), plus income in kind from honey and maple products (Handbook of Agricultural Statistics, Part II, p. 58);
(n) Handbook of Agricultural Statistics, Part II, p. 58.

Table 34.- Farm Price Indexes (1935-39 = 100) Pertaining to Seventeen Farm Output Categories, Canada, 1935-1957

Year	Grains (a)	Potatoes (a)	Fruits* (a)	Vegetables (a)	Tobacco* (a)	Sugar Beets* (a)	Forage Crop Seed (b)	Tame Hay (c)
1935	82.0	66.5	101.8	101.7	96.5	87.1	66.7	98.2
1936	94.9	130.4	105.7	104.2	99.0	93.0	111.1	98.7
1937	145.2	102.4	103.0	104.0	113.3	94.2	111.1	97.0
1938	105.8	81.1	97.0	97.2	103.8	105.4	88.9	97.7
1939	72.3	118.9	92.2	94.7	87.2	120.6	100.0	108.2
1940	78.3	112.2	82.1	100.2	79.7	108.6	100.0	111.3
1941	82.0	100.2	96.6	116.7	82.7	121.2	155.6	159.3
1942	95.7	170.4	121.5	139.4	91.6	135.1	100.0	137.2
1943	124.1	209.5	160.4	173.3	106.8	167.7	155.6	142.9
1944	161.7	176.6	184.7	184.7	123.4	177.2	155.6	163.5
1945	186.4	211.4	188.0	187.6	128.7	169.5	166.7	157.2
1946	212.4	227.2	201.4	189.3	143.6	199.7	200.0	166.1
1947	219.0	186.5	186.4	209.3	149.8	229.1	188.9	199.1
1948	226.8	245.9	185.3	234.5	155.6	233.4	255.6	205.7
1949	222.4	168.6	180.8	223.6	174.5	218.5	266.7	253.1
1950	220.7	155.0	158.9	213.4	174.5	262.0	200.0	234.0
1951	216.9	177.1	169.2	231.5	182.5	239.0	211.1	196.6
1952	215.1	469.6	187.8	266.4	179.7	242.0	155.6	183.5
1953	202.1	181.3	213.5	245.8	172.0	214.0	133.3	176.7
1954	181.3	172.6	220.0	233.8	178.8	192.6	200.0	180.3
1955	179.4	242.8	188.0	240.5	178.3	214.4	122.2	193.7
1956	183.6	243.7	180.0	248.4	186.4	276.8	211.1	198.4
1957	161.7	199.2	213.5	258.9	190.9	217.6	133.3	196.3

* The D.B.S. indices were adjusted to get a base period average of 100.

(continued)

Table 34.- Continued

Year	General Wholesale Index (a)	Livestock (a)	Dairy Products (a)	Poultry and Eggs (a)	Domestic raw wool (e)	Fur (a)	W.P.I. ☆ Lumber and Timber (f)	Maple Products (a)	Building Materials, Tax and Interest Rates (g)
1935	94.4	91.1	90.5	93.6	77.4	138.2	86.4	94.8	94.0
1936	96.8	91.2	96.6	101.4	104.7	121.4	97.0	98.2	98.2
1937	107.7	105.0	106.2	101.1	138.9	100.2	109.7	99.1	103.4
1938	102.0	105.1	109.5	104.6	82.9	79.8	99.2	97.6	99.6
1939	99.2	107.5	97.3	99.4	95.6	60.5	106.4	110.7	104.6
1940	108.0	114.3	106.3	99.2	142.3	67.8	118.5	115.6	109.0
1941	116.4	134.6	133.6	113.5	147.7	93.3	137.1	130.9	115.5
1942	123.0	165.4	155.5	135.5	147.4	83.4	152.8	166.6	126.4
1943	127.9	187.4	172.0	158.3	147.4	117.9	170.2	203.0	130.6
1944	130.6	186.8	182.0	148.3	147.4	125.9	183.9	249.8	142.1
1945	132.1	193.8	183.0	158.0	147.4	125.2	185.2	258.7	144.1
1946	138.9	210.1	198.2	166.3	147.4	113.4	197.7	258.2	146.2
1947	163.3	231.5	224.4	168.9	167.0	68.4	262.7	303.4	155.8
1948	193.4	312.5	279.3	201.3	209.2	57.3	330.1	311.0	178.0
1949	198.3	337.4	260.2	210.6	219.2	48.4	349.2	320.1	187.9
1950	211.2	378.6	248.0	193.3	328.6	52.8	388.2	310.9	199.6
1951	240.2	477.4	274.7	247.6	485.8	54.8	457.3	317.8	224.0
1952	226.0	368.3	273.4	197.5	251.2	48.3	437.8	305.5	232.4
1953	220.7	330.3	269.5	219.2	260.3	38.4	419.2	325.8	238.0
1954	217.0	317.1	267.6	190.9	261.1	54.7	419.0	396.6	240.8
1955	218.9	296.8	265.9	197.6	244.0	50.5	441.3	434.4	243.0
1956	225.6	296.4	267.8	200.2	248.8	42.4	450.6	340.3	250.6
1957	227.4	291.9	273.9	177.7	272.2	42.4	433.3	284.1	257.4

☆ Wholesale price index.

(continued)

Table 34.- Concluded

SOURCES.- Canada, Department of Trade and Commerce, D.B.S., Ottawa:

(a) Agriculture Division, Farm Finance Section;

(b) derived from quantity and current value estimates of domestic production,
1935-1945: Quarterly Bulletin of Agricultural Statistics, Vol. 39, pp. 146-150,
1946-1957: Ibid., April-June issues;

(c) derived from average Canadian farm prices of tame hay,
1935-1940: Handbook of Agricultural Statistics, Part I (Field Crops), Ref. Paper No. 25, 1951, p. 133 (under heading "Hay and Clover"),
1941-1953: Ibid., Supplement to Ref. Paper No. 25, Part I, 1955, p. 9,
1953-1957: Agriculture Division, Crops Section;

(d) 1935-1952: Prices and Price Indexes, 1949-1952, p. 20,
1953-1957: Prices and Price Indexes (monthlies);

(e) 1935-1952: as under (d), p. 30,
1953-1957: as under (d);

(f) 1935-1952: as under (d), p. 32,
1953-1957: as under (d);

(g) 1935-1957: as under (c), Table 20.

Table 35.- Farm Outputs (Seventeen Categories) at 1935-39 Prices, Canada, 1935-1957

Year	Grains	Potatoes	Fruits	Vegetables	Tobacco	Sugar Beets	Clover and Grass Seed	Hay and Clover
				- thousands of dollars -				
1935	214528	24129	26453	22832	11150	3308	1265	3798
1936	150876	21656	23430	23847	9513	3775	1063	2321
1937	124758	21104	28316	25894	14830	2999	2111	4746
1938	235680	21894	29791	28412	19527	3230	3370	3477
1939	389118	24377	25143	34428	22298	3662	2827	1448
1940	347527	16367	27117	34427	11568	4567	2202	1417
1941	185772	27624	27533	39519	15048	4189	2644	1048
1942	567768	22428	28869	35187	24500	4538	3950	1362
1943	168762	23410	24952	34144	20013	3040	4369	3198
1944	337317	25491	26933	36516	19066	3107	5195	4959
1945	180255	23886	22980	36034	25008	3942	5376	3548
1946	266273	23455	26689	39166	25476	3776	5246	3391
1947	273258	26489	27682	38148	32416	3856	4672	2759
1948	382796	23698	28365	38262	26934	3978	8166	2820
1949	336610	29058	25815	34550	31184	4809	5368	1630
1950	317760	28218	28023	34197	32527	5145	6910	1826
1951	526911	49232	27391	37981	31475	6878	5540	1690
1952	561094	20885	29662	39512	37102	6112	7066	750
1953	546362	25981	28735	37875	34870	6365	7201	1046
1954	269620	26017	28833	37668	37409	6216	6387	999
1955	404377	21156	28486	37857	42533	6005	7328	636
1956	549396	25012	27730	37080	34404	4479	5078	745
1957	324941	26645	24455	35546	38273	7441	4653	548

(continued)

Table 35.- Concluded

Year	Miscell-aneous	Cattle, Hogs and Sheep	Dairy Products	Poultry and Eggs	Wool	Fur	Forest Products	Honey and Maple Products	House Rent
				- thousands of dollars -					
1935	8860	155257	134273	62923	1535	3990	40197	6828	68057
1936	9489	178710	137140	63248	1434	5380	37029	7116	63647
1937	9421	179567	132088	65360	1502	6788	34467	4982	60682
1938	10619	160647	135884	62088	1701	8115	36678	7396	60735
1939	12996	200987	142886	67754	1432	9575	35209	6014	58988
1940	12781	234231	134427	75743	1554	9068	33432	5857	54617
1941	15236	246958	140643	80715	1736	5140	32230	5068	51489
1942	17558	253416	164051	94066	2125	8072	31848	6083	50260
1943	19838	278506	164092	99647	2286	7597	30153	5703	52546
1944	22938	282321	167315	112470	2362	6546	28943	6030	50931
1945	22104	233758	168620	120854	2313	8208	29656	4008	50859
1946	20580	223225	166257	111381	2096	5983	29726	4240	52810
1947	19841	226993	166209	121750	1664	17132	23705	7376	53585
1948	20541	211054	159398	111384	1084	13909	19022	5864	51349
1949	19590	226761	156277	104510	929	18176	17088	4508	49656
1950	17113	205707	153656	104596	1045	20521	15394	4854	49830
1951	18924	211808	156734	118715	871	20836	16834	4598	49498
1952	20207	256942	159993	147036	950	21246	16233	5731	49180
1953	20047	237366	167794	143863	941	26549	17176	3618	51436
1954	18512	252493	172602	158280	939	23718	15954	3708	50460
1955	18403	271618	178079	163606	933	31046	15164	3528	52148
1956	19512	273202	174494	173918	936	35656	17583	4266	52633
1957	19121	288392	180380	192924	921	38014	16135	5653	52280

Table 36.- Total Farm Outputs at (mainly) Average Farm Prices of 1935-39, 1940-44, 1945-49 and 1950-54, Canada, 1935-1957

	Weight Period			
	1935-39	1940-44	1945-49	1950-54
	- thousands of dollars -			
1935	789384	1062312	1717435	2087396
1936	739676	1017632	1622780	2016795
1937	719615	993255	1570607	1960055
1938	829243	1107133	1795286	2163102
1939	1039140	1358116	2255517	2665246
1940	1006905	1334498	2205911	2646475
1941	882594	1215441	1946753	2419533
1942	1316081	1697396	2864244	3333263
1943	942258	1305789	2076335	2599537
1944	1138442	1527563	2492904	3015097
1945	941409	1288663	2043393	2521561
1946	1009770	1356338	2189007	2647930
1947	1047535	1399591	2248062	2703975
1948	1108625	1450035	2378901	2791635
1949	1066519	1405968	2289347	2715769
1950	1027322	1351382	2192111	2589173
1951	1285917	1650657	2741452	3147153
1952	1379701	1770145	2949762	3410404
1953	1357226	1739515	2887728	3328679
1954	1109818	1483010	2365208	2845340
1955	1282905	1679726	2728324	3223373
1956	1436313	1850063	3052357	3544404
1957	1256322	1669082	2665796	3195941

Table 37.- Aggregate Quantity Index Numbers of Farm Outputs (1935 = 100) Based Primarily on Farm Prices Using (1) Constant Weight (Weight Periods: 1935-39, 1940-44, 1945-49, and 1950-54), (2) Paasche, and (3) Chain Index Formulas, Canada, 1935-1957

Year	Constant Weight; Weight Period:				Paasche	Chain
	1935-39	1940-44	1945-49	1950-54		
1935	100.0	100.0	100.0	100.0	100.0	100.0
1936	93.7	95.8	94.5	96.6	93.6	94.5
1937	91.2	93.5	91.5	93.9	88.0	92.2
1938	105.0	104.2	104.5	103.6	105.0	110.5
1939	131.6	127.8	131.3	127.7	126.8	139.0
1940	127.6	125.6	128.4	126.8	124.8	136.3
1941	111.8	114.4	113.4	115.9	114.7	124.4
1942	166.7	159.8	166.8	159.7	156.5	170.0
1943	119.4	122.9	120.9	124.5	123.7	135.3
1944	144.2	143.8	145.2	144.4	144.0	158.0
1945	119.3	121.3	119.0	120.8	118.1	130.5
1946	127.9	127.7	127.5	126.9	127.4	140.6
1947	132.7	131.7	130.9	129.5	130.3	145.1
1948	140.4	136.5	138.5	133.7	137.0	154.7
1949	135.1	132.3	133.3	130.1	132.3	149.3
1950	130.1	127.2	127.6	124.0	125.5	142.6
1951	162.9	155.4	159.6	150.8	150.2	174.4
1952	174.8	166.6	171.8	163.4	161.3	191.6
1953	171.9	163.7	168.1	159.5	159.1	187.8
1954	140.6	139.6	137.7	136.3	134.5	160.1
1955	162.5	158.1	158.9	154.4	150.3	180.6
1956	182.0	174.2	177.7	169.8	165.3	198.2
1957	159.2	157.1	155.2	153.1	148.2	179.3

Table 38.- Aggregate Quantity Indexes (1926=100) of Total Output Based (mainly) on Wholesale Prices for Years 1926-1934 and Farm Prices for Years 1935-1957, Using (1) Constant Weight (Weight Periods: 1935-39, 1940-44, 1945-49 and 1950-54), (2) Paasche, and (3) Chain Index Formulas, Canadian Agriculture, 1926-1957

Year	Constant Weight; Weight Period:				Paasche	Chain
	1935-39	1940-44	1945-49	1950-54		
1926	100.0	100.0	100.0	100.0	100.0	100.0
1927	107.3	106.8	106.8	106.4	107.7	107.6
1928	112.3	111.0	111.2	109.8	112.3	113.4
1929	90.2	91.5	90.7	92.3	89.9	90.9
1930	94.8	94.4	94.6	94.5	94.4	95.6
1931	89.0	91.0	90.3	92.9	92.4	92.0
1932	99.4	99.5	99.4	99.8	99.7	99.3
1933	88.2	89.9	89.2	90.9	88.6	89.5
1934	91.0	91.6	91.2	91.7	91.3	92.2
1935	92.0	92.6	92.2	92.9	92.4	93.2
1936	86.2	88.7	87.1	89.7	86.5	88.1
1937	83.9	86.6	84.3	87.2	81.3	85.9
1938	96.6	96.5	96.3	96.2	97.0	103.0
1939	121.1	118.3	121.0	118.6	117.2	129.5
1940	117.4	116.3	118.3	117.7	115.3	127.0
1941	102.9	105.9	104.5	107.6	106.0	115.9
1942	153.4	148.0	153.7	148.3	144.6	158.4
1943	109.8	113.8	111.4	115.6	114.3	126.1
1944	132.7	133.1	133.8	134.1	133.1	147.3
1945	109.8	112.3	109.7	112.2	109.1	121.6
1946	117.7	118.2	117.5	117.8	117.7	131.0
1947	122.1	121.9	120.6	120.2	120.4	135.2
1948	129.2	126.4	127.6	124.1	126.6	144.2
1949	124.3	122.5	122.9	120.8	122.3	139.1
1950	119.7	117.8	117.6	115.1	116.0	132.9
1951	149.9	143.9	147.1	140.0	138.8	162.5
1952	160.8	154.3	158.3	151.7	149.1	178.6
1953	158.1	151.6	154.9	148.1	147.0	175.0
1954	129.3	129.3	126.9	126.6	124.3	149.2
1955	149.5	146.4	146.5	143.4	138.9	168.3
1956	167.4	161.3	163.8	157.7	152.8	184.7
1957	146.5	145.5	143.0	142.2	137.0	167.1