AN ECONOMIC ANALYSIS OF TECHNOLOGICAL PROGRESS

ON

DAIRY FARMS IN THE LOWER FRASER VALLEY, BRITISH COLUMBIA

by

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ABSTRACT

This study is based on the hypotheses that technical advances have increased the efficiency with which factor-inputs are converted into output on dairy farms, and have induced shifts in the input structure of dairy farms. The method used to test these hypotheses has been to measure changes in: (1) the real savings in the use of factors during the period 1946 to 1954, and then to make a linear projection of the trend, which existed during the 1946 - 1954 period, into 1961; and (2) the relative importance of inputs over the period 1946 to 1954.

Inputs have been divided into seven categories viz: feed purchased; custom work; labour; cost of operating farm machinery and repairs and maintenance of machinery, equipment and buildings; depreciation; interest on investment; and miscellaneous items. Milk was the only output considered in this thesis. Efficiency was measured as the ratio of total output to total input within a given year.

The results of the study support the hypotheses. They show that shifts had taken place in the relative importance between labour, and the other factors of production, and that associated with these shifts had been an increase in overall efficiency between 1946 and 1954 of 20 percent, which if projected to 1961 would amount to 34 percent.

Thus technological progress had resulted in gains in overall efficiency, with which inputs were converted into output on dairy farms. The study has also shown the types of adjustments on dairy farms which were necessary in order to achieve gains in overall efficiency.

It has also been indicated that the dairy farm industry of the Lower Fraser Valley has the potentialities for increasing its output of milk in response to future increases in demand, which growth in population would render necessary.

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INTRODUCTION

Economic analysis of dairy farm organization may be useful to public boards, which are responsible for establishing milk prices, and to entrepreneurs who make the resource use and production decisions in the industry. The latter need the information to assist in effecting adjustments in their plans in order to maximise net income.

Since 1920, three economic surveys have been made of the industry. The first of these was carried out in the Arrow Lakes, Chilliwack, Courtenay, Ladner and Salmon Arm districts in the years 1920 - 1921.[1] The aim of this survey was to determine the factors that contributed to gain or loss on farms in those areas. In 1945 - 1946 a study was made of farms costs, farms organisation, and labour earnings of whole milk producers in the Lower Fraser Valley.[2] This was followed by a similar study in 1954.[3] Using the data from the

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1 Hare, H.R., "Dairy Farm Survey", British Columbia Agriculture Department Bulletin No. 91, British Columbia Department of Agriculture, 1921.

2 (i) Anderson, W.J., Farm Organisation and Labour Earnings of Whole Milk Producers in the Lower Fraser Valley, 1946, University of British Columbia, 1948.

(ii) Department of Agricultural Economics, University of British Columbia, Dairy Farm Incomes and Cost of Producing Butter fat in the Coastal Areas of British Columbia, University of British Columbia, Vancouver, February, 1947.

3 Campbell, R.H., Dairy Farm Organisation in the Lower Fraser Valley of British Columbia, Economics Division, Marketing Service, Department of Agriculture, Ottawa, June, 1957.

1954 study, along with standard input-output data, a management manual was produced in 1957 which was designed for use by dairy farmers and extension staff.[4]

Based on general observation and to some extent from the farm records compiled during these investigations, it often has been stated that technological progress has radically changed input-output coefficients and through those changes the input structure of dairy farms. The three surveys cited above were directed towards recording the state of the industry, but no empirical work has been done to measure the contribution of technological progress to overall efficiency or the extent to which it has shifted the input structure of dairy farms.

This study therefore is designed to concentrate, by economic analysis, on the effects of technical change within dairy farms and particularly to measure its effect upon (1) the overall gain in efficiency, (2) the changes in the input structure which have been associated with the advance in physical efficiency of inputs.

This study proceeds by reviewing the theory and method relevant to the measurement of technological progress and then examines the source, nature and method of collection of the data. Consideration is also given to the sampling problems, and the limitations associated with the data, which may affect the results. The theoretical

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4 Menzie, E.L., et al, Dairy Farm Management Manual, British Columbia Department of Agriculture and Department of Agricultural Economics, University of British Columbia, 1957.

model is then set up, and the statistical problems which are inherent in the model, are then considered. The remainder of the thesis is devoted to the actual measurements, and the interpretation of the results.

THEORY AND MEASUREMENT OF TECHNOLOGICAL PROGRESS

Concept of Technological Progress

Mill, the synthesist of classical economic doctrines, has stated that

> All inventions by which a greater quantity of any commodity can be produced with the same labour, or the same quantity with less labour, or which abridge the process so that the capital employed need not be advanced for so long a time, lessen the cost of production of the commodity.[1]

He, therefore, has envisaged that progress has taken place when less of the factors of production are used to produce a given quantity of goods and services in the subsequent period as compared to the amount used in an earlier period.

Mill also has pointed out that

> The characteristic features of what is commonly meant by industrial progress resolve themselves mainly into three, increases in capital, increase in population, and improvements in production; understanding the last expression, in its widest sense, to include the process of procuring commodities from a distance as well as that of producing them.[2]

Mill's theories were supported, in part, by George, who in his writings on the effects of material progress concluded that

> The changes which constitute or contribute to material progress are three: (i) increase in population; (ii) improvements in the arts of production and exchange; and (iii) improvements

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1 Mill, J.S., Principles of Political Economy, D. Appleton and Company, New York, 1907, p. 477.

2 Ibid., p. 489.

> in knowledge, education, government, policy, manners, and morals so far as they increase the power of producing wealth.[3]

He also said that:

> The effect of inventions and improvements in the productive arts is to save labour - that is, to enable the same result to be secured with less labour, or a greater result with the same labour.[4]

Later, Boulding defined progress as consisting in "an improvement in the efficiency of the use of means to attain ends".[5]

He said too that:

> Whenever, we discard an old method of doing something in favour of a new method that has proved its worth without doubt, then economic progress is taking place. Economic progress, therefore, means the discovery and application of better ways of doing things to satisfy wants.[6]

Kaldor in outlining his views on technical progress has stated that:

> A change in technique (in the widest sense of the term, as referring to changes in the methods of production) can be initiated by one or more of three causes: (i) inventions, or "autonomous" improvements; (ii) a change in the relative scarcity of factors, originating from the supply side; (iii) a change in the price of factors, their relative scarcity remaining the same. The main difference, of course, is between (i) and the

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3 George, Henry, Progress and Poverty, Robert Schalkenbach Foundation, New York, 1954, p. 228.

4 Ibid., p. 244.

5 Boulding, K.E., The Economics of Peace, Prentice Hall Inc., New York, 1945, p. 74

6 Ibid., p. 74.

> others i.e. the adoption of methods which were not previously known, and the adoption of methods which were not previously profitable. Only (1) can be properly called economic progress.[7]

From the above concepts, technological progress can be defined as a change in the technical coefficients, which makes it possible to procure a larger quantity of goods and services with a given quantity of resources. An improvement in technology is therefore interpreted to mean using the factors of production so that a smaller amount of resources is used in one period than in a previous period to produce a unit of goods and services.

An example to illustrate this concept can be taken from this study. In 1946, dairy farmers in the Lower Fraser Valley used, on the average, 4.3 hours of labour to produce a hundredweight of milk, whereas in 1954, they used 2.6 hours, a saving of 40 percent in the use of this factor over an eight year period. During the same period the outlay on non-labour inputs was reduced by 16 percent.

The Supply Function in Relation to Technological Progress

Heady has stated that the nature of the supply function

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7 Kaldor, Nicholas, "A Case Against Technical Progress?", Economica, Volume XII, Numbers 35-38, London School of Economics and Political Science, 1932, p. 184.

For an elaboration of this argument, see J.R. Hicks, "The Theory of Wages", Peter Smith, New York, 1948, pp 121-130. Also American Economic Association, "Readings in the Theory of Income Distribution", J. Robinson, "The Classification of Inventions", No. 9, p. 175.

depends on

(1) the nature of the physical production functions in the relevant supply period,

(2) the nature of the market for factors used in production including

(a) the supply function of agricultural resources, and
(b) the flexibility of factor prices,

(3) the structure of the firm costs as related to fixed and variable outlays,

(4) the nature of the firm-household interrelationships including the motivating forces behind the production response to farmers, and

(5) the expectations of farmers.[8]

Movements along the supply function are called changes in supply. These are really short-term phenomena to which the industry adjusts itself through the pricing mechanism. Distinct from these short changes in supply, are complete movements of the supply function from its former position. These are really shifts in the supply function. The forces in the long run which cause the supply function to change its former position are independent of, and are distinct from those which cause a movement along the supply function. There are three forces which, in the long run, can cause the supply function to shift outwards and downwards to the right, (1) an improvement in technology i.e. in the technical coefficients, (2) discovery of new resources, and (3) a decline in prices of

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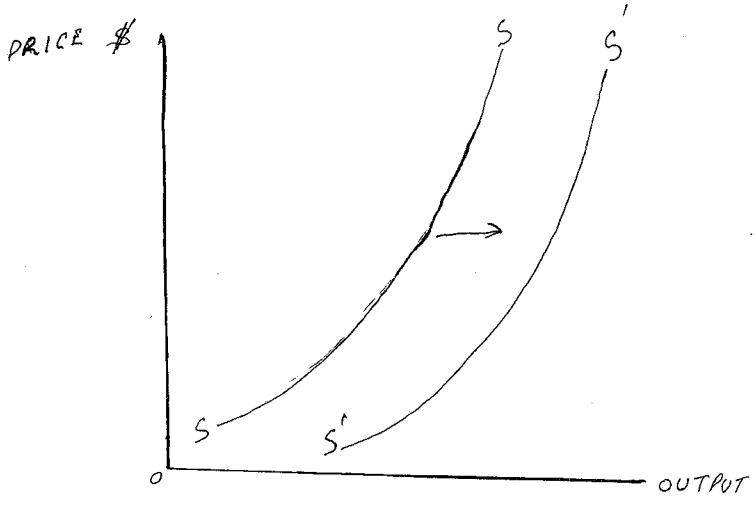
8 Heady, E.O., Economics of Agricultural Production and Resource Use. Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1957, Chapter 23, p. 677.

factors of production. The overall effects of these forces on the position of the supply function are illustrated in Figure 1. With given technology, resources, and factor prices, the supply function of the industry initially was SS. With a discovery of new resources or a decline in factor prices or an improvement in technology in a later period the supply function has taken up the new position S'S'.

Figure 1. Effects of changes in technology on the position of the supply function



In making this study, the effects of new resources and changes in factor prices on the position of the supply function were eliminated, and only the effects of technological innovations were evaluated. This means that the study is really concerned with the shift that has taken place in the production function which is basic to the supply function.

Heady has stated that there are two general properties to

technological improvements viz:-

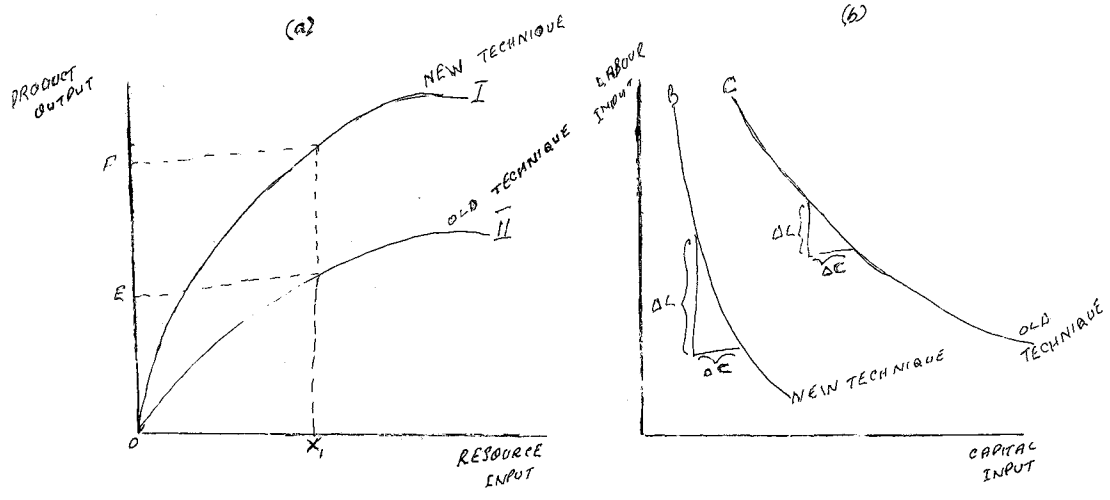
1. The development of a new production technique such that a greater output is forthcoming from a given total input of resources.

x x x

2. The marginal physical rates of substitution (the elasticity of substitution) are always altered in favour of one factor by specific innovations. In other words the entire production surface is altered. The production is increased more for some factors than for others.[9]

The nature of these phenomena are illustrated in Figure 2 below

Figure 2. Nature of innovations.



In Figure 2(a) the production function I represents a shift induced by technological innovation from production function II such that with a given resource input (OX_1) output is increased from OE to OF.

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9 Ibid., pp 802 - 805.

Regarding this type of phenomenon, Heady has pointed out that

> development of production function II after I is already known could not be considered technological advance where the transformation coefficients (rates at which resources are transferred in products) are known with (or near) certainty. However, it would qualify as an improvement under a situation where uncertainty is reduced and hence the value of anticipated returns is increased.[10]

In Figure 2(b) B and C are two iso-product functions for the same output. B represents the new technique and C represents the old technique. The slope of B is different from that of C and has changed in the direction of one factor. The position of the new contour is lower and to the left as compared with the old technique. Hence, less of one factor (capital in this particular case) will be required to replace a given amount of labour after the entrepreneur adopts the new technique. To illustrate, Δ C has been held constant under both techniques which made Δ L greater in the case of the new technique as compared to Δ L in the old. The slope of B therefore indicates that the rate of substitution has been increased in favour of capital, and its marginal physical productivity has increased relative to that of labour. An example of this phenomenon is the substitution of machinery for labour.

Method of Measurement

The hypotheses in this study are that technical advances

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10 Ibid., p. 803.

have increased the efficiency with which factor-inputs are converted into output on dairy farms, and have induced shifts in the input structure of dairy farms. The purpose of this study is to measure the changes which have occurred.

For the main objective of this study, i.e. to measure changes in the efficiency with which input as a whole is converted into output on dairy farms, measures of aggregate input and output are required. In order to obtain the measures of inputs the constant dollar method was used. This method involves weighting the inputs of each year by the prices which existed in the base period. Then the resulting constant dollar values of all inputs for each year were added to give aggregate input. The measure of output did not involve aggregation since one output only was involved in the analysis; it was expressed in its physical unit (hundredweight of milk).

Inputs consist of physical items such as tons of hay, pounds of fertilizer and man hours of labour. In order to aggregate these factors in a form that is meaningful, the different physical units of each input must be converted into the same units, i.e. their dollar value. The aggregate outlay for year 1 can then be expressed in the form:

$$(Px_{11} \cdot Qx_{11}) + (Px_{21} \cdot Qx_{21}) + (Px_{31} \cdot Qx_{31}) + (Px_{41} \cdot Qx_{41}) + (Px_{51} \cdot Qx_{51}) + (Px_{61} \cdot Qx_{61}) + (Px_{71} \cdot Qx_{71}) + \ldots + (Px_{n1} \cdot Qx_{n1}) \quad (1)$$

where $Px_{11} \ldots Px_{n1}$ refer to the prices of factors $X_1 \ldots X_n$ in year 1 and $Qx_{11} \ldots Qx_{n1}$ are the quantities of $X_1 \ldots X_n$ in year 1.

Similarly the aggregate outlay for year 2 can be obtained from

$$(Px_{12} \cdot Qx_{12}) + (Px_{22} \cdot Qx_{22}) + (Px_{32} \cdot Qx_{32}) + (Px_{42} \cdot Qx_{42}) + (Px_{52} \cdot Qx_{52}) + (Px_{62} \cdot Qx_{62}) + (Px_{72} \cdot Qx_{72}) + \ldots + (Px_{n2} \cdot Qx_{n2}) \quad (2)$$

where $Px_{12} \ldots Px_{n2}$ and $Qx_{12} \ldots Qx_{n2}$ are the prices and quantities respectively of factors $X_1 \ldots . X_n$ in the year 2.

In equations (1) and (2) the input aggregation in each year therefore is the sum of the quantities of inputs weighted by the current prices. Since the price levels may have changed the aggregates from (1) and (2) cannot be compared directly. Thus the prices used should be those of one year. In this study inputs for each year were weighted by the prices which existed in year 1. In making the calculation the outlay for each input was divided by its price index for year 1. The price indexes for year 1 are the ratios $\frac{Px_{11}}{Px_{11}} \ldots . \frac{Px_{n1}}{Px_{n1}}$. Thus the expression for the aggregate outlay weighted by prices in year 1 is given by

$$\frac{Px_{11} \cdot Qx_{11}}{\frac{Px_{11}}{Px_{11}}} + \frac{Px_{21} \cdot Qx_{21}}{\frac{Px_{21}}{Px_{21}}} + \frac{Px_{31} \cdot Qx_{31}}{\frac{Px_{31}}{Px_{31}}} + \frac{Px_{41} \cdot Qx_{41}}{\frac{Px_{41}}{Px_{41}}} + \frac{Px_{51} \cdot Qx_{51}}{\frac{Px_{51}}{Px_{51}}} + \frac{Px_{61} \cdot Qx_{61}}{\frac{Px_{61}}{Px_{61}}} + \frac{Px_{71} \cdot Qx_{71}}{\frac{Px_{71}}{Px_{71}}} + \ldots . + \frac{Px_{n1} \cdot Qx_{n1}}{\frac{Px_{n1}}{Px_{n1}}} \quad (3)$$

which simplifies into

$$(Px_{11} \cdot Qx_{11}) + (Px_{21} \cdot Qx_{21}) + (Px_{31} \cdot Qx_{31}) + (Px_{41} \cdot Qx_{41}) + (Px_{51} \cdot Qx_{51}) + (Px_{61} \cdot Qx_{61}) + (Px_{71} \cdot Qx_{71}) + \ldots . + (Px_{n1} \cdot Qx_{n1}) \quad (4)$$

The expression for the aggregate outlay for year 2 weighted by prices existing in year 1 was determined as follows:-

The price index for year 2 is the ratio $\frac{Px_{12}}{Px_{11}} \ldots . \frac{Px_{n2}}{Px_{n1}}$.

The value of the outlay for each input was divided by the index. The expression for input X_1 is

$$\frac{(Px_{12})(Qx_{12})}{\frac{Px_{12}}{Px_{11}}} = \frac{(Px_{12})(Qx_{12})}{1} \times \frac{(Px_{11})}{Px_{12}}$$

which simplifies to the form $(Px_{11} \cdot Qx_{12})$

Proceeding in this manner with each of the inputs, the expression for the weighted aggregate outlay for year 2 is given by:-

$$(Px_{11} \cdot Qx_{12}) + (Px_{21} \cdot Qx_{22}) + (Px_{31} \cdot Qx_{32}) + (Px_{41} \cdot Qx_{42}) + (Px_{51} \cdot Qx_{52}) + (Px_{61} \cdot Qx_{62}) + (Px_{71} \cdot Qx_{72}) + (Px_{n1} \cdot Qx_{n2}) \quad (5)$$

This model was then used to aggregate input factors.

One of the problems involved in the use of this model is the weight period bias which occurs when prices of a given period are used to weight the respective input categories.

Lok has shown that the discrepancies among the aggregate input indexes for agriculture can be considerable.[11] From Lok's study it was seen that some items comprising the aggregate index number of inputs will tend to make the Laspeyres index larger than the Paasche index, whereas in some other cases the opposite effect may occur. Lok notes that

> 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.

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11 Lok, S.H., An Enquiry into the Relationship between changes in overall Productivity and Real Net Return per farm, and between changes in total output and Real Gross Return, Canadian Agriculture, 1926-1957, Technical Publication, Canada Department of Agriculture, Economics Division, Ottawa, October, 1961.

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.[12]

Where discrepancies exist between index numbers which are based on different weight periods, the problem arises as to the selection of the period which provides a set of weights that would form a true aggregation of input.

12 Lok, op. cit. pp 38 - 39

Prices in 1946 were distorted by the effects of World War II but those in 1954 were affected by the Korean War and the post war inflation, and the removal of price controls. Hence 1946 seemed to be as good a weight period as 1954 for purposes of the comparisons to be made in this study.

DATA FOR EMPIRICAL STUDY

Source, Method of Collection and Nature of Data

The empirical data of input and output used in this study were obtained from the information sheets, compiled from actual farm records taken in 1946 and 1954. The surveys included 208 farms in 1946 and 65 in 1954. The sampling technique used in selecting the farms is explained by the following extract taken from a report on the 1946 survey.

> ..Data were obtained from the dairy farmers by the survey method. Each farmer co-operating in the study was personally interviewed by a fieldman from the University and every effort was made to obtain accurate information concerning receipts, expenses, inventories, crop acres and production. This information was recorded in the field schedule designed for the purpose. Many of the farmers visited kept either full or partial records relative to expenses and income. Such records were used when available, but when not, the co-operator was asked to make careful estimates of those items required to complete the field schedule.
>
> x x x x
>
> In selecting farms to be included in this study, a very definite attempt was made to choose farms which were representative for the areas being studied.[1]

The same sampling technique was used in the 1954 survey. Dairy farms in the Lower Fraser Valley, like all other farms are

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1 Department of Agricultural Economics, University of British Columbia, Dairy Farm Incomes and Cost of Producing Butterfat in the Coastal Areas of British Columbia, University of British Columbia, Vancouver, 1947, p. 2.

heterogeneous in regard to the scale of operation, amounts of resources available and the level of managerial ability. It would seem then, that for any particular sample of farms to be studied, there is a possibility that the distribution will be skewed to either the left or right depending on the particular variable used.

Hansen, Hurwitz and Madow have pointed out that

> two aspects of the distribution of a population are of particular importance in their effect on sample design. The first is whether or not the population is highly skewed, i.e. whether or not a small proportion of the units in the population account for a high proportion of an aggregate or average value being measured. The second aspect which needs to be considered is the geographic distribution of the population.[2]

Since the locus of the study is the Lower Fraser Valley, the second point i.e. the geographical distribution of the population, does not apply. However, with regard to the problem of skewness Hansen, Hurwitz and Madow have stated as follows:

> The sampling of farms, business establishments etc., to estimate magnitudes such as aggregate or average production, stock, sales, and employment, or absolute or relative changes in such magnitude, or sampling for certain types of data for individuals or families, such as average or aggregate income where a few individuals or units contribute a considerable part of the total, calls for emphasis on sampling procedures that have not been treated in the preceeding sections of this chapter. In these problems, for example, stratification, and the use of special lists assume especially important and significant roles.[3]

The method of sampling i.e. the method of selecting, or choosing the elementary units in a sample, actually used in the surveys might be

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2 Hansen, M.H., William N. Hurwitz and William G. Madow, Sample Survey Methods and Theory, John Wiley and Sons Inc., New York Chapman and Hall, Limited, London, 1953, Volume 1, Chapter 3, Section 3, p. 93.

3 Ibid., p. 102.

termed "purposive sampling" rather than random sampling, in which one chooses a sample which is "representative" with respect to certain known characteristics of the population. An evaluation of purposive sampling and limitations of the data is included later in the study.

Since this study was limited to measuring the effect of technical change in milk production an arbitrary basis of selection was used to eliminate those farms in which other sources of income were important. Those farms retained included all those that received 75 percent or more of their gross current receipts from the sale of milk. Using this test 160 farms (77 percent of total sample) from the 1946 survey and 50 farms (77 percent) from the 1954 survey were used in this analysis.

Table I shows a frequency distribution of the farms retained in the study, made on the basis of the percentage of gross current receipts received from dairy production. The purpose is to note the distribution within the limits set by the 75 percent test.

TABLE I

FREQUENCY DISTRIBUTION OF FARMS BASED ON PERCENTAGE OF GROSS CURRENT RECEIPTS FROM DAIRY PRODUCTION, LOWER FRASER VALLEY, 1946 AND 1954

Class Intervals Percent	Year	
	1946 No	1954 No
75 - 79	12	4
80 - 84	19	4
85 - 89	25	6
90 - 94	37	4
95 - 100	67	32
Total	160	50

Further to Table I, in 1946 41 farms, i.e. 25 percent of the sample, received between 97 and 100 percent of total receipts from dairy production. In 1954, 19 farms, i.e. 38 percent of the sample, were one hundred percent dairy producing units, and 30 farms i.e. 60 percent of the sample were in the class interval 97 to 100 percent. In both 1946 and 1954 8 percent of the farms in the samples received less than 80 percent of their gross current receipts from milk production.

Sampling Problems and Limitations of Data

It was mentioned earlier that there are some problems in the nature of the sample which may impose certain limitations on the results derived from the measurements to be made in this study.

Hansen, Hurwitz and Madow state that

> precision of the results obtained from a sample survey depends not only on the size of the sample but also on the other parts of the sample design, i.e. on the way in which the sample is selected and the way in which the estimates are prepared from the sample survey returns.[4]

They also recommend that for a population as skewed as the one under study stratified random sampling may have been more adequate. The central idea in selecting a simple random sample and subjecting it to statistical treatment is to estimate from the sample the population parameters so that inferences can be made about the population. With a population of size N, and from which the sample to be choosen is size n

4 Hansen, Hurwitz and Madow, op. cit., p. 4.

the sample should be chosen such that each of the items has the same probability of being included and that the probability of selection is known, i.e. the probability will be $\frac{1}{\binom{N}{n}}$. Of essence here is the fact that the surveyor gives up control as to which units are to be included in the sample because a sample chosen at random is one in which all the elements or units in the population have the same probability of selection.

Stratified random sampling is a special case of simple random sampling in which the population is divided into several strata, and then the principles of simple random sampling are applied to each stratum separately. To derive gains from the use of stratified random sampling, stratification of the population should result in strata which are homogeneous with regard to the characteristic to be measured, and there should also be heterogeneity between strata. Hence the virtue in using stratification for a population with highly variable characteristics lies in the increase in the reliability of the results.

However, the 1946 and the 1954 surveys used a method in which a definite attempt was made to choose farms that were representative of the area to be studied. These surveys made use of what appears to be "purposive sampling" to choose a sample that is representative of the area with respect to the characteristics to be studied. It is obvious that the first limitation in this method of sampling is that a representative sample could only be as representative as the judgement of the person as to what a representative sample is. In this connection reference will again be made to Hansen, Hurwitz and Madow

who advise that

> reliance upon relationships observed in past experience may be particularly dangerous in times of important economic or social change, yet it is in such times that the need for reliable results is most vital.[5]

In defence of purposive sampling, however, it may be stated that this method is useful where it is necessary to include a comparatively small number of units in the sample. Compared with random selection purposive sampling tends to be biased, but the biases probably would be smaller for a sample of say one area selected purposively to represent British Columbia, than the random errors would be in a measurable method that depended on a random selection of a single area. Where, however, the sample is to include a considerable number of units, then the biases of the purposively selected samples will often be more serious than the random errors introduced where random or chance selection rather than purposive selection is used.

The efficiency of any sample design must be considered in the light of the cost and time involved. Both of these factors undoubtedly played a part in the choice of the particular sample design. To stratify the dairy farm population in the Lower Fraser Valley would be expensive and time consuming. Depending on the particular population characteristic to serve as the criterion for deciding on strata limits, lists and statements would have to be taken clearly defining each unit with respect to the characteristic. This is a time consuming and expensive task.

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5 Hansen, Hurwitz and Madow, op. cit., p. 6.

Thus having regard to the time factor, the outlay and the other problems involved, those who assemble data may decide against stratification and so sacrifice some reliability of the estimates. To terminate the defence of the method of sampling here used, reference will be made to Hansen, Hurwitz and Madow who have stated sic:

> If it is important that reliable results be obtained, and if a fairly heavy loss may be involved if the wrong action or decision is taken as a consequence of having depended on results the actually turn out to have large errors that are considered tolerable, then a method for which the risk of error can be controlled should be used if possible, On the other hand, if conditions are such that only fairly rough estimates are required from the sample, and important decisions do not hinge on the results, then only a small sample is required, and the price to be paid for using a sample whose accuracy can be measured may not be justified. Under these conditions it may be that the biases of low-cost non random method will be considerably less important than the random errors resulting from the small size of the sample, and then such methods may be expected to produce results of sufficient reliability more economically than would more rigorous alternative methods.[6]

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6 Hansen, Hurwitz, and Madow, Op. cit., p. 73.

RESULTS AND INTERPRETATION

The Data

Inputs were divided into seven categories, viz:- (1) feed purchased, (2) custom work hired, (3) labour, (4) cost of operating farm machinery, repair and maintenance of machinery, equipment and buildings, (5) depreciation, (6) interest on investment, and (7) miscellaneous expenses.

Feed Purchased[1] - The outlay on this input, which does not include feed grown on the farms, was determined by dividing the outlay on purchased feeds by the index of feed prices[2] (1946 = 100).

Custom Work Hired - This item includes the use of machinery and equipment and the labour to operate it. It was a small item which was difficult to include elsewhere. The outlay on this input was obtained by dividing the expenditure incurred by the index of farm wage rates.[3]

Labour - This input includes the outlay on hired labour, an

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1 In 1954 hay was purchased usually only when a shortage of farm-grown hay was anticipated. Silage as such was not purchased but materials for making silage, such as grass, corn pulp, corn stalks and pea vines were purchased on about 25 percent of the farms. In a few cases wet Brewer's mash was purchased and fed as a substitute during part of the year. Vide: Campbell, R.H., Dairy Farm Organisation in the Lower Fraser Valley of British Columbia, Economics Division, Marketing Service, Department of Agriculture, Ottawa, June, 1957.

2 Dominion Bureau of Statistics, Prices and Price Indexes 1949-1952. Queen's Printer and Controller of Stationery, Ottawa, 1954, Volume 23, p. 95.

3 _____ Price Index Numbers of Commodities and Services used by farmers, August 1956 (1935-1939), Queen's Printer and Controller of Stationery, Ottawa, 1956, Volume 12, No. 3, p. 2.

imputed value to operators' labour, and the value of family labour. The number of man-hours of labour per year was calculated at 3120 hours on the basis of a 26 day month and a 10 hour day. The monthly wage rate for farm labour without board in British Columbia in 1946 was $105.56[4] and $159.00 for 1954.[5] The annual wage rate for farm labour was therefore $1,267 for 1946 and $1,908 in 1954. The outlay on this input was determined by multiplying the total number of man hours for the year by the annual wage rate and then dividing the current outlay so obtained by the index of farm wage rates.

Cost of Operating Farm Machinery, Repair and Maintenance of Machinery, Equipment and Buildings - The value of this input was determined by dividing the expenses incurred in operating tractors, trucks, automobiles, engines and combines by the index of prices of gasoline, oil and grease,[6] and adding to this amount the outlay for maintenance and repair of farm buildings, machinery and equipment, which had been calculated by dividing the current outlay on these items by the price index of building material or the price index of farm machinery prices.[7]

Depreciation - Depreciation on buildings was computed at

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4 Dominion Bureau of Statistics, The Canada Year Book 1948 - 1949, King's Printer and Controller of Stationery, 1949, p.678.

5 _____ The Canada Year Book 1956, Queen's Printer and Controller of Stationery, 1956, p. 757.

6 _____ Prices and Price Indexes, 1949 - 1952, op. cit., p. 98.

7 _____ Price Index Numbers of Commodities and Services used by farmers, August, 1956 (1935-1939=100), op. cit., p. 3.

5 percent of the replacement cost. Machinery and equipment were classified into 2 groups, viz: (1) general equipment and (2) special equipment. The latter included such items as automobiles, trucks and tractors. The rate of depreciation on special equipment was 24 percent of replacement cost while that on general equipment was 15 percent of the replacement cost. The expenditure on this input was determined by dividing the outlay on buildings by the price index of building material, and then adding to this amount the outlay on machinery and equipment which had been divided by the price index of farm machinery prices.

Interest on Investment - The outlay on this input was obtained by taking 5 percent of the operator's average net worth, and then dividing this amount by the index of interest rates.

Miscellaneous Expenses - This input includes the value of such items as hardware and small tools, taxes, telephone, electricity, sprays, germicides, disinfectants, artificial insemination charges, and other miscellaneous expenditures not specifically classified in the other six categories. The value of this input was determined by dividing the total outlay by the price index of hardware prices.

Thus, the value of input used on the individual farms in 1946 and 1954 could be added in current dollars for the particular year, or the value of input could be found in constant dollars according to equations 4 (in the case of 1946) and 5, (in the case of 1954) on pages 12 and 13 respectively. By dividing output into the aggregate input, the ratio of input to output was determined. Another calculation of these ratios was made by aggregating the results from all the farms, rather than the average of the ratios calculated for the individual farms.

Analysis

The first part of the analysis presents some of the gross changes in the input - output ratios, and in the factor-factor ratios which have occurred from 1946 to 1954.

The best gross output data available are from the records of the Dairy Herd Improvement Association, which reveal changes in the output per cow for the period 1914 to 1960 as shown in Table II.

This table shows that, apart for the years 1936, 1948-1949 and 1954-1956, there has been a steady rate of increase in the average production of 4 percent fat corrected milk per cow over the period 1914-1960. The total increase in the average output per cow was 62.4 percent, and the average annual rate was 1.3 percent.

The average output per cow in 1946 was 9,136 pounds of 4 per cent fat corrected milk. This average was based on the performance of 498 cows. In 1954, the average output per cow was 9,761. Within this 8-year period the total increase in the average output per cow was 6.8 percent, and the average annual rate was .8 percent.

In 1960, the Dairy Herd Improvement Association showed that the average output per cow was 10,795 pounds of 4 percent corrected milk. The average total increase over the period 1954-1960 was 10.6 per cent, and the average annual rate was 1.8 percent. This study of the records of the Dairy Herd Improvement Association shows a 1.8 percent average annual rate of increase during the period 1954-1960 in contrast to a .8 percent rate of annual increase for the period 1946-1954.

The dairy farms studied in this investigation showed that in

TABLE II

ANNUAL PRODUCTION PER COW, DAIRY HERD IMPROVEMENT ASSOCIATION, 1914-1960 AND SAMPLE FARMS 1946 AND 1954

Year	PRODUCTION MILK		PRODUCTION FAT		FOUR PERCENT FAT CORRECTED MILK	
	Dairy Herd Improvement Association lbs	Sample Farms lbs	Dairy Herd Improvement Association	Sample Farms lbs	Dairy Herd Improvement Association lbs	Sample Farms lbs
1914-1916	6,563		268		6,645	
1930	8,015		337		8,261	
1932-1934	8,113		343		8,390	
1936	7,857		338		8,213	
1938	7,959		347		8,389	
1940	8,265		362		8,736	
1945	8,606		374		9,052	
1946-1947	8,627	6,757	379	302	9,136	7,233
1948	8,588		378		9,105	
1949	8,623		375		9,074	
1950	9,088		393		9,530	
1951	9,363		393		9,640	
1952	9,382		400		9,753	
1953	9,538		402		9,845	
1954	9,477	7,782	398	322	9,761	7,943
1955	9,438		395		9,700	
1956	9,498		394		9,709	
1957	9,759		404		9,964	
1958	10,330		425		10,507	
1959	10,576		435		10,755	
1960	10,600	8,700*	437	354*	10,795	8,790*

Source: (a) For period 1914-1934 - British Columbia Department of Agriculture Settlement Series Circular No. 5, p. 8.

(b) For period 1936-1960, Reports of the Dairy Herd Improvement Association, vide Appendix on pp. 47-52.

* These figures are based on a linear projection of the trend observed in the Dairy Herd Improvement Association records between the period 1954 and 1960.

1946 there were 2909 dairy cows in the 160 sample farms. These cows produced 21,040,797 pounds of 4 percent fat corrected milk, and the average production per cow was 7,233 pounds. In 1954 there were 1316 dairy cows which produced 10,452,988 pounds of 4 percent fat corrected milk and the average production per cow was 7,943 pounds. The total increase in output per cow over this 8-year period was, therefore, 9.8 percent, and the average annual rate was 1.2 percent. On the assumption that the annual rate of increase in the case of the sample farms during the period 1954-1960, was the same as the Dairy Herd Improvement Association, a projection of this trend would show an average output per cow of 8,790 pounds of 4 percent fat corrected milk in 1960; and a total increase over the 6-year period of 10.6 percent.

The average annual production of 4 percent fat corrected milk per cow for 1946 and 1954 as shown in the records of the Dairy Herd Improvement Association are higher than the averages for the sample farms, presumably because the production figures from the Dairy Herd Improvement Association are based on herds that do better than the whole population because of being on test, and probably because the owners of these herds are better dairymen.

It is noted, however, that the annual average rate of increase in the output per cow during the period 1946-1954 was 0.4 percent greater in the case of the sample farms as compared to the records of the Dairy Herd Improvement Association. The reason for this greater rate of increase is that the level of average output per cow in 1946 and 1954 in the case of the records of the Dairy Herd Improvement Association was higher than the level of average for the sample farms.

It is expected that the rate of increase in output will be greater at lower levels than at higher levels of production.

Table III shows the changes in output single-factor ratios which are based on the data from the sample farms studied in this investigation.

This table shows that average physical productivity of labour had increased by 59.2 percent over the period 1946-1954, and that the average annual rate of increase in productivity was 7.4 percent.

TABLE III

SINGLE FACTOR RATIOS 1946, 1954, AND 1961 (PROJECTED)
LOWER FRASER VALLEY

Output Single Factor Ratios	1946 lbs	1954 lbs	Change 1946-1954 percent	1961 Projected lbs
4 percent fat corrected milk output per cow	7,233	7,943	9.8	8,610*
4 percent fat corrected milk output per man year	78,423	124,886	59.2	189,577*
4 percent fat corrected milk output per farm acre	2,083	3,174	52.4	4,640*
Butterfat output per cow	302	322	6.6	340*

* These estimates are based on a linear projection of the trend observed between the period 1946-1954.

It is indicated also that the average milk output per acre has undergone a 52.4 percent increase over the period 1946-1954; and that the average annual rate of increase in milk output per acre was 6.6 percent. Table VI shows that feed purchased had changed very little in real terms during the period, and Table V indicates that the increase in average acreage per farm had been rather insignificant over the period. Hence the increased rate of change in milk output per farm shows the efficiency of land use which was associated with increased output per cow during the period.

The impact of technical progress had changed the amount of capital used by the farm and its allocation within the farm. Table IV shows that the total capital investment had more than doubled over the period 1946 to 1954.

TABLE IV

DISTRIBUTION OF FARM CAPITAL ON 160 DAIRY FARMS IN 1946 AND 50 DAIRY FARMS IN 1954, LOWER FRASER VALLEY

Items of Capital	Average value per farm 1946	Percent of Total	Average value per farm 1954	Percent of Total
Real Estate	$13,102	67	$25,978	63
Livestock	3,808	19	8,324	14
Machinery and Equipment	1,899	10	5,883	20
Feed and supplies	764	4	1,329	3
Total Capital	$19,576	100	$41,478	100

This table shows that the investment in real estate, livestock, feed and supplies had doubled approximately, whereas investment

in machinery had tripled. Thus machinery and equipment constituted 10 percent of farm capital in 1946, and 20 percent in 1954. Real estate, livestock, feed and supplies declined by 4, 5 and 1 percentage points respectively. These changes represent the capital readjustment which was necessary to achieve the saving in labour input which was realized.

In addition to the changes in the output single-factor ratios in the amount of capital, and in its distribution within the farm, technological progress had also caused changes in the size of the farms during the period under study. Table V shows some of the changes which had occurred in the size of the average farms in 1946 to 1954.

This table indicates that there had been an increase in the output per farm of 59.0 percent during the period 1946 to 1954. The annual average rate of increase in output over this 8 year period was therefore, 7.4 percent. During the same period the total increase in acreage per farm was 4.8 percent and the annual average rate was .6 percent. Over the same period the size of the dairy herd had increased by 44 percent and the annual average rate of increase was therefore 5.5 percent. These figures show that during the period investigated, associated with a .6 percent average annual increase in the number of acres per farm plus an average annual increase in the size of the milking herd of 5.5 percent, there was an average annual increase in the output per farm of 7.4 percent. This phenomenon is indicative of the potentialities that exist for possible expansion in the output of the industry in response to the future increases in the demand for dairy products in the Vancouver and surrounding districts.

TABLE V

MEASURES OF CHANGES WITHIN FARMS 1946 TO 1954, LOWER FRASER VALLEY

Criterion	1946	1954
	per farm	per farm
4 percent fat corrected milk output (lbs)	131,505	209,060
Acres No.	63	66
Cows No.	18	26
Labour earnings	$ 899	$ 1,640
Gross receipts	$ 5,317	$11,045
Gross outlay	$ 3,915	$ 9,950

Changes in the Quantity of Different Factors Used

Changes were also made in the quantities of the various factors used. These are presented in Table VI. In calculating these input-output ratios, the base year in the Dominion Bureau of Statistics price indexes for the various inputs, was shifted from 1935-1939 to 1946.

This table shows that there had been real savings in factor-use to the extent of 20 percent between the years 1946 and 1954. Based on the assumption that the rate of growth in economic efficiency was the same in 1954-1961 as that in 1946-1954, the real savings in factor-use in 1961 has been approximated by a linear extrapolation of the trend which existed between 1946 and 1954. This projection shows a real savings in factor-use for the period 1954 to 1961 of 14 percent, and,

TABLE VI

INDEX NUMBERS (1946=100) OF INPUTS PER HUNDREDWEIGHT OF 4 PERCENT FAT CORRECTED MILK MEASURED AT 1946 PRICES, LOWER FRASER VALLEY, 1946, 1954 AND 1961 (PROJECTED)

INPUT	1946		1954		1961 Projected	
	Input per cwt milk	Index	Input per cwt milk	Index	Input per cwt milk	Index
	$		$		$	
Feed purchased	.73*(.08)	100	.68*(.03)	93	.64	84
Custom work	.06*(.004)	100	.05*(.004)	83	.04	67
Labour	1.47*(.13)	100	.92*(.15)	62	.62	42
Cost of operating farm machinery, Repair & maintenance of machinery equipment & buildings	.23*(.01)	100	.23*(.01)	100	.23	100
Depreciation	.70*(.06)	100	.49*(.01)	70	.36	51
Interest on Investment	.74*(.08)	100	.69*(.04)	93	.65	88
Miscellaneous	.64*(.04)	100	.59*(.02)	92	.55	86
Total	4.57*(.18)	100	3.65*(.16)	80	3.01	66

*( ) signifies that there is 95% confidence that the true population mean for the characteristic is the number outside the bracket ± the number in the bracket.

therefore, an annual average rate of decrease in cost of 2.0 percent. This is an estimate made by using the trends method in the absence of empirical data. In order to determine the reliability of this estimate, it is necessary that a survey be undertaken so that data be collected and analysed, in order to obtain the true savings in factor-use for 1961.

The most significant fact which these tables show is that the input of most factors per hundredweight of 4 percent fat corrected milk

had decreased, but the input represented in the cost of operating farm machinery, and in the repair and maintenance of machinery, equipment and buildings had remained the same. There had been a savings in labour used to the extent of 38 percent between the years 1946 to 1954. If projected to 1961, it would mean a saving of 58 percent in labour input. The decreasing use of labour was made possible by the extent to which machinery and other forms of capital were substituted for labour as indicated in Table IV.

A significant change also had occurred in the input represented by depreciation of buildings, machinery and equipment. Real savings in the use of this factor were 30 percent between the years 1946 and 1954, which if projected to 1961 would amount to 49 percent.

Significant changes were also made in the input represented by the cost for the use of capital in the industry. Table IV indicates that more than twice the amount of capital per farm measured in current dollars was used in 1954 as compared to 1946. There was an increase in the real porductivity of capital in 1954 over 1946 which amounted to 7 percent. Projection of this trend to 1961 would make this sum 12 percent.

There were savings in the use of miscellaneous items amounting to 8 percent over the period 1946 to 1954, which if projected to 1961 would show a savings of 14 percent.

Over the entire period 1946 to 1954, the real savings in all factors used amounted to 20 percent. Projection of this trend to 1961 gives real savings of 34 percent.

Changes in the Relative Importance of Inputs

Technical change had also caused shifts in the relative amount of each input used, and a small shift occurred in the order of importance of inputs.

Table VII shows total inputs measured in constant dollars and their distribution among the seven categories of inputs.

TABLE VII

RELATIVE IMPORTANCE OF INPUTS, LOWER FRASER VALLEY, 1946 AND 1954

Inputs	1946		1954	
	Input 1946 (dollars)	Percent of total	Input 1946 (dollars)	Percent of total
Feed Purchased	153,970	16.0	70,676	18.5
Custom work	13,004	1.3	5,092	1.3
Labour	309,251	32.1	96,267	25.3
Cost of operating farm machinery and repair and maintenance of machinery, equipment and buildings	47,366	5.0	24,549	6.4
Depreciation	146,802	15.2	50,963	13.3
Interest on Investment	156,602	16.2	72,200	18.9
Miscellaneous Expenses	134,930	14.2	62,130	16.3
Total	961,925	100.0	381,877	100.0

The data in this table indicate that the order of importance had not changed, except that in 1954 miscellaneous expenses have displaced depreciation as the fourth most important input factor. However, changes had occurred in the relative amount used of each input.

The most significant change had been made in the case of labour, whose share as percent of total outlay had been decreased by 6.8 percentage points. Inspite of this, however, labour had remained the most important single factor of production both as a percentage of total input and in the amount of it used per hundredweight of milk.

Less significant changes were made in the distribution of total input among the other six factors. The proportion of total input that went to depreciation had declined by 1.9 percentage points, whereas the share to interest on investment had risen by 2.7 percentage points. The proportion that was allotted to feed purchased increased by 2.5 percentage points, and the share to miscellaneous expenses had risen by 2.1 percentage points. The proportion spent on the cost of operating farm machinery and repair and maintenance of machinery, equipment and buildings had been increased by 1.4 percentage points, while the share to custom work had remained unchanged.

Although the inputs had all maintained their relative positions, but for the exception noted above, small changes were made in the amounts of each factor used. The use of some factors had increased whereas the use of others had decreased.

In summary, this analysis has demonstrated that there was a decrease in the input of most factors per hundredweight of milk, but

the input represented in the cost of operating farm machinery and in the repair and maintenance of machinery, equipment and buildings had remained unchanged. The most substantial decrease was in the case of labour. The decrease in the amount of labour used per hundredweight of milk had been induced by labour-saving innovations in dairy farming, which involves the substitution of capital for labour.

Finally, the analysis has shown that real savings had been made in input-output conversion in milk production.

Conclusion

In this investigation, an attempt was made to test and measure the rate at which technical change has increased the efficiency with which factor inputs are converted into output on dairy farms, and to measure also the changes in the input structure of dairy farms in the Lower Fraser Valley.

The results of this study indicate that shifts have taken place in the relative importance between labour and the other factors of production, and that associated with these shifts had been an increase in overall efficiency between 1946 and 1954 of 20 percent, which if projected to 1961 would amount to 34 percent.

From this study indications are that the industry has the potentialities for increasing its output of milk, in response to future increases in demand, which growth in population would render necessary.

The annual rate of population growth in the Vancouver area[8] was 1 percent during the 5 year period 1956 to 1960[9]. The report of the Clyne Commission had estimated an annual rate of population growth in the Vancouver area of 3 percent[10] between the years 1960 to 1970. It was noted earlier that associated with an average annual increase of .6 percent in the number of acres per farm plus an a average annual increase of 5.5 percent in the number of dairy cows per farm and an increase in the average annual output per cow of 1.2 percent, there was an average annual increase in the milk output per farm of 7.4 percent. Hence if the population grows at the rate of 3 percent per annum, with an average annual rate of increase in the annual output per farm of 7.4 percent, the dairy industry in the Lower Fraser Valley will have very little difficulty in meeting the milk requirement of the increasing population.

However, in this process dairy farmers will have the need to continue making re-adjustments in resource use. On the basis of the trend noted in this study, it is anticipated that there will continue to be a steady decline in labour input, both as percentage of total input and in the amount used per hundredweight of milk.

In order to offset the decline in labour input, it is

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8 This includes the cities of New Westminster, North Vancouver, Port Coquitlam, Port Moody and Vancouver; the municipalities of Burnaby, Coquitlam, North Vancouver, Richmond, West Vancouver, and Fraser Mills, and the unorganized areas. It does not include the University of British Columbia transient population.

9 Dominion Bureau of Statistics, Canada Year Book, 1960, Queen's Printer and Controller of Stationery, 1960, pp 173-175.

10 Clyne, J.V., Report of the British Columbia Royal Commission on Milk, Printer to the Queen's Most Excellent Majesty, Victoria, 1955, p. 184.

anticipated that there will be an increase in the total amount of capital used in the form of machinery and equipment, livestock, and to a lesser degree in real estate. There need hardly be an appreciable increase in total acreage per farm. Intensification of land use, irrigation and more efficient fertilizer application and rotational system would render unnecessary a substantial increase in acreage.

It is expected that the average size of the herd will increase, and hence the milk output per farm will continue to rise. With better management, there will probably continue to be also a steady increase in the output per cow which could reach 10,000 to 12,000 pounds of milk per cow by 1970. Along with these re-adjustments in resource use, and the estimated increases in the physical productivity of labour and capital, it is anticipated that the industry will effect further real savings in the use of factor inputs.

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A P P E N D I X

DESCRIPTION OF THE REGION AND ITS FARMS

The locus for this study is the Lower Fraser Valley, which constitutes the delta of the Fraser River, and extends from Hope to the Pacific Ocean in an east west direction. It is bounded on the north by the Coastal Mountains and on the south by the State of Washington. The political units include the municipalities of Delta, Surrey, Sumas, Chilliwack, Richmond, Langley and Matsqui to the south of the river and Pitt Meadows, Mission, Nicomen, Dewdney, Kent, Maple Ridge and Coquitlam to the north.

As a farming area, the Lower Fraser Valley, is set apart from the remainder of the country by topography, soil, climate, history and particularly in regard to its location with respect to large concentrations of populations.

There are approximately 700,000 acres of land in the region[1]. About 320,000 acres of this amount are cultivated, 200,000 acres of which are in hay and pasture.

Elevation in the region ranges generally from sea-level to some 400 feet. In the vicinity of Chilliwack and Agassiz, there exist some rock hills, which vary in height to about 1,000 feet. The soils

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1 British Columbia Department of Agriculture, Settlement Services Circular No. 5, The Fraser Valley of British Columbia, Canada, Don McDairinio, Printer to the Queen's Most Excellent Majesty, 1953.

of the Valley were mapped and classified by Kelley and Spilsbury[2] in 1939. Much of the upland soil is suitable for agricultural purposes, but the cost of clearing has impeded its adoption for farming. The soils of the recent delta, however are fine textured and fertile. Several factors influence the climate of the area. The most important ones are the mountains to the north, and the modifying effect of the Pacific Ocean. Comparatively uniform temperatures, characteristic of a maritime climate, prevail throughout the year. The difference between the average temperature of the coldest month and the warmest month is small. The average for the coldest month, January, is 36°F., and for the warmest month, July, 63°F. This gives a variation of 27°.

Industrial expansion in the cities has been associated with the rapid urbanisation of some parts of the area. The growth of the cities has brought a corresponding growth in the demand for farm products. The agriculture of the region has responded by increasing the production of fluid milk and other bulky perishable products, which can be produced to advantage in areas relatively close to the market. Livestock production primarily dairy and poultry constitutes the source of over 80 percent of the farm cash income in the area.

The population of the Fraser Valley in 1956 was estimated to be 750,000 persons comprising 57 percent to 60 percent of the provincial total. About 7 percent of these people lived on 9,900 farms, which comprised 38 percent of all the farms in the Province.

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2 Kelley, C.C., and Spilsbury, R.H., Soil Survey of the Lower Fraser Valley, Dominion Department of Agriculture Technical Bulletin 20, 1939.

It has also been estimated that there were 110,000 head of cattle - mostly dairy cattle. The estimated number of milk cows was 56,000, producing upwards of 400,000,000 pounds of milk annually, about 45 percent of which is sold as fluid milk in the Vancouver market. About 66 percent of the Provincial total dairy output is produced in the Lower Fraser Valley. The output in the Lower Fraser Valley was valued at $2.5 million.

With regard to dairy-herd improvement work in the Fraser Valley there are two major agencies which are available to dairy farmers viz: (1) the Dominion Record of Performance for pure-bred registered dairy cows, and (2) the Dairy Herd Improvement Association. In any part of the Valley where dairy farming is engaged in to any considerable extent, one of these agencies serves the dairy farmers. Table II indicates that through the facilities of the Dairy Herd Improvement Association, and with better care and management, dairymen have been successful in improving the performance of their herds.

DEPARTMENT OF AGRICULTURE
PROVINCE OF BRITISH COLUMBIA
VICTORIA

November 9, 1961

Mr. Hugh V. Walker,
Department of Agricultural Economics,
c/o Faculty of Agriculture,
University of British Columbia,
VANCOUVER 8, B.C.

Dear Mr. Walker:

Replying to your request for D.H.I.A. annual production figures we are sending you our full annual report for the past five years. Unfortunately, these reports for previous years are not now available, however, here briefly are the figures for the other years requested:

Year	Completed Periods	lbs Milk	Fat%	lbs. Fat
1945	5,179	8,606	4.34	374
1946) 1947)	11,527	8,627	4.39	379
1948	6,358	8,588	4.40	378
1949	6,645	8,623	4.35	375
1950	7,309	9,088	4.32	393
1951	7,432	9,363	4.26	393
1952	8,086	9,382	4.26	400
1953	9,530	9,538	4.21	402
1954	4,333	9,477	4.20	398
1955	11,278	9,438	4.18	395

Trusting this is the information you require.

Yours sincerely,

H. Johnson (sgd)
H. Johnson, Inspector.
D. H. I. Services.

HJ/djb

Enclosures: 5

BRITISH COLUMBIA DEPARTMENT OF AGRICULTURE
(Livestock Branch)
DAIRY HERD IMPROVEMENT SERVICES

ANNUAL SUMMARIZED REPORT FOR 1956

Average ACTUAL Production of all Dairy Herd Improvement Association Records completed during the year (or which milked 180 days or over)

Number of Milking Periods	Milk lbs	Fat %	Fat lbs
11,918	9,498	4.15	394

A further increase of 640 completed milking periods took place during 1956. This increase of 5.7% combined with severe Winter killing of hay and pasture grasses and exceptionally dry spring weather, contained the potential for a sharp drop in average production. However, 1955 production was maintained and, given average weather conditions during the following year, a definite rise should take place during 1957.

The following figures illustrate the progress that has been made during the past 20 years.

1946	8627	4.39	379
1936	7857	4.30	338

Of all cows at present on test in D.H.I. Association, 23.2% are purebreds. Their average butterfat production is 405.

BREED AVERAGES FOR 1955

% of Total D.H.I. records	Milk lbs	Fat %	Fat lbs
4.2 Ayrshire	8,465	4.11	348
17.4 Guernsey	8,139	4.77	388
48.6 Holstein	10,987	3.69	405
19.3 Jersey	7,508	5.10	383
10.5 Unclassified (Crossbreds etc)	8,931	4.33	387
100.0			

It is interesting to note that the number of animals with a life-time production of a minimum of a ton of butterfat is steadily rising, for this is an important factor in the economical operation of a herd of dairy cows.

1940 --- 417 cows: 1946 --- 498 cows: 1953 --- 948 cows.
1955 --- 1312 cows: 1956 ---1379 cows.

BRITISH COLUMBIA DEPARTMENT OF AGRICULTURE
(Livestock Branch)
DAIRY HERD IMPROVEMENT SERVICES

ANNUAL SUMMARIZED REPORT FOR 1957

Average ACTUAL Production of all Dairy Herd Improvement Association Records completed during the year (or which milked 180 days or over)

Number of milking periods	Milk lbs	Fat %	Fat lbs
12,014	9,759	4.14	404

These figures represent a new high for both completed periods and production in herds on D.H.I. test in British Columbia. The ten pounds of fat increase means that approximately 500 dairymen had earnings of around $90,000 more than the cost of the feed needed to secure this increase over last year.

The following figures illustrate the progress that has been made during the past 20 years.

1946	8,627	4.39	379
1936	7,857	4.30	338

Of all cows at present on test in D.H.I. Associations, 22.7% are purebreds. Their average butterfat production is 418 lbs.

BREED AVERAGES FOR 1955

% of Total D.H.I. Records	Milk lbs	Fat %	Fat lbs
3.9 Ayrshire	8,700	4.11	358
16.2 Guernsey	8,291	4.79	397
51.6 Holstein	11,165	3.72	415
18.7 Jersey	7,647	5.14	393
9.6 Unclassified (Crossbreds etc.)			
100.0			

It is interesting to note that the number of animals with a life-time production of a minimum of a ton of butterfat is steadily rising, for this is an important factor in the economical operation of a herd of dairy cows.

1940 -- 417 cows: 1946 -- 498 cows: 1955 -- 1312 cows: 1957 -- 1448 cows

BRITISH COLUMBIA DEPARTMENT OF AGRICULTURE
(Livestock Branch)
DAIRY HERD IMPROVEMENT SERVICES

ANNUAL SUMMARIZED REPORT FOR 1958.

Average ACTUAL Production of all Dairy Herd Improvement Association Records completed during the year (or which milked 180 days or over)

Number of milking periods	Milk lbs	Fat %	Fat lbs
13,075	10,330	4.11	425

These figures represent a new high for both completed periods and production in herds on D.H.I. test in British Columbia.

The following figures illustrate the progress that has been made during the past 20 years.

1948	8,627	4.39	379
1938	7,959	4.36	347

23.0 percent of the cows on test in D.H.I. Associations are purebreds. Their average butterfat production is 433 lbs.

BREED AVERAGES FOR 1958

% of Total D.H.I. Records		Milk lbs	Fat %	Fat lbs
3.2	Ayrshire	9,192	4.11	378
15.0	Guernsey	8,870	4.75	421
54.5	Holstein	11,692	3.73	436
17.1	Jersey	7,936	5.14	408
10.2	Unclassified (Crossbreds etc)	9,584	4.36	418
100.0				

The number of animals with a life-time production of a minimum of a ton of butterfat is steadily rising. This is an important factor in the economical operation of a herd of dairy cows.

1940 -- 417 cows: 1946 -- 498 cows: 1955 -- 1312 cows:
1958 -- 1621 cows

BRITISH COLUMBIA DEPARTMENT OF AGRICULTURE
(Livestock Branch)
DAIRY HERD IMPROVEMENT SERVICES

ANNUAL SUMMARIZED REPORT FOR 1959

Average ACTUAL Production of all Dairy herd Improvement Association Records completed during the year (which milked 180 days or over).

Number of Milking periods	Milk lbs	Fat %	Fat lbs
14,286	10,576	4.11	435

These figures represent a new high for both completed periods and production in herds on D.H.I. test in British Columbia. The increase in milking periods was 1,211 and in production, 246 pounds of milk and 10 pounds of butterfat. Butterfat percentage remained constant.

The following figures illustrate the progress that has been made during the past 20 years.

	Milk lbs.	Fat %	Fat lbs
1949	8,623	4.35	375
1939	8,292	4.37	363

Pure bred cattle on D.H.I. test have always outproduced grades until this year. The following table could well cause a re-examination of some breeding policies.

3,139 pure breds (22.0% of total) produced an average of 434 lbs of B.F.
11,147 grades (78.0% of total) produced an average of 435 lbs of B.F.

BREED AVERAGES FOR 1959

% of total D.H.I Records (1958)%		Milk lbs	Fat %	Fat lbs	(1958) Fat lbs
3.2	3.3 Ayrshire	9,407	4.11	387	378
15.0	13.9 Guernsey	8,920	4.82	430	421
54.5	58.0 Holstein	11,874	3.76	447	436
17.1	15.5 Jersey	7,833	5.17	405	408
10.2	9.3 Unclassified (cross breds etc)	9,937	4.40	437	418
	100.0	(1958) figures shown for comparison			

The number of animals with a life-time production of a minimum of a ton of butterfat is steadily rising. This is an important factor in the economical operation of a herd of dairy cows.

1940 -- 417 cows: 1958 -- 1,621 cows: 1959 -- 1,780 cows:

BRITISH COLUMBIA DEPARTMENT OF AGRICULTURE
(Livestock Branch)
DAIRY HERD IMPROVEMENT SERVICES
ANNUAL SUMMARIZED REPORT FOR 1960

Average ACTUAL production of all Dairy Herd Improvement Association records completed during the year (or which milked 180 days or over).

Number of milking periods	lbs Milk	Fat %	lbs. Fat
14,665	10,600	4.12	437

These figures again represent a new high for both completed periods and production in herds on D.H.I. test in British Columbia.

The following figures illustrate the progress that has been made during the past 30 years.

1950	8,606	4.34%	374
1940	8,265	4.38%	362
1930	8,015	4.20%	337

20.6 percent of the cows on test in D.H.I. Associations this year were purebreds. Their average butterfat production was 431 pounds.

BREED AVERAGES FOR 1960

% of total D.H.I. records	lbs. Milk	Fat %	lbs. Fat
3.2 Ayrshire	9,321	4.13	385
13.3 Guernsey	8,918	4.84	431
60.7 Holstein	11,735	3.80	446
14.2 Jersey	7,864	5.21	410
8.6 Unclassified (Crossbreds etc.)	10,181	4.35	443

The number of animals with a life-time production of a minimum of a ton of butterfat is steadily rising. This is an important factor in the economical operation of a herd of dairy cows.

1940 -- 417 cows: 1958 -- 1,621 cows: 1960 -- 2,007 cows: