INVESTMENT AND PRODUCTION IN AUSTRALIAN AGRICULTURE.

by

G. O. GUTMAN.*

SUMMARY.

SUMMARY.

The article sets out to investigate statistically the relation between investment and production in Australian agriculture during a period of roughly thirty years stretching from the end of World War I to the end of World War II. It also attempts to assess the broad effect of changes in the size of the labour force and in relative price levels on the volume of rural output.

Before discussing the inter-relation of the main variables, means must be devised to measure them. Problems of measurement and the derivation of indexes of production, investment and employment are consequently the subject of the three central parts of the article.

The quantity *Index of Production* differs from most published indexes in that it is a *net* index designed to measure the quantity of production attributable to the joint employment of labour and capital in agriculture. In other words it aims at measuring net value added in agriculture at constant prices.

* Mr. Gutman is an officer of the Bureau of Agricultural Economics, Canberra. This article is based largely on a thesis submitted by him for the Degree of Master of Commerce, University of Melbourne.

The writer gratefully acknowledges his indebtedness to Mr. J. G. Crawford for encouragement and much helpful comment, to Mr. F. H. Gruen and Professor H. W. Arndt for a great deal of constructive criticism and to numerous others. but especially to Professor T. W. Swan, Dr. R. Mendelsohn and Mr. J. N. Lewis for valuable suggestions.

The index therefore has the advantage of avoiding the element of double counting (as regards fodder for example) which is usually involved in indexes of gross farm production. At the same time the net index attempts to bring to account the changing quantities of other outputs required in the process of agricultural production. This is of some importance in an attempt to trace production changes over a long period during which technology has progressed and individual primary industries have expanded at different rates with consequent changes in the over-all ratio of net to gross production for the agricultural sector as a whole. The problem of how to derive such an index from published data is taken up in detal in Part 2.

The *Index of Investment* is based on separate measures for the four main components of farm investment: permanent improvements, machinery and implements, livestock and investment in irrigation works. In essence this index represents the annual percentage addition to agricultural capital. Figures are expressed in constant value terms and relate to net investment, i.e., they exclude expenditure on replacement.

Figures for farm improvement derive from an analysis of improved and unimproved land value data, supplemented in many instances by estimates. The measure of improvements was obtained as the difference between improved and unimproved values deflated by suitable series.

The series for investment in machinery and implements is based mainly on published statistics. An annual rate of depreciation of 10 per cent was assumed for equipment in making allowance for replacement purchases, to obtain a measure of net investment.

Investment in irrigation works was derived from the published accounts of irrigation authorities. Expenditures were adjusted to a basis of constant prices to obtain a series showing investment changes in constant value terms.

For the index of investment in livestock separate series for the various types of livestock were aggregated on the basis of the average value per head.

The *Index of Rural Employment* had to be based largely on unpublished data whose shortcomings are reviewed in Part 4.

A *Price Index* is introduced in the final section; it is based on published data of farm prices, deflated so as to show farm price movements relatively to the general price level and gives a rough indication of the varying levels of profitability of agricultural production as against non-agricultural.

The concluding section attempts an *Interpretation* of the data in the form of a production function. Net production is presented as a function (linear in logarithms) of investment and employment. The analysis is carried out in terms of first differences of lagged moving averages and the implications of this method are discussed in some detail.

Net production changes over the period under review were closely associated with variations in the investment level but appear to bear little relation to changes in the size of the labour force. The latter result may in part be explained by shortcomings in the rural employment data.

An estimate of returns to scale suggests that Australian agriculture during the period was operating under conditions of increasing returns. Returns to capital alone were close to unity and the marginal efficiency of capital (i.e., the net return on investment) was about 26 per cent.

Investment during the period was subject to a cyclical trend with high levels in the mid-1920's and again in the late 1930's and steep drops during the depression and during the war when substantial disinvestment took place.

A distinct lag relationship, apparent between the main variables, supports the view that changes in the relative level of agricultural prices react after a lapse of time upon the level of rural investment and that variations in rural production are in turn closely related to the investment level of immediately past seasons.

1. INTRODUCTION.

The purpose of this study is, firstly, to obtain some statistical measures of trends in the use of resources in Australian agriculture during the last three decades and, secondly, with the help of these measures to attempt to arrive at some generalization about the inter-relation of agricultural investment and production over that period.

The immediate starting point of the enquiry was a thesis put forward during recent years by American economists which, put in its broadest terms, asserts that there is over-employment and under-investment in United States agriculture.[1]

Stated a little more precisely, this argument contends that higher returns than are at present received would accrue to labour on leaving and to capital on entering the primary industries.[2] The analysis has been applied by this group of economists specifically only to comparisons between agriculture and manufacturing industries, but it would probably not be invalidated if it were extended to cover tertiary industries.

The present investigation, however, must be more limited in range. Adequate material is not readily available for making a comprehensive comparison between agriculture and manufacturing (let alone tertiary) industry in Australia. In its absence no more will be attempted than to answer (in the main) two questions: "What have been the major changes in the allocation of resources in Australian agriculture during the period under review?" and secondly: "What have been the principal inter-relations (if any) between those movements?" On posing the questions in this manner, it is tempting to divide the whole of the enquiry into two separate and successive stages. The first of these stages would be wholly descriptive, chronicling (statistically, if not verbally)

---

[1] For the original and fullest exposition of this thesis see T. W. Schultz, *Agriculture in an Unstable Economy* (New York; McGraw-Hill, 1945). The discussion engendered by this has been widespread; for another contribution by Schultz's group (the "Chicago School" of agricultural economists) see D. Gale Johnson, *Forward Prices for Agriculture* (Chicago; Chicago University Press, 1947).

[2] Following Schultz and other writers the terms "agriculture" and "primary industry" will here be used interchangeably. Both will be understood to exclude fisheries, forestry and mining. Agriculture in the narrow sense will be referred to as crop agriculture.

what has happened during the period. The second part would then be concerned with the attempt at tracing the causal connections during the period, between the variables whose progress had previously been plotted.

Because of its obvious convenience this twofold division will indeed be used. It is nevertheless important to remember that although they will be treated successively the two stages are by no means separable. The number of distinct variables whose course could be described is legion. It is necessary to concentrate on only a few—those, obviously, which are regarded as the most important. Judgment as to which variables are important must naturally be guided by general notions of the operation of economic forces, i.e., by economic theory.

The theoretical framework in terms of which the investigation is to be conducted must satisfy two conditions: It must be theoretically plausible and it must be stated in terms of variables capable of being statistically identified and measured.

It is evident that only very simple models will qualify under these conditions. The one provisionally chosen is a simple production function which represents production as being determined by two independent variables, viz., employment and investment.

A definition of these variables will be presented below when the assumptions underlying the production function will also be discussed in some detail. In the present context it seems, however, desirable to indicate the considerations that led to the provisional decision to restrict to a minimum the number of independent variables (the factors of production) in this production function.

It is clear, first of all, that certain productive agents such as uncertainty bearing, waiting, new inventions and the like—though some of them could possibly be identified— are incapable of being measured in quantitative terms. If allowance is to be made for them at all, it will have to be done in a roundabout fashion by measuring them with the help of indicator series or by even rougher processes of estimation. Leaving aside these more intangible factors of production, it yet remains true that the factor of capital could without difficulties have been divided into several sub-groups.

To classify productive agents into factors of production involves the making of arbitrary decisions. The accepted criterion on which these decisions should be based is that of substitutability. Classes of factors should have a high degree of internal and a low degree of external substitutability.[3] More generally a classification might be defended on three grounds:

(*a*) The principle of substitutability.

(*b*) Because it classifies factors according to their role in the productive process (e.g., chemical, mechanical, etc.).

(*c*) Because it is useful for studying the distribution of incomes.

[3] It is essential, however, for some degree of substitutability to exist between classes of factors for the purpose of formulating a production function; otherwise factors would bear a fixed proportion to one another and the production function would become a constant ratio. See for full discussion of this point J. M. Cassels, "On the Law of Variable Proportions" in *Explorations in Economics* (New York; McGraw-Hill, 1937) and F. Machlup, "On the Meaning of the Marginal Product" (*ibid*), as well as J. Robinson, *Economics of Imperfect Competition* (London; Macmillan, 1933), Appendix, esp. p. 330 *et seq.*

The simple classification adopted was felt to have considerable merits with respect to (*c*) above in addition to conforming reasonably closely to the two other criteria.

Our aim then is to explain changes in the quantity of agricultural production by reference to changes in the quantities of two factors of production, labour and capital. The measurement of the factor labour presents no great theoretical obstacles, though as will be seen, certain practical difficulties arise from the scantiness of the data. The problems involved in obtaining a serviceable series of capital are very much more complex and will be considered at length further below. At the present stage it seems desirable to give an indication of the definition of capital that it is intended to employ throughout the present paper.

Capital will be defined in constant value terms and will be meant to exclude what is generally classed as working capital. It will exclude, that is, both capital funds and stocks and all such physical aids to production the result of expenditure on which is in the main exhausted during the year in which it is undertaken. Capital thus defined stands then in the main for agricultural land, permanent improvements to such land, irrigation works, mechanical farm equipment of the more permanent type and livestock (breeding) herds.

2. THE INDEX OF RURAL NET PRODUCTION.

(a) The Meaning of the Index.

It is clear that a definition of capital such as has just been outlined, which excludes a broad group of productive agents(fertilizers, seed, fuel, etc.) must to a large extent determine our choice of definition for the dependent variable production.

Production will be taken as a net concept, i.e., we must attempt to exclude from the quantity of gross output all those elements which cannot reasonably be imputed to the joint employment of labour and capital. Leaving aside for the moment the statistical problems associated with the construction of an index of net production, it becomes necessary to look a little more closely at the economic assumptions involved.

It is evident that the computation of an index of net agricultural product will raise a host of special difficulties which are altogether absent in assembling indices of gross production. For this reason the latter type of series is almost invariably used in measuring changes in agricultural production. It appears, however, here that for our present purpose of deriving a production function for agriculture the conventional approach is not adequate for a number of reasons.

To start with, the form chosen for our production function makes it imperative to exclude from agricultural product (as far as is feasible) that part which is *directly* attributable to the contribution of the non-agricultural sector of the economy. The emphasis here rests on the word "direct"; for it is not, of course, implied that we should exclude the contribution made by, say, agricultural implement manufacturers. Their contribution will be embodied in capital equipment employed on farms which will enter the production function under the heading of investment. What is meant is, that we must make allowance, as best we can, for transport and all those other services provided by the non-agricultural sector as well as for those adjuncts to production (e.g., materials) which do not enter the index of investment.

The gross index, naturally, makes no such allowance and to use it for the purpose of the production function would implicitly involve the assumption that net product varies proportionately with gross product. This may be a plausible assumption to make when undertaking a comparison of production in, say, two successive years or possibly over a short period of years. But when attempting to cover a period of three decades, as is intended in the present essay, such an assumption could easily obscure the true picture.

Over such a period changes in methods of production may be expected to affect the share of agricultural output attributable respectively to factors within and without the agricultural sector. Moreover, the fact that individual primary industries may expand at different rates must affect the overall ratio of net to gross product, in view of the fact that this ratio differs widely between the various primary industries.

An even more serious drawback of the gross index of rural production is that it involves an important and highly variable element of double counting. This results from the fact that such an index fails to make allowance not only for adjuncts to production "imported" into the agricultural sector from without, but also for those derived from within the agricultural sector itself. Thus, to take an example, if grain usually sold to the non-agricultural sector for human food were to be diverted to stock feed with a consequent expansion in livestock production, this would be reflected in the gross index as a rise in production to the full extent of the additional quantity of livestock products turned out. This clearly means that the diverted wheat would enter the index twice; once at its source when originally produced and then again in its converted (processed) form of meat, wool, eggs, etc.

As against that the net index approach would record only that part of the additional output of livestock products which is not attributable to the increase in the quantity of grain fed to stock. It would in this way make allowance for the offsetting loss of grain for human consumption (outside the agricultural sector) at the expense of which the increase in livestock production was achieved.

To reiterate the point, we must in order to obtain the quantum of production imputable to labour and capital alone (i.e., what we shall call the quantum of net production) eliminate from the gross product (i.e., output) that quantum of product which is due to the input of productive agents other than labour and capital. The only method by which this can be accomplished with the scanty statistical information available is a rather crude one and involves deducting from the quantum of gross agricultural product measured in constant value terms the quantum of those other factors also measured in terms of constant value. The assumption underlying this procedure is that the relation between the quantum of other inputs and the quantum of total product is an additive one. Put somewhat more loosely we are in fact assuming that these inputs make a contribution to the quantum of output, equal to their own value, measured in constant prices.

This assumption is likely to fall short of the truth because of two main influences; the first is the occurrence of complementarity between factors of production which makes it impracticable to measure by means of imputation (or indeed in any other way) the effect of large (as against marginal) variations in the quantity of factors. This is to say that even in the case of factors where our assumption holds that their relation to total product is an additive one, this is likely to be true only for small changes near the margin and not for large changes in the total quantity of those factors.

Secondly, for certain productive agents (included among what we have called "other factors") empirical evidence suggests that our assumption is unlikely to hold good even for marginal changes. The most important case in point is fertilizers whose relation to output is probably a function of the second degree rather than of the simple type which we have postulated. In the absence of more accurate information, however, we shall for the present assume that over the whole of agriculture fertilizers bear a relation which is close to linear for small year-to-year changes. Where large changes have, in fact, occurred (e.g., during the war when the shortage of fertilizers was acute) their probable effect will have to be taken into account by a qualitative evaluation of statistical results obtained with the use of the simple assumptions.[4]

The method outlined is, in fact, closely analagous to the one often employed to obtain for manufacturing industries the "value added by labour and capital".[5]

While admittedly imperfect, it makes at least some attempt to measure directly the quantum of inputs other than labour and capital and (albeit inadequately) bring them into account, whereas the alternative approach employing the gross index would have to neglect altogether the effect of variations in those other inputs.

(b) Statistical Implications of the Index.

We must now turn to the statistical procedure to be adopted in working out a series for the quantum of net production as we may call the value added in agriculture. The quantum of net production is defined provisionally as the physical volume of net production. If the problem were

[4] There is some statistical evidence to suggest that even very drastic variations in fertilizer applications show little immediate effect on agricultural production. See for this K. S. Lomax, "An Agricultural Production Function for the United Kingdom" (*The Manchester School of Economic and Social Studies*, May, 1949, esp. p. 150). Another problematic type of input is the value of agricultural extension services. See for this W. B. Reddaway, "Some Problems in the Measurement of Changes in the Real Geographic Product" in *Income and Wealth*, Series I, Erik Lundberg (Editor), Cambridge, Bowes and Bowes, 1951. The difficulty is that agricultural extension services comprise to a significant extent labour (and management) inputs which it is not intended for the present purpose to deduct from gross output—they are part of net output. The difficulties of obtaining a satisfactory dissection of this item from State financial accounts and budgets frustrated attempts at detailed analysis.

[5] Cf. e.g., *Production Bulletin*, Part 2—*Secondary Industries*, Commonwealth Bureau of Census and Statistics.

to measure the quantum of net production of a single homogeneous product the task would be a relatively simple one. The problem confronting us, however, is one of measuring over a period of time the total quantities of a number of heterogeneous commodities and this must be handled by means of an index of value-quantity aggregates. It will then be necessary to obtain for each commodity an index of quantum of net production in order to combine these various indices (or more precisely the relatives for each year) by multiplying each into a suitable quantity-value aggregate and summing the products.

Thus if N^1, N^2, N^3, etc., are the respective units of net value contents of (i.e., the units of quantum of net production embodied in) one unit of commodity, 1, 2, 3, etc., and W^1, W^2, W^3, represent the weights (in units of constant value) of units of net production of commodity 1, 2, 3, respectively, the index required will be of the form—

$$\frac{\sum\left(\frac{N_1}{N_0} \times NW\right)}{\Sigma\, NW} \qquad (1)$$

where the suffix 0 refers to the base period, and suffixes 1, 2, 3, etc., to the year for which the relative is being computed.

This, of course, is similar in form to the usual quantity index of production—

$$\frac{\sum\left(\frac{Q_1}{Q_0} \times PQ\right)}{\Sigma\, PQ} \qquad (2)$$

the difference being that both weight and quantity in index (1) are net concepts, referring to units and weights not of output but of net production.

It is not necessary here to deal in detail with the principles of index number construction, but some account must be given of the nature of the index which will be used for the present purpose and the reason for its adoption.

The general form of the index here to be used will be that of an arithmetic average of relatives. One of the main reasons for preferring the arithmetic average is its simplicity, making for greater ease in computation. Moreover, because it is simple it is always possible to express and conceive of what is being measured, in non-mathematical language; on this ground, too, it was regarded as more satisfactory than more sophisticated measures even though some of these are superior in respect of formal consistency.

It is evident that from a given set of quantity relatives an infinite number of indices can be derived (by using different sets of relative prices) and each of these indices may tell a different story about movements in the value of net production. For an index designed to measure net production over a period of years a commonsense solution of this problem might seem to be to select a set of weights consisting of average prices over the period for each individual item. Or else a particular year or period may be identified as having been "average" or "normal" for the period as a whole, and prices prevailing then could be chosen as weights.

To the extent that prices during the period have, in fact, fluctuated around an equilibrium level, this approach appears sound. It could be argued that deviations from the equilibrium of a random nature were due to essentially short-term maladjustments and may be safely disregarded in an investigation of long-term movements, such as we are here concerned with. If, however, prices have shown movements not attributable to randomness but resulting from, say, systematic cycles or trends, the position becomes more complex.

It must be recalled that the problem we intend to investigate with the help of the index to be derived, is concerned with resource allocation over a considerable period of time. The valuation of resources, however, tends to vary in the long run and such variations must be obscured by indices computed with the aid of fixed-weight aggregates. Such indices cannot give a complete answer to the question raised, which is, whether the real value (or "utility") of net production in agriculture has fallen or risen during the period.

The problem of utilities, their aggregation and comparison, is not one that need be considered here, nor, indeed shall we attempt to define the term. All that it is intended to convey is, that even if it were possible to construct a "pure" quantity index of production, this would not completely solve the problem, for it is beyond "pure" quantities and to relative prices that one must look in order to obtain an indication as to the worth (or utility) of the increased or reduced net output.

This problem which permits of no simple solution is, of course, common to all attempts at deriving aggregative indexes over long periods. If it were possible to isolate relevant long-term variations in relative prices from the vast mass of recorded price changes and allow for them in the index, its value for our specific purposes would be much enhanced. There is no way of doing this, however, and it is plain that the great bulk of price changes that have occurred (mainly as a result of changes in the price level) are not relevant to our purpose. Thus we are inevitably led to the use of the fixed-weight aggregative index as a rough but serviceable makeshift.

One further point is worthy of note. Though the prices of agricultural commodities, i.e., agricultural outputs are subject to violent fluctuations as a result of short-term shifts in the demand pattern the same is not necessarily true for the prices of agricultural inputs. These are to a large extent the product of industry rather than agriculture and, broadly speaking, both their supply and the demand for them are considerably more elastic than is true for agricultural commodities. If this generalization could be accepted, it would follow that those changes which do, in fact, occur in the prices of agricultural inputs are more likely to reflect the effect of long-term influence than is true in the case of outputs. This line of argument is, no doubt, partly vitiated by the existence of imperfections in the market for many of the most important materials, the effects of which have already been adverted to. It remains true, nevertheless, that there is a case for separate treatment of outputs and inputs wherever it becomes necessary to make use of deflator series in the course of arriving at our final index for agricultural net production.

(c) Construction of the Index.

We must now bring down this discussion of production indices from the abstract level on which it has so far been conducted and investigate how data actually at our disposal can best be fitted into the theoretical framework outlined. The following data appear to be useful for the purpose.

(*a*) A series for the value of gross production for the three major primary industries (crop agriculture, dairying and pastoral), covering the period from 1912 to the present (published by the Commonwealth Statistician).

(*b*) A series for the value of gross and net production from 1928-29 to the present. Gross values for the purpose of this series have been arrived at, at a basis different from that used for the purpose of those employed in (*a*) above. The series gives —in addition to gross and net values—marketing costs and the value of materials (seed, feed, fertilizers, fuels, etc.). The difference between gross and net values corresponds thus closely to the value of what we have termed "inputs". (Source: same as (*a*).)

(*c*) Another series of value of production is available; this presents both gross and net values of output from 1920-21 to 1942-43. The gross values are identical with those in (*a*) while the net values are those of (*b*). (Source: Melville, *The Cost of the Australian Tariff*; paper read to ANZAAS, 1946 Meeting.)

(*d*) An index of quantity of (gross) production calculated on the fixed base aggregate formula and using for multipliers average prices for the period 1923-24 to 1927-28. This is available for each major group as well as for the total of all primary industries. (Source: same as (*a*).)

(*e*) An index of prices of gross production calculated on the fixed base aggregate formula using weights similar to (*d*). (Source: same as (*a*).)

In surveying this list of materials from which the index of net agricultural production must be constructed, it is evident that the most serious deficiency is the absence of any information on the quantity (as distinct from the value) of inputs. Some such information is available for recent years, but to obtain it for the whole or even a major part of the period under review is not practicable. Figures for the quantity of inputs for use in our index must thus be arrived at by deflating the value data contained in (*b*) or (*c*).

We may now turn to the consideration of the precise formula to be employed.[6] There are two main types of formulas that can be used for the construction of an index of net production, viz.:

$$\frac{\Sigma(N_1\,W_0)}{\Sigma(N_0\,W_0)} \quad (3) \quad \text{and} \quad \frac{\Sigma(N_1\,W_1)}{\Sigma(N_0\,W_1)} \quad (4)$$

Of these, (4) has the merit of bringing into account changes in relative prices; however, it has the weakness of yielding index numbers which are not strictly comparable as between successive years. This is due to the fact that production in each year is compared to base year production, both valued at present year prices. With prices varying from year to year the difficulties of obtaining a clear interpretation of such index numbers are obvious. An additional drawback of this approach is the vast amount of computation involved in working out the data for the denominator of the formula.

The use of the fixed weight aggregative formula seems, therefore, indicated. The formula as shown above (3) refers to net products and their values. But the net product as defined here is rather a hypothetical concept and it is not, of course, possible to talk about its price in the sense in which this term is generally understood, i.e., the value determined in a market. We must, therefore, adopt a more roundabout procedure for measuring it by representing it as the difference between output and input. We may then write the formula as follows:—

$$\frac{\Sigma(P_0\,Q_1 - p_0\,q_1)}{\Sigma(P_0\,Q_0 - p_0\,q_0)} \quad (5)$$

Where

P is the price of gross product.
Q is the quantity of gross product.
p is the price of input.
q is the quantity of input.

---

[6] A very careful and stimulating discussion of the statistical problems involved in the construction of an index of net production for manufacturing industries is to be found in R. Wilson, *Prices, Quantities and Values* (paper read to the Victorian Branch of the Economic Society of Australia and New Zealand, September 24, 1937).

Wilson arrives at a formula identical with formula (5) in the text and comments: "If there is any valid quantitative concept of the services of manufacture, it would seem to be this. Whether or not the concept is a useful one, it at least expresses the quantum of manufacturing production in terms of its own net product allowing for the number of 'units of manufacture' and the number of units of material saved or lost."

Results substantially similar to Wilson's were reached by R. C. Geary—"The Concept of Net Volume of Output with Special Reference to Irish Data" (*Journal of the Royal Statistical Society,* Volume 107 (1944) p. 251) and applied to the gross and net output of Irish manufacturing industries in two successive years (1941 and 1942). Geary employs two formulas, one using base year and the other later year prices. The former formula is of the form:

$$\frac{\dfrac{P_1Q_1}{R} - \dfrac{p_1q_1}{T}}{P_0Q_0 - p_0q_0}$$

where R and T are price index numbers computed by the use of Fisher's "ideal" formula.

For an interesting pragmatic approach to the measurement of net production in cases where detailed statistical information on inputs is unavailable *cf.* Carter, C. F., Stone and Reddaway—*The Measurement of Production Movements,* C.U.P. 1948, and also W. B. Reddaway, *op. cit.*

The data for the denominator of this formula are readily available. Further, $P_0 Q_1$ can be obtained without difficulty if it is remembered that the formula for an index of quantity of gross production on the fixed weight aggregative formula is—

$$\frac{\Sigma P_0 Q_1}{\Sigma P_0 Q_0}.$$

Such an index is available and all that needs to be done to obtain the $P_0 Q_1$ values is to multiply the relatives for each year by the fixed base year values. The data for the inputs are less easily obtained for the reason that quantitative data for inputs are totally lacking. We must thus have recourse to the value data for inputs ($p_1 q_1$) adjusted with the help of a suitable deflator.[7] The formula may then be written as—

$$\frac{\Sigma\left(P_0 Q_1 - \frac{p_1 q_1}{r}\right)}{\Sigma(P_0 Q_0 - p_0 q_0)} \quad (6)$$

whre 'r' is an index number of change in the price of inputs.

One additional complication becomes apparent in computing the aggregate for the volume of gross production: The official quantity index published by the Commonwealth Statistician excludes a considerable number of items (e.g., eggs, poultry, fruits and many vegetables) and is estimated to include only 80 to 88 per cent. of total agricultural production. The bulk of the excluded commodities are of a kind which are produced by intensive methods of cultivation and as this type of farming has expanded considerably during the last thirty years (owing to closer settlement and irrigation) its exclusion may introduce serious inaccuracy. It could, of course, be justified only if we could safely assume that production of those crops has increased proportionately with those included in the regimen which forms the basis of the official index; for the reason referred to this is an extremely doubtful assumption. An improved index is, however, available which attempts to bring the excluded items into account. This index is arrived at in the following manner.[8]

"It (the index) has been constructed by—(1) dividing the official quantity index into the total value of items of production included in the official quantity index (which gives a price index on the changing-weight aggregative formula); and (2) dividing this resulting price index into the total value of all recorded production. The resultant ('revised official') index of quantity is not a pure fixed weight aggregative index, but the nearest approximation to it that can be calculated from the available data."

---

[7] As there is generally a lag between the purchase of materials (e.g., fertilizers) and their use in production, the question of valuation of inputs becomes of some importance. Deflation by the method used in the text implies valuation at original cost rather than replacement, but the difference is unlikely to be significant. For fuller discussion of this and related points see E. Frickey, "Some Aspects of the Problem of Measuring Historical Changes in the Physical Volume of Production" in *Explorations in Economics* (New York; McGraw-Hill, 1937).

[8] Ronald Wilson, *Facts and Fancies of Productivity*, p. 43.

If we call the aggregate of the old index PQ and the aggregate of the revised regimen $P^1 Q^1$ we obtain:

$$\frac{P_0Q_1}{P_0Q_0}. \quad (7)$$

This is the old quantity index; dividing this into an index of value of gross production we obtain:

$$\frac{P_1Q_1}{P_0Q_0} \div \frac{P_0Q_1}{P_0Q_0} = \frac{P_1Q_1}{P_0Q_1} \quad (8)$$

which is a price index on the changing weight aggregative formula. Dividing (8) into the total value of the revised regimen:

$$\frac{P^1_1Q^1_1 \times P_0Q_1}{P^1_0Q^1_0 \times P_1Q_1} \quad (9)$$

this is the revised quantity index.

Now it is clear that a fixed weight aggregative quantity index for the revised regimen would be of the form:

$$\frac{P^1_0Q^1_1}{P^1_0Q^1_0} \quad (10)$$

and that (9) is an approximation to this. What condition must be fulfilled for (9) to be equal to (10)? If—

$$\frac{P^1_1Q^1_1 \times P_0Q_1}{P^1_0Q^1_0 \times P_1Q_1} = \frac{P^1_0Q^1_1}{P^1_0Q^1_0}$$

then—

$$\frac{P^1_1Q^1_1}{P^1_0Q^1_1} = \frac{P_1Q_1}{P_0Q_1} \quad (11)$$

i.e., price indices calculated on the changing weight aggregative formula are identical for the old and for the revised regimen. In other words, we may take (9) to be the true index of the quantity of recorded production, if it is true that the prices of items included in the new regimen move in exactly the same way as do prices of the items of the old regimen (i.e., the old quantity index). This assumption is unlikely to be completely correct, but is likely to be more nearly so than the alternative assumption (referred to above) that the quantity produced of the items of the two regimens move in exactly the same way. If we thus make the former assumption and accept (11) as correct we obtain by simple transformation—

$$P^1_0Q^1_1 = \frac{P^1_1Q^1_1}{P_1Q_1} \times P_0Q_1 \quad (12)$$

This means that the fixed weight quantity aggregate for the revised index may be obtained by multiplying the quantity aggregate of the official (unrevised) index by the ratio which the gross value of the items in the revised index bears to the gross value of the items in the official index.

The index for the quantity of net production then presents itself in its final form as follows:—

$$\frac{\frac{P^1_1Q^1_1}{P_1Q_1} \times P_0Q_1 - \frac{p_1q_1}{r}}{P_0Q_0 - p_0q_0} \quad (13)$$

In undertaking the actual computation of this we may begin with the expression on the left-hand side of the enumerator and note that this may be written as:

$$\frac{P_1^1Q_1^1 \times P_0Q_1}{P_0^1Q_0^1 \times P_1Q_1} \times P_0^1Q_0^1 \quad (14)$$

This means that the expression is really nothing but Wilson's revised official quantity index multipled by base period gross value of production; that is to say, it represents the quantity of annual gross production in constant value terms and the computation is simple arithmetic. (Table 1).

TABLE 1.

The Index of Agricultural Net Production.

(a) Year.	(b) Wilson's Revised Index (9)*.	(c) Wilson's Revised Index x $(P_0^1Q_0^1)$ (14)*.	(d) Deflated Value of Inputs $\frac{(p_1q_1)}{r}$	(e) = (c) —(d) Deflated Value of Net Production.	(f) Index of Quantity of Net Production. (13)*.
1921 ...	940	241	85	156	886
1922 ...	904	232	77	155	881
1923 ...	887	227	77	150	852
1924 ...	1,039	266	86	180	1,023
1925 ...	994	255	81	174	989
1926 ...	1,077	276	79	197	1,119
1927 ...	1,003	257	78	179	1,017
1928 ...	1,101	282	85	197	1,119
1929 ...	1,051	269	79	190	1,080
1930 ...	1,216	311	85	226	1,284
1931 ...	1,202	308	76	232	1,318
1932 ...	1,300	333	92	241	1,369
1933 ...	1,222	313	86	227	1,290
1934 ...	1,221	313	83	230	1,307
1935 ...	1,180	302	84	218	1,239
1936 ...	1,206	309	91	218	1,239
1937 ...	1,309	335	99	236	1,341
1938 ...	1,266	324	101	223	1,267
1939 ...	1,407	360	102	258	1,466
1940 ...	1,212	310	93	217	1,233
1941 ...	1,373	352	103	249	1,415
1942 ...	1,394	357	96	261	1,483
1943 ...	1,352	346	86	260	1,477
1944 ...	1,205	309	80	229	1,301
1945 ...	1,295	332	88	244	1,386
1946 ...	1,195	306	89	217	1,233
1947 ...	1,340	343	104	239	1,358
1948 ...	1,329	340	110	230	1,307

* The numbers in brackets refer to formulas in the text.

The expression on the right-hand side of the enumerator represents the value of inputs deflated by an appropriate series. The choice of such a deflator presents certain difficulties.

The value of inputs is easily found as the difference between gross and net production as given in Melville's paper for the period covered by it.[9] For subsequent years figures computed on the same basis can be obtained from the Commonwealth Statistician's annual production bulletin, as the difference between the gross value of rural production (computed on the "old" basis) and the net value, on making some minor adjustments in regard to costs of maintenance and depreciation.

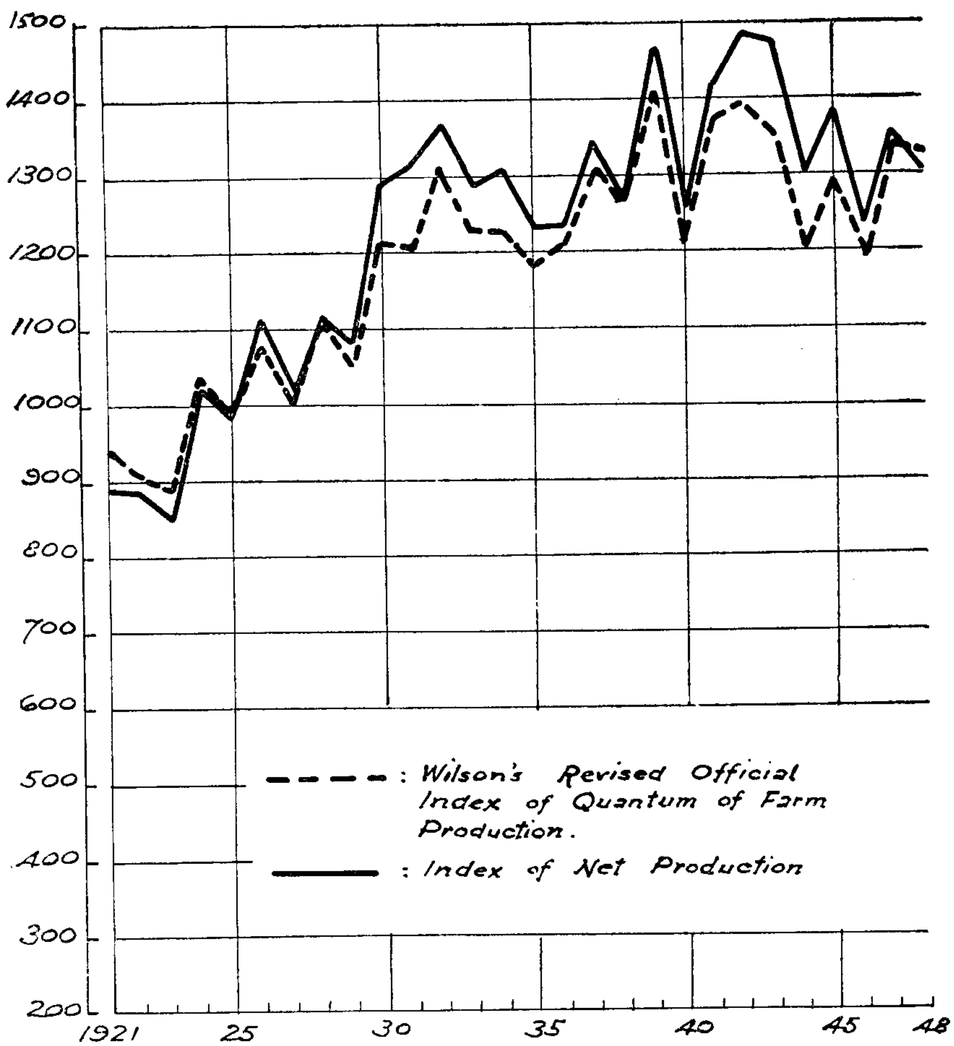

Fig. 1.—Indices of Farm Production (1923-24 to 1927-28 Average = 1,000).

The fact that data for inputs are not available in quantitative but only in value terms, constitutes, as already mentioned, one of the major shortcomings of the index here to be constructed. We may say, however, in general terms, that the two major types of item included in inputs are materials (feedstuffs, fertilizers, fuel, etc.) and general transport

[9] Melville, *The Cost of the Australian Tariff* (paper read to ANZAAS, 1946 Meeting).

and marketing costs. Whether marketing costs (including the cost of transport of produce to the principal market) should be included among inputs is, indeed, a moot point. In a study concerned with the allocation of resources, the case for inclusion is quite a strong one, for the effect of locational factors is thereby to some extent brought into account. In any case, the available data for inputs do include these costs, and the merit of the case apart, it would be difficult to eliminate the item from the figures.

It is a familiar fact, of course, that transport and other marketing costs are, generally, a good deal "stickier" than is the cost of other inputs. The procedure adopted was, therefore, to split the figure for the value of inputs each year into two parts, one of which was taken to represent marketing costs and the other the cost of materials, and to deflate them by separate series.

For the purpose of deflating the value of materials, an unweighted index was constructed of the prices of ten important items used in agricultural production.[10]

With regard to marketing costs no data on which a price series could, with any confidence, be based, was found available.[11] In the absence of better indicators it was considered that the familiar lagging movements of these costs might best be portrayed by making the assumption that their level each year during the period under consideration, was governed by the average movement of the cost of living during the five preceding years. A five-year moving average of the cost of living centred in the last year was therefore used as a deflator series.

In this manner the series for the quantity of inputs measured in constant value terms is obtained and the computation of the index of net production is completed by deducting this series from that of quantity of gross production (also expressed in constant value terms, as arrived at above) and dividing through by the denominator of formula (7) which represents the base period net production.

3. THE INDEX OF RURAL INVESTMENT.

Two types of difficulties which were experienced in the derivation of a serviceable index of production will be encountered—in more acute form—in the construction of a series for agricultural investment. They are—scantiness of reliable data and difficulties of definition.

To overcome the former a lengthy process of estimation of varying degrees of accuracy is needed, details of which will be discussed presently. Difficulties of definition centre largely around the distinction

[10] The index was based on four types of foodstuffs (chaff, hay, oats and pollard), two fertilizers (lime and superphosphate), one fuel (kerosene) and three general items (sheep dip, cornsacks and wool-packs). The source of these prices was the New South Wales *Statistical Register*.

[11] A tentative index of transport costs was computed on the basis of freight earnings of the N.S.W. Railways, but was found to be so much influenced by irrelevant factors, such as the composition of freights and method of enumeration, as to be practically useless.

between income (or cost) and capital, and will, as previously indicated, be settled more or less arbitrarily by reserving the term investment to four main types of expenditure, embodied respectively in:

(*a*) Land and Permanent Improvements.
(*b*) Machinery and Implements.
(*c*) Livestock.
(*d*) Irrigation Works.

(a) Land and Improvements.

Theoretical Aspects.

Basic Determinants of Unimproved Value.—Land was once looked upon by economists as a factor of production par excellence, a genus apart, by virtue of the natural limitation of its total quantity and its consequent ability to earn "rent". Nowadays, the tendency is to regard it as distinct in degree rather than in kind from other productive agents (such as rolling mills or fashionable crooners) whose earnings ("quasi-rent") are partly or wholly due to temporary or absolute scarcity of supply. This view of land as a factor of production has consequently been adopted and serves as a justification of the procedure to be followed, of compounding its measure into an index with those of the other types of investment enumerated above.

In casting around for a measure of land used as a productive agent in primary production, area as a measure of broad acres appears as the most obvious. This measure is nevertheless clearly precluded by the heterogeneity of the subject to be measured: There is scarcely any conceivable way in which 1 acre of irrigated citrus land in Mildura can be said to be the equivalent of an acre of marginal grazing land in the Western Division of N.S.W., less than 30 miles to the north. Nor will more concrete units of measurement serve such as the sheep (or beast) area, as there are clearly many types of land to which they can hardly be meaningfully applied. Because of this and also because we intend eventually to combine our series of investment in land with similar series for other non-homogeneous factors we are again, as in the case of production, thrown back on money value as the only practicable unit of measurement.

The problem on hand thus becomes one of deriving a series of values of land used for purposes of primary production.

Land value data, almost invariably, are of two kinds—improved and unimproved—and the difference between them corresponds to the value of improvements. The distinction between these three magnitudes is a basic one even though it is frequently neglected in common speech and occasionally in economic discussion.

It is not possible to discuss specific value data without reference to the particular valuation practice on which these values were assessed and the legal framework that determines this practice. Before giving detailed attention to these matters, however, some theoretical aspects of the subject of land values must be briefly reviewed. We may begin by reiterating the truism that Improved (or Total) Value is equal to Unimproved Value plus Value of Improvements and proceed by asking "What determines unimproved value?"

The economics of urban real estate values present certain difficulties which are absent in the case of rural land values which alone need here claim our attention; it may be added, though, that what will be said will, on the whole, apply equally if with different emphasis to urban values.

The unimproved value of rural land, then, is governed in the main by two factors, its productive capacity and its facility of access to prospective markets. The second criterion may be expressed in value terms as the transport cost incurred in getting produce to (and obtaining supplies from) the market and presents no great difficulties.

Productive capacity of land is clearly determined by such physical factors as the constitution of the soil, climatic conditions controlling the rate of evaporation and precipitation, incidence of floods, dust-storms, etc., and the availability of irrigation waters. These factors govern the productive value (as against the position value referred to earlier) of land which, as in the case of other assets, must be measured by capitalizing its net return. The net return is obtained by deducting from gross receipts all cost incurred in production, including transport of finished product to the market, but excluding rent (if paid) and interest on capital invested in the unimproved value of land.

It is not intended here to enter into the problems associated with the determination of these costs, and the methods of estimation that will at times be needed in order to ascertain them. Non-cash costs, especially labour costs, probably present the most serious difficulties; for here a purely subjective factor enters when the cost of the farmer's own labour is determined. An unusually thrifty (or efficient) individual may bring the cost of his own labour into account at a price well below the average; as a result the net return—to him—of a given property will be higher than current market valuation, as will also its value, given the prevailing rate of capitalization. It is sometimes claimed, probably not without justification, that in this way an influx of immigrant farmers accustomed to lower living standards and labour rewards, has resulted in increased land values in certain districts.

The difficulty is apparent that to any prospective purchaser the productive value of the land will be represented not so much by the net returns it has yielded its owner in the past, but by those he himself might expect to derive from it in the future. Their dependence on the vagaries of the seasons and of the market make forecasts of future net income precarious. Past performance is, as a rule, a reliable guide to future yields, at least for arriving at a probable average for a reasonably long period ahead. For an estimate of future costs over a lengthy period the margin of error that must be allowed is large and as regards price estimates for primary commodities sold on world markets and not subject to long-term purchase agreement, even the most searching inquiry can provide little more than an informed guess.

But even if perfectly stable conditions—or inspired vision—enabled correct forecasts to be made, some basis would still have to be found on which to determine the rate at which net returns shall be capitalized in order to obtain a figure for the unimproved capital value. The solution most in accordance with common sense would probably be to make the rate correspond to the prevailing rate of interest plus a premium for the special risks associated with primary production. If this view is accepted it follows that there would have to exist as many capitalization rates as there are different types of climatic and environmental conditions, in fact, an unlimited number corresponding to the infinite progression of farming lands from the gilt-edged to the marginal.

The risk premium applicable to investment in each parcel (or type) of land could then be defined as some function of, say, the standard deviation of net returns over the period for which these have been averaged. In other words, the less reliable these returns are the higher the risk premium, the higher the capitalization rate and the lower, consequently, the unimproved value of the land.

In whatever manner the risk premium, if any, is arrived at, it is beyond dispute that some investors at least will compare the return obtainable from investment in land to that offering in other avenues and that, therefore, the prevailing rate of interest is bound to affect the rate of capitalization of net returns, though a time lag may occur before these effects can work themselves out fully.

The capacity of land to produce crops or carry stock is not the only determinant of its value. We may call this capacity its productive value as distinct from its position value, determined by its access to markets. Position value will thus be represented by marketing costs capitalized at the prevailing rate of interest. This is best conceived as a negative quantity which must be set off against productive value to find the improved (total) value of the land. We may then say that "the value of any given land would be the value of the superiority in situation which it had over marginal land of the same productive value; or it would be the value of the productive advantage it had over marginal land of the same position value".[12]

Even this statement still unduly simplifies the position. Unimproved land may derive its value not only from the net returns available from its production, but from possible capital increments that may accrue to it due to a variety of causes, e.g., possible uses as a building site or railway siding. This element in its value may be called its prospective value. Another distinct though rather intangible element may arise from the desire for land-ownership for non-economic reasons, say, the preference for farming "as a way of life". There are thus at least four distinct "value" components in what we customarily designate as land "value" and others could no doubt be added.

Nor does this exhaust the full range of meanings that attach to the the term "value". For the "value" as determined by the four constituents just referred to, is still something quite distinct from the market value of the unimproved land which may be varied almost *ad lib.* by means of the imposition of land taxation as we shall see presently, while yet another concept, viz., cost of production, is involved in the discussion of the "value" of improvements.

[12] J. M. Garland, *Australian Land Taxation* (Melbourne; Melbourne University Press, 1934), from which the fourfold classification of unimproved land values is taken.

Attention will occasionally be drawn to the different meanings of the term. In any case, it is necessary to remember that the constant use of the term (value) in the ensuing paragraphs may reflect the poverty of language rather than any underlying uniformity in the economic phenomena discussed.

The Effects of Land Tax and Rates.—A further complication needs now to be faced: the effect of land taxation on unimproved value. This subject is of special significance in Australia, where this instrument of economic policy was first pioneered and reached its fullest (or as some have thought, most iniquitous) development.

It may be well to begin by stating that a tax on unimproved land values may have one or all of three purposes: the raising of revenue, the appropriation for the public benefit of some of the "unearned increment" of land, and the breaking up of large estates, and to add that each of these objectives has, in fact, been aimed at, at times, by Australian policy makers.

A proportional (flat) tax on unimproved land values—in common with other forms of property taxation—differs from other taxes in two important ways. Firstly, unlike sales tax, its effects cannot generally be passed on and, secondly, unlike income tax, it can with ease be capitalized. For this reason the effects of this tax must, as a rule, be borne in their entirety by whoever owns the land at the time it is imposed. It represents a charge against the net return from land the value of which will consequently be reduced by the capitalized value of the tax. In other words, the tax acts as an impost, not on income, but on capital in much the same way as a direct capital levy.

It is this circumstance, of course, combined with the fact that land tax to a greater extent than other property taxes, is a tax on pure rent, which has made the tax a political *cause célèbre,* and the subject of often heated controversy.[13]

The many interesting political and economic problems raised by the principle of land taxation are beyond the range of this discussion, but what must be stressed is the fact that the economic effect of the tax will, in the main, be exhausted in the year of its original imposition: The taxing authority, in effect, appropriates that part of the value of the land represented by the capitalized value of the tax and thereafter derives an income from its "property" directly proportional to the net return from the land. As a result of this, the market price of land will drop and will no longer give a true indication of the productive, position and other value of the land. In the extreme case where the tax is so high as to absorb the whole of the net return, land will cease to be a commercial asset. If, at any time, a tax were to be imposed at a rate higher than the one at which the net return of land is being capitalized, the amount of tax payable would exceed the net return by a sum equal to the percentage of total unimproved value given by the difference between the two rates. If the payment of the tax were defaulted, the arrears would presumably become a charge against the property, the

[13] See for this Henry George, *Progress and Poverty* (London; Hogarth Press, 1953) and publications of the Henry George Foundation, e.g.—*Public Charges upon Land Values,* by the Land Value Research Group (Melbourne, 1944).

taxing authority making itself legal as well as beneficial owner of the land; this process would have to continue until the taxpayer's equity in his holding was reduced to an amount equal to net returns capitalized, not at the normal rate, but at the rate of land tax. At that point the amount of tax payable annually would be equal to net returns and the unimproved market value of the land would be zero. As taxation is assessed (almost invariably) on the market value of the unimproved land, it would then follow that the yield of the tax would also be equal to zero.

This conclusion may appear paradoxical, but is nevertheless inescapable, given the nature of land tax and the almost universal method of making assessments. It carries the corollary that a land tax, once it has been capitalized, will always give a yield below the one obtained from the original assessment.

The stock example of proportionate land taxation is, of course, local rates. These are apt to fluctuate from year to year and evidence is lacking for deciding whether or not they are in fact capitalized on an annual basis. The extent to which the rate is, in fact, capitalized will depend both on the expected future movement of the rate and the frequency with which changes in it actually occur.[14]

When considering forms of land taxation other than local rates, two complications are encountered which rob our analysis of much of its simplicity and, indeed, make the outcome to a considerable degree, unpredictable. The trouble is that land taxes other than local rates—land taxes proper, that is to say—are not levied at a flat rate; and not only are they imposed at a progressive rate, but they also have been frequently in Australia, in any case, subject to substantial exemptions.

The practice of progressive taxation has its theoretical foundations in the principle of the diminishing marginal utility of income. The rationale of such a tax is to snatch the egg without injuring the goose, i.e., to obtain revenue without reducing the incentive to earn income. A scale of progression in a sound income tax must always be such as to preclude any possibility of a taxpayer's increasing his net income (after taxation) by earning a lower gross income and having it taxed at a correspondingly lower rate. In the case of an income tax, this presents no insuperable problems, but where land or other property taxation is concerned, no method of levying it can prevent a taxpayer from selling part of his holding and investing the proceeds in assets other than land and pay tax on the remainder at the lower rate.

This contingency is a weakness of the tax if looked upon as an instrument for raising revenue, but it is also one of its prime virtues where it is wielded as a tool of economic policy. For the fact that the tax penalizes the large as compared with the small landholder will militate against the agglomeration of land on one hand and promote the establishment of small holdings. Where exemption from the tax is granted to holdings below a certain capital value—as is done in most Australian land tax legislation—a definite tendency will, in addition, be set up for land to be subdivided into holdings of a size approximating to the exempt value.

[14] See the Appendix where the subject of capitalization is discussed in some detail.

This tendency will clearly be modified and to some extent counteracted by considerations concerning the most economic use of each particular parcel of land subject to the tax and the optimum size of holding appropriate to that use. These are matters which cannot be entered upon in the present context. But it may be noted that in every instance where land is employed most productively in units of a value in excess of the exemption limit, the tax will give an inducement to reduce the size of the holding below the economic optimum. This inducement will be the stronger the higher the rate of tax and the lower is the rate of capitalization of net returns.[15]

To the extent, therefore, that valuation practice accords with the principle formulated above, *viz.*, that the rate of capitalization should vary as between different types of land, excessive subdivision will be most common on the best types of land in the safe rainfall zone. This would follow from the fact that on such land the risk premium (which it will be recalled constitutes a part of the full capitalization rate) will be relatively low.

The effect on land values of a proportionate tax, as was seen before, are—within a reasonably narrow range—predictable. But where land tax is being levied at a progressive rate, the taxpayer, in many instances, has the option of escaping part or all of the incidence of the tax by fragmenting his estate and disposing of a portion of it. The scope or lack of scope for profitably subdividing the property will thus become an important determinant of its unimproved value. The "divisibility" of the property will be a function of the earning capacity of the subdivisions, the rate of progression of the tax, and the appropriate rate of capitalization.[16] It is worth noting that the "divisibility" of the land (assuming it susceptible to estimate) will govern its value even where the land has not actually been sub-divided; for a prospective purchaser would have to pay for the potential as well as the actually realized value of the land.

The conclusion, therefore, emerges that a progressive land tax may not necessarily be capitalized; the extent to which it is will be governed by the divisibility of the land on which it is imposed, and cannot be determined for that reason without reference to the agronomic characteristics of the land, which will decide both the return earnable after subdivision and (the risk component of) the rate of capitalization. If the land can be parcelled up without any reduction in revenue its capital value will not be affected by the tax, however steep the rate of progression. In such a case the land tax will be paid each year out of income and will partake of none of the once-and-for-all nature peculiar to a capital tax. At the opposite extreme, a holding that cannot be divided without total loss of revenue will have to bear the full amount of the capitalized tax. Indeed, it is possible here to imagine a case where, with the rate of progression very steep and the unimproved value high (before the imposition of the tax), the value will be reduced to somewhere around the zero level.

[15] See the Appendix.

[16] See the Appendix.

From the discussion so far the progressive land tax appears to emerge as a tool of iniquity which puts a premium on the wasteful use of resources: where subdivision is impracticable, its effect is similar to that of the proportionate tax, except that it discriminates against bigness; where sub-division is possible, it abets evasion provided only that the land be diverted from its most profitable use. There remains the additional case where land is parcelled up and thereupon gives a yield higher than in its undivided state. This seems at first sight hypothetical, because where it applies it would clearly have paid the landowner to divide his land—even in the absence of the tax. Nevertheless, a number of clearly defined situations exist where such cases will arise.

Reference has already been made to the fact that non-economic motives may be involved in a decision concerning investment in land. Few people would allow themselves to be swayed by other than commercial considerations in purchasing securities or industrial stock; but unlike these the ownership of real estate, especially broad acres, once did, and to some still does, confer a status not entirely dependent on the profitability of the investment. This attitude may occasionally lead to the aggregation in one hand of land that could be put to better advantage if sub-divided; a progressive land tax, under these conditions will add to the cost of maintaining that status and may persuade some to relinquish it. The same will apply where land is held not (or not only) as a source of income, but as a speculative investment in the expectation of a capital gain, from, say, a projected railway extension or from an expansion of municipal boundaries; here, too, the tax, by making the investment less profitable, may force its abandonment.

Considerably more important than either of these cases is another type of situation in which a progressive tax may be conducive to beneficial changes in the use of land. It is a situation that was, more or less, clearly visualized by the early proponents of the tax who saw in it a device for blazing a trail for close settlement which, in the fullness of time would bestow untold benefits on a growing population. There can be no doubt that there was a great deal of truth in that vision. A denser rural population brings in its train the prospects of external economies—better transport, electrification, irrigation—which may increase the productive and position value of the land far above what it would have been in its previous setting.

The promotion of such developments is, as a rule, beyond the resources of even the most venturesome private entrepreneurs; nor are they easily analysed—ex ante—in terms of static economic theory; for they are concerned with structural rather than marginal changes in the allocation of resources. Unlike most other economic activity they do not aim at adjusting resource use to current market valuations but aim rather at modifying the economic framework within which these valuations are determined. In certain circumstances, therefore, it might be possible for a progressive tax to set in motion a chain of events that may ultimately result in such structural changes; but in the majority of cases more positive government interference will be needed to bring them about.

Finally, we may shed the assumption implicit in the foregoing discussion of progressive taxation, viz.: that policy should aim at maximizing economic in preference to other magnitudes. The desire for subdivision, even where it will inevitably lead to smaller returns and incomes, may spring from any of a multitude of beliefs, all of which are irrational only in the limited sense in which that term is generally used by economists. The call for a larger (and, if need be, poorer) rural population because it promotes health, the good life, conservative citizenship, or the military virtues has inspired a great deal more rural policy measures between the days of Virgil and Wakefield (and since), than the criteria of economists; but it is with the latter that we must here be concerned.

One significant social effect of land taxation, both proportionate and progressive, is that by reducing the market price of land it brings land-ownership within reach of sections of the population who would otherwise be excluded from it. Such a tax will make competition for land more nearly perfect by providing a greater measure of equality of opportunity to all those seeking ownership. To the extent that the natural differential advantages of different types of land are appropriated by the State by means of a progressive tax, rural incomes will tend to reflect more nearly the efficiency of producers rather than the differential quality of the land. Where capital rationing is severe, lower land values will enable prospective buyers to reserve a larger proportion of their available funds for the improvement of the property, resulting in more productive land use. The same end could, of course, be achieved more directly by improving agricultural credit facilities.

The most familiar argument in favour of taxing unimproved values which cannot here be discussed in detail is, of course, that it "hurts no one" for the reason that increases in these values are of the nature of windfalls; and further that these unearned increments are due to the activities of the community at large and that, therefore, it is fit and proper that they should be appropriated by the State and their proceeds used in ways beneficial to the whole community.

The Value of Improvements.—We must leave this brief discussion of the determinants of unimproved value and turn to a consideration of the value of improvements. Not a great deal will need to be said about this; for fortunately improvements belong to a more common species of economic magnitude than is true of unimproved land values. The difficulty with the latter, as has long been known, arises from the fact that, unlike the majority of economic commodities, land in its natural state has no cost of production and its value can only be inferred from its income-earning capacity. As against that, improvements have almost invariably a clearly definable cost of production or installation.

The difficulty, nevertheless, remains that cost of production is by no means an unambiguous concept. The term can be taken to refer to original or actual cost or to replacement cost; in the former case, the many problems arising from changes in the purchasing power of money will be encountered, and in either case the question of proper allowance for depreciation will present certain complexities. For the purpose of an index, such as we intend to construct here, what is of special interest is, of course, the "quantum" of improvements in existence at any particular time. In order to assemble such an ideal index we would have to be able to identify each particular type of "improvement", build up a series for its movements over the period and then combine these various series into an index with the aid of appropriate weights. Unfortunately, the great profusion of dissimilar types of improvements makes this approach impracticable and our index must therefore fall short of perfection.

We will have to make do with deflated value series derived from such data as are in fact available. As will be seen, the only obtainable data for improvements are generally valuations based on replacement costs minus depreciation. This will make our task somewhat easier than it would have been if we had been confronted with data representing original cost of production which would have involved the separate deflation of each annual increment of total improvements. Below, when considering public investment in irrigation works, we shall have to deal with data of this latter type.

It is evident that in what has just been said about the value of improvements, the term "value" has been used in rather a different sense from that attached to it when the value of unimproved land was being discussed above. For, in the present context, "value" means cost of replacement (allowing for depreciation), while earlier on it was taken to stand for "capitalized net returns". The relation between these two concepts is a simple one; for clearly improvements will not be worth installing unless their capitalized net returns are at least equal to their cost, nor will any prospective buyer be prepared to pay more for them than just that amount. Reasoning along familiar lines we may, therefore, say that the value of improvements (using the term in the sense of replacement cost) will tend to equal their value (using the term in the second sense, viz.: capitalized earnings) in their marginal use.[17] In intra-marginal uses they will be worth an amount for which the upper limit is given by their capitalized earnings and the lower limit by the cost of replacement, allowing for depreciation. As a large proportion of improvements is composed of constituents which have their main and probably their marginal uses outside primary industry (e.g., timber, concrete, etc.) it is possible that, in fact, all their uses within primary industries are of an intra-marginal nature, i.e., yield returns in excess of replacement costs. This is all the more likely as the existence within agriculture of indivisibilities and of capital-rationing will often tend to prevent improvements from being applied to the fullest extent, i.e., from being pushed to their marginal uses.

The deduction is then unavoidable that over a wide range the cost of improvements will not equal their earning capacity and that their "value" in the two senses indicated will not be the same. This aspect of the matter raises some points—fundamental to the problem of deriving a series for investment—which need to be entered into in some detail .

Before entering upon them, however, we may once more draw attention to the effects of land taxation. The incidence of this—and its relevance for our purposes—on unimproved values has already been discussed. Not all land taxation is, however, levied on unimproved value; in several Australian States local taxation falls upon improved values, or,

[17] This argument, of course, is subject to the usual proviso that the adjustment may fall short of "perfect equilibrium" owing to the presence of indivisible factors and of others that may have to be used in fixed proportions.

alternatively, on annual value. Such an impost will inevitably tend to discourage the making of improvements; for where it is levied it will not be enough for improvements to earn an additional income sufficient to earn adequate returns on the capital invested in making them. Over and above this they will have to earn enough to pay the tax to which they are subject; in the case of a progressive tax there will, furthermore, be added on to this the additional tax payable on the rest of the estate as the result of the higher rate to which the taxpayer is liable owing to the increase in the taxable value of his estate.

Improvements already in existence when the tax is imposed (or the rate increased) may be allowed to wear out without being replaced if they fail to pass the new and more severe test of profitability. Where existing improvements are of a permanent and indestructible nature the effect of the tax will not be different from one levied on unimproved value, i.e., it will be capitalized, but, in addition, of course, new improvements will be restricted to those capable of repaying both their own cost and that of the tax imposed on them.

Subject to these considerations, however, taxes levied on improved values will be capitalized to reduce total value in much the same way as in the case of taxation of unimproved values. As the value of (productive) improvements cannot fall below the cost that would be incurred in replacing them, it follows that in most cases the whole weight of the tax will eventually be shifted on to unimproved values—even in those cases where they have been originally assessed on the improved value. The same will hold good where the tax is assessed on (improved) annual value.

Land Values and the Concept of Rural Capital.—It will be recalled that the object of the present essay is to investigate the relation existing over a period between agricultural (net) product on the one hand and agricultural employment and investment on the other. One of the conditions that must be fulfilled if we are to make unambiguous statements about any such relation is that each of these magnitudes must be capable of being defined independently, i.e., without reference to the others. But we have seen above that improvements can, and unimproved land values must almost inevitably be, defined with reference to the value of the net product that is imputable to them; for productive value which forms one of the principal constituents of unimproved value is basically nothing more than the value of net production capitalized.

The dilemma thus confronts us that if we use these data to build up a series of agricultural investment and then use this series in order to account for movements in net production, we shall, in fact, be "explaining" net production by reference to its own capitalized value, that is, we will be involved in circular reasoning. Where improvements are concerned we may extricate ourselves from the complexities by squarely plumping for replacement costs as their true measure, but as regards unimproved value, no such easy route of escape seems open; it seems that movements in unimproved land values can throw no light on changes in net production, as they themselves are the result and not the cause of these changes.

This conclusion, however, must be modified in several significant respects. Firstly, we have seen that it is only the productive value component of unimproved value which reflects the trend in net returns;

the other components which we have previously distinguished—prospective, prestige and position value—are largely governed by other forces. The prospective and prestige value components, however, are purely adscititious from our point of view as they bear no relation to the value of land regarded as a capital asset for purposes of primary production; in fact, had there been a practical way of doing it, it would have been preferable to eliminate their effect from the land value data altogether. Their continued presence in the data is therefore not so much a reassuring feature as an occasion for further misgivings.

Position value is in a different category. Changes in this magnitude will reflect largely developments in the availability of transport which are of real significance to agricultural production. These changes are probably a fairly good indicator of movements in the value of external economies accruing to agriculture. Such movements will not be a direct result of investment within primary industry (though they may have an important effect on it), but we may expect them to be correlated with factors such as variations in non-agricultural investment and population.

Another group of phenomena somewhat akin to external economies that will tend to exert a steady upward pressure on unimproved values, are those generally classified as inventions and innovations. Improved methods of pasture treatment and disease control, better strains of seed or breeding stock, etc., will add to returns far in excess of the cost involved in procuring them; unimproved values by way of their productive component will then be correspondingly enhanced. Indeed, it is clearly true for all improvements that whatever contribution they make to net returns above their own cost of establishment will eventually be capitalized into unimproved value, assuming only the latter to be defined consistently as the value of improved land minus the cost of improvements.

In summing up the main conclusions from this review of the anatomy of unimproved value we may begin by briefly recapitulating the principal factors which were found to determine these values.

The capitalized value of net production was seen to be of paramount importance. Both present and expected future prices will exert an influence on it as well as costs. The latter as well as the former may vary as a result of general economic fluctuations or because of institutional changes such as price control and tariff revisions; increased productivity due to innovations will tend to increase the total product and modify the price-cost structure and the steady growth of external economies will have far-reaching effect whose full significance evades analysis though transport costs may give some indication.

Interest rates through their effect on the rate of capitalization will exert an important influence on unimproved values in the long term and the level of land taxes, in their various forms, constitutes a powerful distorting factor.

In the face of this array of disturbing elements it is evident that market quotations for land values—and these are generally the only type of data available for them—cannot be a reliable measure of unimproved land, regarded as a physical factor of production. It is precisely such a measure, of course, that we are in search of. Indeed, the mere fact referred to above that land (being a specialized factor) has its price determined in the last analysis by reference to the product it yields makes it difficult, if not impossible, to obtain from such data an indication of movements in the "real" physical factors. Unimproved land is in fact (as Ricardo first recognized) the residuary legatee of primary industry, taking the remainder of the total product after all the other factors have been paid off.

It seems thus tempting to omit unimproved land altogether when aggregating rural capital; for it could be argued that as unimproved land does not change, i.e., remains unimproved, changes in production can and must be explained without reference to it. Against this it may be advanced that the total quantity of unimproved value employed in agricultural production may change from year to year and that some allowance will have to be made for this. In order to do this we would have to fall back upon some physical measure of area, unsatisfactory as this approach was found to be at the outset of the discussion. The second objection to excluding unimproved land from our series for rural capital stems from the fact that data for unimproved values, suitably deflated, could give *some* indication of the contribution made to production by those elusive accessories to production, external economies and innovations. But this method of determining the importance of these two factors would again involve circular reasoning if it were intended to use the quantitative measure, if any, obtainable in this way, in order to explain movements in production. It seems preferable, therefore, to leave those factors out of account at present, confining ourselves to some general qualitative observation on their operation, in recognition of the fact that no explanation of production movements can be complete without reference to them.

The final objection to be raised against the omission of unimproved land from a series of aggregate rural investment is based on the fact that unimproved land beyond doubt is a factor of production and makes a contribution towards total output. Whenever it is therefore a matter of identifying the determinants of total production rather than the causes of changes in that total, allowance will have to be made for unimproved land. This may perhaps best be done by bringing unimproved land into account at a figure equal to its value at the outset of the period under consideration, while, at the same time, making suitable allowance for changes in the purchasing power of money.

As regards the value of improvements, no more need be said in this summary than that it was found that the weight of theoretical argument seems to favour their being measured at replacement cost. This course presents little practical difficulties when dealing with the Australian data.

Improvements measured in this way provide a reliable measure of rural capital which is relatively little affected by the many disturbing influences discussed earlier.

Practical Performance.—A careful examination of Australian valuation law, points to the conclusion that definite rules have been established to cover a considerable part of the field. Though legal instructions have varied a good deal from period to period and have been different for various valuing authorities, there are good grounds for believing that valuation practice is very much more uniform both over time and as between the different authorities than is legal theory. Such differences as are known to exist, can largely (as in the case of capitalization rates) be traced to definite legal enactments. The main technical features of valuation practice may be briefly recapitulated in statements of two eminent practitioners made in evidence before the Rural Reconstruction Commission.

Mr. L. Knibbs,[18] Chief Valuer, Commonwealth Taxation Department, put it in this way: "All the facts being relevant to the property being valued, such as its productivity, its improvements, and so on, having been obtained and recorded, the next step is to obtain some data which would provide a measure of unimproved value in accordance with the definition of the Land Tax Assessment Act. As there are, except in some urban areas, insufficient sales of unimproved land to establish by direct comparison what land would be likely to realize in its unimproved state the method usually employed is to ascertain what the land in its improved state would sell for, and then try to deduct the amount attributable to the value of improvements, the residue being the unimproved value".

The uses of the capitalization method were summed up as follows, by Mr. A. H. Peters,[19] Director of Lands, S.A.: "As a check on values established by (other) methods, the so-called 'productive value' method is utilized. Investigation into settlers' affairs has established a sound basis for calculating the estimated margin of income over expenditure and this figure capitalized at a percentage rate appropriate to the hazards of production from the particular major source of income acts as a guide, together with commonsense view of value, to arrive at a finally adopted figure."

Finally, a caution is needed, for it must be realized that statements such as the above may be indicative of the best rather than of the average of valuation practice. It is evident that in an activity such as valuation carried on by a large number of (relatively) independent and frequently unco-ordinated individuals, errors of judgment and—more important—of method cannot always be avoided. Even more serious, a systematic bias is evident in valuations undertaken for a number of specific purposes. That security valuations undertaken by banks and other lending institutions are likely to err on the side of conservatism, is commonplace, but what is more important for our present purposes here is, that valuations made by many local authorities of which extensive use will have to be made in deriving our series are subject to a similar bias.

This is due to the fact, vouchsafed for by many observers, that local authorities faced with the need for raising a certain amount of revenue are inclined to keep valuations low in order to save the expenses involved in possible appeals that may follow from high (i.e., proper) valuations. The necessary revenue is then obtained by rates being levied at a somewhat higher percentage in the pound than would have

[18] Quoted by W. V. Fyfe in "Report on the Main Country Land Valuation System in Australia", Annexure B, 9th Report, Rural Reconstruction Commission.

[19] Quoted by W. V. Fyfe, *op. cit.*

been required with more realistic valuations. This course commends itself also for the reason that in certain States (e.g., N.S.W.) Government contributions to local finances are conditional upon rates having been levied at the statutory maximum.[20]

The Data.

Definitions and Sources.—We are now ready to turn to the final section of this discussion of land values and to look at the statistical data which form the basis of our series for the improved and unimproved values of rural lands and for the value of improvements.

The definition of "rural lands" presents some difficulties. All available figures for land values on a State or Commonwealth basis which can be used for our purposes refer not to "lands used for primary production" but to total rural lands. This may not be a very serious flaw, but what is somewhat more serious is the fact that largely because of this, the value of improvements refers not purely to improvements of a kind used for purposes of primary production. A part of these and probably quite an appreciable one consists of dwellings for human use and presumably some other types of improvements which either do not contribute to agricultural production at all, or do not contribute to that part of agricultural production which is statistically recorded; "kitchen gardens" may be an example of the latter type of improvement. On the other hand, certain types of primary production are quite often carried on within the metropolitan boundaries (e.g., some dairying, poultry farming and fruitgrowing) and the land employed there will not be included in our series.

In addition to these shortcomings, the definition of rural lands tends to vary somewhat from State to State and even from period to period. Broadly speaking, however, the term always stands for lands under the authority of shire councils or their equivalents in the various States. It thus includes all lands with the exception of those situated in the metropolitan areas and those under the control of country municipalities. Where significant variations have occurred during the period in municipal or metropolitan boundaries, suitable adjustments have been made in the figures for rural lands to keep them comparable from year to year.

The principal types and sources of data used may now be indicated. The most important of these were the valuation of shires or corresponding local bodies in each State, as recorded annually in the Statistical Registers of the States and/or the State and/or Commonwealth Yearbooks. Commonwealth land tax records as published by the Commissioner of Taxation were another source used. Their value is somewhat circumscribed because of the fact that a large proportion of rural lands are not subject to the tax which exempts all owners of properties of an unimproved value of less than £5,000. For that reason land tax valuations though easily accessible and highly uniform in contents are not a representative sample of land values and considerable care had to be taken in using them for purposes of estimation.

[20] The imposition of price control and land sales control in 1943, too, may have imparted a downward bias to official valuations which are largely based on the evidence provided by "comparable sales".

TABLE II.

Unimproved Land Values—By States.

Year.	New South Wales.	Victoria.	Queensland.	South Australia.	Western Australia.	Tasmania.	Total.
	£m.	£m.	£m.	£m.	£m.	£m.	£m.
1921	131	114	45	44	14·5	13·1	361·6
1922	138	117	46	48	15·1	13·7	377·8
1923	143	122	47	53	16·2	14·0	395·2
1924	148	124	48	59	17·3	14·3	410·6
1925	151	126	48	62	18·4	14·5	419·9
1926	158	131	48	64	20·1	14·5	435·6
1927	162	134	49	65	21·1	14·5	445·6
1928	162	141	49	63	24·0	14·7	453·7
1929	170	143	49	60	24·6	14·8	461·4
1930	172	144	49	58	25·6	14·8	463·4
1931	166	143	48	56	26·6	14·5	454·1
1932	152	137	45	54	23·3	14·0	425·3
1933	147	131	45	52	22·7	13·8	411·5
1934	145	128	44	50	22·3	13·8	403·1
1935	142	127	44	48	22·3	13·4	396·7
1936	142	126	43	48	22·1	13·6	394·7
1937	142	125	44	47	22·0	14·0	394·0
1938	145	126	44	47	21·7	14·1	397·8
1939	147	126	44	46	21·9	14·1	399·0
1940	148	127	44	46	21·8	14·0	400·8
1941	150	128	44	45	21·7	14·3	403·0
1942	151	128	45	45	21·7	14·2	404·9
1943	151	129	45	45	21·6	14·3	405·9
1944	152	130	45	46	21·6	13·9	408·5
1945	151	131	46	46	22·2	14·4	410·6
1946	154	132	46	47	22·7	14·6	416·3
1947	158	133	46	49	23·3	14·7	424·0
1948	163	...	...	...	...	...	...
1949	169	...	...	...	...	...	...

Much the same is true for State land taxation records; in Western Australia and Queensland primary producers are altogether exempt from land tax and in other States the distinction between rural and other lands is not sufficiently clearly drawn to make the figures useful for the present purpose. The exception to this is South Australia where the State Land Taxation Act grants no exemption and useful records are available. In N.S.W. land taxation is not levied except in the unincorporated part of the Western Division.

A source of great interest was found to be *The Private Wealth of Australia,* a report by the Commonwealth Statistician (G. Knibbs) on the War Census of 1915. That Census included a survey of the value of all lands (improved and unimproved) in Australia, as well as all other forms of private wealth and is the only survey of that type ever to be carried out in Australia. Some of the material accumulated by Knibbs, including information on land values, was brought up to date by C. H. Wickens, his successor as Commonwealth Statistician, in articles published in the Commonwealth Yearbooks of 1925 and 1929.

Finally, a large number of detailed estimates had to be undertaken to link up gaps in the published statistics and to supply others either not collected or not obtainable. The methods of estimation employed

TABLE III

Improved Land Values—By States.

Year.	New South Wales.	Victoria.	Queensland.	South Australia.	Western Australia.	Tasmania.	Total.
	£m.	£m.	£m.	£m.	£m.	£m.	£m.
1921	263	216	72	63	34	25·0	673·0
1922	284	222	76	68	36	26·6	712·6
1923	300	235	79	74	39	27·3	754·3
1924	311	250	81	81	42	28·1	793·1
1925	334	257	82	85	46	28·8	832·8
1926	357	267	87	94	49	28·7	882·7
1927	368	274	95	101	52	28·9	918·9
1928	374	288	97	107	56	29·2	951·2
1929	416	295	97	110	60	29·5	1,007·5
1930	432	294	100	115	61	29·7	1,031·7
1931	424	278	98	114	62	29·2	985·2
1932	407	269	94	106	61	28·8	965·8
1933	400	261	93	95	60	28·6	937·6
1934	400	260	92	91	59	28·6	930·6
1935	400	261	91	83	58	27·9	920·9
1936	404	263	90	84	58	28·0	927·0
1937	409	265	91	83	59	28·7	935·7
1938	419	268	93	84	60	29·0	953·0
1939	425	271	95	86	61	29·3	967·3
1940	427	275	97	87	62	29·6	977·6
1941	431	276	98	87	63	30·9	985·9
1942	433	277	100	89	63	31·1	993·1
1943	434	279	102	90	63	31·2	999·2
1944	447	283	104	92	65	30·1	1,021·1
1945	449	286	105	93	67	30·8	1,030·8
1946	445	306	106	96	...	32·3	...
1947	440	322	110	102	...	32·9	...
1948	465	...	...	...	...	...	...
1949	491	...	...	...	...	...	...

were closely modelled on those developed by Knibbs when undertaking the original estimates in 1915.[21] Some aspects of the estimates as they relate to the data for the various States must now be briefly reviewed.

The Estimates: Scope and Method.—For New South Wales data for the unimproved value of shires are published annually; particulars of the area to which these valuations refer, which has changed little over the years, are also published. The main difficulty with respect to this State arises from the absence of complete data for improved land values. These data are not collected by the great majority of shires whose rates are levied on unimproved valuations exclusively. A comparatively small number of shires, however, assess rates either on improved or annual value or a combination of both of these and for such shires data for improved valuations are available. These shires—their number fluctuates somewhat from year to year between 15 and 30 out of a total of about 140 were regarded as a representative sample of the total. For this sample the ratio between improved and unimproved values was determined; this ratio was then applied to the figure for unimproved values for the State as a whole, in order to obtain an

[21] G. Knibbs, *op. cit.*

TABLE IV.

Value of Land Improvements—By States.

Year.	New South Wales.	Victoria.	Queensland.	South Australia.	Western Australia.	Tasmania.	Total.
	£m.	£m.	£m.	£m.	£m.	£m.	£m.
1921	132	102	27	19	19	11·9	310·9
1922	146	105	30	20	21	12·9	334·9
1923	157	113	30	21	23	13·3	357·3
1924	163	126	33	22	25	13·8	382·8
1925	183	131	34	23	28	14·3	413·3
1926	199	136	38	30	29	14·2	446·2
1927	206	142	46	36	31	14·4	475·4
1928	212	147	48	44	32	14·5	497·5
1929	246	152	48	50	35	15·1	546·1
1930	260	150	51	57	35	14·9	567·9
1931	258	134	50	58	36	14·7	550·7
1932	255	132	49	52	38	14·8	540·8
1933	253	130	48	43	37	14·8	525·8
1934	255	132	48	41	37	14·8	527·8
1935	258	134	48	35	36	14·5	525·5
1936	262	137	47	36	36	14·4	532·4
1937	267	140	47	36	37	14·7	541·7
1938	274	142	49	37	38	14·9	554·9
1939	278	145	51	40	39	15·2	568·2
1940	279	148	53	41	40	15·6	576·6
1941	281	148	54	42	41	16·6	582·6
1942	282	147	55	44	41	16·9	587·9
1943	283	150	57	45	41	16·9	592·9
1944	295	153	59	46	43	16·2	612·2
1945	298	154	59	47	45	16·4	619·4
1946	291	174	60	49	46	17·7	637·7
1947	282	189	64	53	47	18·2	653·2
1948	302	...	...	...	...	...	...
1949	322	...	...	...	...	...	...
1950	348	...	...	...	...	...	...

TABLE V.

Index of Volume of Improvements.

(1923-24 to 1927-28 = 1,000.)

Year.	New South Wales.	Australia.	Year.	New South Wales.	Australia.
1921 ...	841	867	1936 ...	1,763	1,568
1922 ...	884	887	1937 ...	1,809	1,606
1923 ...	911	907	1938 ...	1,861	1,649
1924 ...	909	934	1939 ...	1,897	1,696
1925 ...	994	982	1940 ...	1,886	1,706
1926 ...	1,068	1,048	1941 ...	1,866	1,693
1927 ...	1,119	1,129	1942 ...	1,820	1,660
1928 ...	1,193	1,225	1943 ...	1,749	1,603
1929 ...	1,413	1,373	1944 ...	1,752	1,591
1930 ...	1,547	1,479	1945 ...	1,713	1,558
1931 ...	1,576	1,472	1946 ...	1,620	1,553
1932 ...	1,584	1,470	1947 ...	1,524	1,545
1933 ...	1,598	1,453	1948 ...	1,567	......
1934 ...	1,649	1,494	1949 ...	1,580	......
1935 ...	1,702	1,517			

estimate for total improved value. The value of improvements was, of course, obtained as the difference between improved and unimproved value. The ratio of these two showed a consistent trend which accords well with the known economic developments over the period.[22] A check was possible on the accuracy of the data so obtained with the help of an estimate of total improved value for the State for shires and municipalities combined made by the Valuer-General for New South Wales in 1942. The difference between that estimate and the one obtained by the method as outlined was found to be less than 4 per cent.

For the unincorporated section of the Western Division of New South Wales shire valuations do not exist and a separate estimate had to be made to bring this area into account. Such an estimate was undertaken by the Commonwealth Statistician (in the articles in the 1925 and 1930 Yearbooks referred to earlier) on the basis that unimproved value per head of population in the unincorporated area was assumed to be the same as in the shires contiguous to that area. This probably involves a considerable over-statement as the bordering shires include extensive areas of irrigation land; a considerably lower estimate published by the New South Wales State Statistician in the 1933-34 Yearbook was therefore accepted and projected backward over the period.

The New South Wales data as a whole are subject to a bias, which in the absence of adequate information could not be eliminated. This is due to an amendment in the Act governing valuations by local authorities which excluded certain types of crown lands and some other lands from the rating field; some proportion of the large drop (almost 9 per cent.) in total unimproved values in 1932 was no doubt due to the introduction in that year of the new Act.

Land value data for Victoria are rather less complete than for New South Wales. During most of the period considered here, the Local Government Act required all rates to be assessed on the basis of improved or annual value. Legislation passed in 1935 gave local authorities the option to assess unimproved values, but comparatively few appear to have availed themselves of that opportunity to date. Those that have are in the main municipalities or shires in, or close to, the metropolitan area and can hardly be regarded as a representative sample for the State, let alone for rural areas which concern us here. Some other indicators had therefore to be found to enable an estimate of unimproved values to be undertaken.

Two estimates of unimproved values of rural lands made by the State Statistician in 1926 and 1928, respectively, are available.[23] According to these the ratio of unimproved to improved value in both years was exactly two-thirds which suggests (in the absence of any explanation offered by the Statistician for this remarkable coincidence) that the figures were, in fact, estimated in both years on the assumption of the two-thirds ratio. This ratio, in turn, was presumably obtained from an analysis of the Commonwealth Land Tax records which indicate that this ratio did, in fact, apply to rural lands assessed to the tax in Victoria over a number of years. In view of the high exemption allowed by the tax, however, lands subject to it are, as already mentioned, not

[22] For further comment on this method of estimation see G. Knibbs, *op. cit.*

[23] Victorian Yearbook, 1926-1928.

a representative sample for total rural lands. The great majority of properties subject to land tax are in fact grazing properties for which the average ratio of unimproved to improved value is considerably higher (i.e., the amount of improvement is less) than is true of rural lands as a whole.

Victorian State land taxation allows only a small exemption but no record is kept which would enable properties assessed to be classified as between rural and metropolitan areas, and the data are therefore inadequate for the present purpose.

Under the circumstances it was necessary to fall back upon the evidence supplied by the 1915 War Census on the ratio between improved and unimproved values of rural lands in Victoria. That evidence, too, is, unfortunately, somewhat tenuous. Though the improved and unimproved value of all rateable lands in the State was obtained for the purposes of the census no split-up is available between rural and other lands. To overcome this deficiency a rather devious procedure had to be employed. Use was made of the fact that the ratio between improved and unimproved values for municipalities (i.e., metropolitan areas and country towns) seems to vary only very slightly as between the different States for which these data are available. The assumption was consequently made that the ratio was in 1915 the same for Victoria as for New South Wales, the State for which the most complete information is published. In this manner an estimate was obtained for the unimproved value of non-rural lands in Victoria and by subtracting this from the total found by the census, the unimproved value of rural lands was found. This estimate yielded a figure for the ratio between improved and unimproved values of rural lands in Victoria very similar to the one obtained for New South Wales by a rather different process of estimation, outlined earlier.

Starting with the base figure so obtained, a projection was then made over the period, on the assumption that the ratio (of improved to unimproved) in Victoria had changed over the years in the same proportion as had been observed in New South Wales. The resulting series was checked and was found to be quite consistent with similar data obtained from the alternative hypothesis that changes in the Victorian ratio bore the same proportion to changes in the ratio of improved to unimproved values given in Commonwealth Land Taxation records for Victoria as applied to the two sets of data (i.e., total rural valuations and Land Tax valuations) in the case of New South Wales.

A further complication encountered was the gradual widening of the metropolitan boundaries of Greater Melbourne which necessitated extensive recalculation of the total figure for rural lands in order to ensure consistency over the whole of the period.

Substantially similar problems had to be faced in regard to Queensland and Western Australia. In both these States the principal difficulty arises from the fact that local rates are assessed almost exclusively on unimproved value and that accordingly improved values are not recorded. Methods of estimation analogous to those employed for Victoria had consequently to be used. These need not again be detailed beyond mentioning that they were based in the main on the War Census data (for the purpose of obtaining a base figure) and Commonwealth Land Taxation records.

The constitution of Greater Brisbane in 1925 introduced difficulties of the same nature as were presented by extension of Melbourne's municipal boundaries and adjustments had to be undertaken correspondingly.

As regards Perth, its metropolitan boundaries include a number of District Road Boards (the Western Australian equivalent of shires) which are administratively part of the Swan District. For this reason, apparently, the whole of that district is included with the metropolitan area for purposes of land valuation in the official statistics. As that district is predominately an agricultural one, it was decided to include the whole of it among the figures for rural lands for the purpose of our land value series.

As regards the remaining two States, South Australia and Tasmania, fairly full records are available. Shire valuations for Tasmania, both improved and unimproved, are published in the annual Statistical Register. Although these valuations on the face of it appear reasonably consistent both over the period and between districts, there can be no doubt that they are in fact unduly conservative. The very slow increase in improvements seems to suggest this and there is additional evidence in the form of records of sales and purchases of rural lands in a number of districts which makes it clear that the increase, especially in improved values that has occurred since the end of the war is reflected inadequately in the published figures. Unfortunately, records of sales and purchases are not obtainable for a sufficiently long period to serve as a basis for a revised series.

In South Australia as in Victoria rating in rural areas proceeds upon the basis of improved (and to some extent of annual) values and unimproved values are published for only a small number of shires. State land taxation, however, allows no exemption on rural lands in South Australia and complete records for unimproved values are therefore kept by the land taxation authorities. An analysis of these figures as between rural and other lands was made available by the courtesy of the Commissioner of Land Taxation. There can be little doubt that these unimproved values of the land tax authorities are more expertly (and less conservatively) assessed than the improved values taken out by local authorities. As a result the value of improvements (the difference between improved and unimproved values), is likely to be somewhat understated by the series obtained, depending as it does on valuation data supplied by these two different valuation authorities.

Some Comments on the Statistics.—Before concluding this section on land values, some further comments on the actual series derived must be made. It has been noted that data for unimproved values, because of the many conflicting forces which determine these, must be looked upon with a great deal of reservation. It is worth, therefore, stressing again the conclusion reached with regard to the valuations of improvements, viz., that these are carried out on a reasonably uniform basis and on one that is independent of the evaluation of unimproved value. This circumstance, naturally, adds materially to the significance of these figures and makes it possible to regard them with a considerable degree of confidence.

It is clear, of course, that during the 27 years covered by the data, fluctuations in prices and the purchasing power of money have been violent and that consequently a value series can only give a very inadequate indication of trends in the volume of improvements (i.e., the total of dwellings, silos, fences, sheds, etc., in existence) which is what we are here concerned with.

A deflator index was therefore constructed from price data published annually in the New South Wales *Statistical Register*. The index used is an unweighted arithmetical average of relatives of the prices of seven important constructional materials, viz.: timber, bricks, cement, roofing tiles, lead piping, fencing wire and corrugated galvanized iron, which between them are regarded as providing the principal constituents of agricultural improvements. The two most important omissions from the index are probably chemical agents (e.g., fertilizer and sprays) for which consistent price quotations could not be procured and direct labour. A wage index, however, was found to exhibit movements almost identical with those of the index of the materials and its inclusion, therefore, could not have added to the usefulness of the former. Though the value of improvements depends mainly on their cost of replacement (as was seen earlier), this does not mean that they vary to exactly the same extent as do costs from year to year. Improvements take time for their completion and their valuation tends to be determined by average cost trends over a period rather than by short-term movements. To quote one authority on the subject—

"Fluctuations in real estate values are relatively slow as compared with those of commodities. Values of improvements do not vary with periodic variations in, say, timber prices, but are affected rather by long-term trends.[24]

Applying this line of reasoning, a ten-year moving average was thus taken of the index as obtained above. In deflating the value figures by this moving average we make the assumption that seems reasonable in the light of the preceding remarks, that in making valuations of improvements valuers are guided by the average cost of making such improvements during the decade preceding the date of valuation.

(b) Agricultural Machinery and Implements.

This subject does not present theoretical obstacles comparable to those encountered in obtaining land value data. Practical difficulties, nevertheless, abound and estimates carrying varying degrees of confidence are needed to supply data where statistical information is either absent or too tenuous to warrant unqualified acceptance.

The principal source of information is the Commonwealth Bureau of Census and Statistics Annual Production Bulletin. This presents, for the years 1921-41, figures for the value of implements and machinery employed on rural holdings for all States with the exception of Victoria. These figures do not go beyond 1941, but from 1943 onwards details are available of the numbers of each of the more important types of farm machinery and implements in use on rural holdings.

For Victoria, figures for the value of machinery and implements are not available prior to 1931. To supply this deficiency an estimate was made by Dr. Wilson.[25] The basis of estimation, however, was the

[24] J. F. N. Murray, *Principles and Practice of Valuation* (Sydney, Commonwealth Institute of Valuers, 1948).

[25] R. Wilson, *Public and Private Investment in Australia* (Paper read before section G of ANZAAS, 1939 Meeting).

assumption that the value of machinery and implements moves from year to year in the same proportion as does the total acreage cropped as far as machinery and implements used on agricultural holdings is concerned; in the case of dairy and pastoral properties, the number of cows and sheep, respectively, were taken as the indicators for the movements in the value of equipment.

TABLE VI.

*Estimated Value of Farm Machinery and Implements.**

Year.	Mainly Agricultural.†	Mainly Dairying.	Mainly Pastoral.
	£m.	£m.	£m.
1921...	22·7	2·3	5·9
1922...	25·1	2·8	6·4
1923...	27·3	3·0	7·1
1924...	28·9	2·9	7·4
1925...	31·5	3·0	8·6
1926...	32·7	3·3	8·9
1927...	34·3	3·3	10·3
1928...	37·4	3·4	10·8
1929...	38·8	3·4	11·0
1930...	39·1	3·9	10·9
1931...	37·6	4·1	10·4
1932...	35·0	3·9	9·6
1933...	32·8	4·2	9·5
1934...	31·8	4·3	9·4
1935...	30·4	4·5	9·4
1936...	31·7	4·7	10·3
1937...	33·0	4·7	10·2
1938...	36·2	4·8	10·4
1939...	40·0	5·7	9·7
1940...	40·7	6·4	9·8
1941...	41·1	6·8	10·2

* Excluding commercial motor vehicles.

† "Agricultural" here refers to crop agriculture.

It was felt, however, that this assumption tends to overstate the year-to-year fluctuation in the value of machinery and implements. The estimates employed for the present purpose (Table VI) were therefore based on the assumption that the Victorian values during the period moved proportionately to those recorded for New South Wales. In the case of agricultural machinery and implements (by far the most important item) this assumption gains additional plausibility by the fact that crop acreages moved to almost exactly the same degree in the two States during the period covered by the estimates.

For the period 1941-43 no published data are available and recourse had to be had to an item "gross private investment in farm machinery" obtained from a split up of the National Income and Expenditure Accounts. After allowing for replacement and by assuming a rate of depreciation of 10 per cent., a figure for net investment was thus arrived at covering the years 1942 and 1943.

From 1943 onwards figures referring to the total number of many different types of farm equipment are recorded, and by suitably pricing each recorded item it might have seemed possible to obtain an estimate of total values. This, however, was found impracticable both because the published inventory is incomplete and because widely different types and makes of equipment are frequently compounded under the one heading (e.g., ploughs) which makes it impossible to bring the item enumerated to account at a uniform price. A considerably more roundabout process of estimation had therefore to be employed.

The method finally decided upon as most likely to yield reasonable results without involving an excessive amount of detailed calculation, set out by dividing total plant and machinery into a small number of rough groups. The rate of increase of each group over the period (1943-48) was then determined and a weight was assigned to each group to reflect its significance as part of the total of all plant and machinery.

The two important items of equipment which showed by far the greatest increase over the period were tractors (both ordinary and caterpillar) and milking machines. Each of these showed an increase of roughly 50 per cent. while the average increase in the remaining items was of the order of 10 per cent. Additional estimates were necessary to obtain these proportional increases as unfortunately the figures are not available uniformly for all the States over the whole of the period.

Records of establishment costs for farm units obtained from War Service Land Settlement authorities indicate that tractors account for approximately 50 per cent. of the value of all machinery on typical sheep-wheat farms while milking machinery represents roughly one-third of the value of equipment employed on dairy holdings. For the purpose of both these estimates it was necessary to omit from the value of equipment the part represented by the value of commercial motor vehicles. The value of these is not included in the figures published annually in the Bureau of Census and Statistics *Production Bulletin* for the years 1921-41; indeed no data are obtainable for the number of such vehicles employed on rural holdings during the period and they had, therefore, to be brought into account by means of a separate estimate.

Using the data for rates of increase in equipment mentioned above as well as their respective weights, the following index numbers for the increase in the volume of equipment on dairy and wheat-sheep holdings respectively are arrived at:

	Weight.	Rate of Increase.
Dairy Holdings—		
Milking machines ..	.. 1/3	50 per cent.
Other equipment ..	.. 2/3	10 per cent.
Total	.. 1	$150 \times 1/3 + 110 \times 2/3 = 123$
Wheat-Sheep Holdings—		
Tractors	.. 1/2	50 per cent.
Other equipment ..	.. 1/2	10 per cent.
Total	.. 1	$150 \times 1/2 + 110 \times 1/2 = 130$

To obtain a figure for the average rate of increase for the two types of holdings combined it is again necessary to apply weights to the index numbers. The weights decided upon were three for wheat-sheep and one for dairy holdings, resulting in an estimated average rate of 128. The high weight for wheat-sheep farms was chosen because it has been ascertained that the capital structure of this type of farm is representative of a fairly wide range of crop as well as mixed farms. The final figure obtained, may for that reason be regarded as a reasonably close approximation to a figure giving the rate of increase in the volume of equipment on all Australian farms.

In order to arrive at a figure for the rate of increase in the *value* of farm equipment (on the basis of the above figure for the volume of the increase) allowance must be made for the rise in the price of farm equipment during the period (1943-48) covered by the estimate. These prices have risen very considerably, but the increase was spread unevenly over the five years concerned, being concentrated mainly in the two final years when the restraining influence of price control became less effective. The annual increase in prices over the period was therefore weighted by the relative quantity of equipment purchased each year, the number of tractors bought being taken as an indicator for this quantity in the absence of more accurate information. An average annual price increase of 6 per cent. was thus arrived at, and applying this to the figure for the increase in the volume of equipment (28 per cent.) a figure of 30 per cent. was thus obtained for the increase in value of farm equipment for the five years 1943 to 1948.

Moreover, allowance must be made for the increased price paid over the period for equipment purchased for replacement purposes. Assuming an annual rate of replacement of 10 per cent. it is found that over the period 1941-48 roughly 70 per cent. of all existing equipment must have been replaced. With the annual (unweighted) average price over the period approximately 7 per cent. above 1941 these replacements would have added another 5 per cent. to the total value of equipment during the period from 1941-48. Thus the total value in 1948 is found as 35 per cent. above the 1943 figure. The figures for individual years during the period were estimated by interpolating, using the assumption that the increase from year to year in the total value of equipment proceeded *pro rata* with the increase in the numbers of tractors; for the latter complete records are available.

It now remains to consider the precise significance of the data obtained in the manner just outlined. Information supplied by the Commonwealth Bureau of Census and Statistics indicates that the data for the value of machinery and implements on rural holdings published for the years 1921-41 were derived from valuations based on original cost minus depreciation. As regards the rate of depreciation, accurate information could, unfortunately, not be procured; it is apparent, however, that the rate was not uniform for all types of equipment and may, in fact, have varied over the period and between the States.

It will be noted that the estimates arrived at above rest on the same basis as those derived from the published records, i.e., they include in the value figures the annual changes which arise from the variations in the prices from year to year of equipment purchased by way of net additions to the existing stock as well as that bought for replacement purposes.

TABLE VII.

Estimated Total Value of Farm Machinery and Implements—Deflation of Series.

Year.	(1) Estimated Value of Farm Machinery and Implements (other than Commercial Vehicles).	(2) Annual Increase in (1).	(3) Estimated Annual Depreciation of (1).	(4) (2) and (3).	(5) Deflator Series* 1923-24 — 1927-28 = 1,000†	(6) Deflated Value of (4).	(7) (1) — (3) + (6) Deflated Value of Machinery and Implements.	(8) Deflated Value of Commercial Vehicles on Farms.	(9) (7) + (8) Deflated Value of Machinery Implements and Commercial Vehicles on Farms.
	£m.	£m.	£m.	£m.		£m.	£m.	£m.	£m.
1921	31	...	...	...	901	...	35	2	37
1922	34	3	3	6	1,173	5	37	2	39
1923	37	3	3	6	1,048	6	40	3	43
1924	39	2	4	6	1,029	6	42	5	47
1925	43	4	4	8	991	8	46	6	52
1926	45	2	4	6	976	6	48	8	56
1927	48	3	4	7	956	7	51	10	61
1928	52	4	5	9	938	9	55	12	67
1929	53	1	5	6	945	6	56	13	69
1930	54	1	5	6	940	7	58	13	71
1931	52	— 2	5	3	923	3	56	11	67
1932	49	— 3	5	2	885	3	54	12	66
1933	47	— 2	5	3	857	4	53	12	65
1934	46	— 1	5	4	830	5	53	13	66
1935	44	— 2	4	2	828	3	54	13	67
1936	47	3	5	8	838	9	58	15	73
1937	48	1	5	6	838	7	60	18	78
1938	51	3	5	8	914	8	63	20	83
1939	55	4	5	9	915	9	67	21	88
1940	57	2	5	7	976	7	69	22	91
1941	58	1	6	7	1,030	7	70	22	92
1942	61	3	6	9	1,077	9	73	21	94
1943	64	3	6	9	1,160	8	75	21	96
1944	65	1	6	7	1,168	6	75	23	98
1945	69	4	6	10	1,164	9	78	24	102
1946	74	5	7	12	1,170	10	81	25	106
1947	79	5	7	12	1,237	10	84	26	110
1948	86	7	9	16	1,406	11	86	28	114

* Price Index of Agricultural Machinery (N.S.W. Statistical Register).

† For deflating base period value 1910-20 average of deflator series is used.

In order to obtain a series for the volume of equipment (Table VII) over the period it was necessary to deflate the gross addition to the value series each year. That gross addition, of course, will be composed of the net addition plus replacement purchases; the latter may again be taken as amounting to 10 per cent. of gross values. Deflation was carried out with the help of an index of the prices of agricultural machinery compiled by the New South Wales Bureau of Statistics and Economics; the index has the years 1923-24 to 1927-28 as a base period. Before applying the deflator series to the value data a further difficulty had to be overcome, viz., that arising in connection with the deflation of the value figure for the base year of our value series, i.e., the year 1921. The equipment covered by the valuation in this year had obviously been acquired at varying prices over a number of preceding years, and as the published valuations had been made on the basis of original cost (minus depreciation) this figure could not justly be deflated on the basis of 1921 prices alone. The problem was settled by the assumption that equipment used on rural holdings in 1921 had been acquired at an even rate over the preceding ten years and the figure was consequently deflated by the average of the price index of agricultural machinery for the period 1912-21.

Finally, some allowance has to be made for the value of commercial motor vehicles employed on farms. As already mentioned these are not included in the figures for the value of farm machinery and implements, published by the Commonwealth Statistician; indeed, no statistics exist for this important item and estimates must therefore be based on rather precarious evidence for most of the period under consideration.

The starting point for these estimates were the figures for the total number of commercial vehicles (i.e., motor trucks, utilities and lorries) on farms which have been published by the Statistician since 1943. For the preceding two decades figures are available for the total number of commercial vehicles registered annually. For Victoria some sketchy data are available referring to primary producers' commercial vehicles for some years during which these enjoyed concessional registration fees. These figures suggest, as do also the complete figures subsequent to 1943, that over the whole of the period from 1920 onwards the proportion of commercial motor vehicles used on farms was very roughly one-third of the total. It may be added that that proportion seems to have declined somewhat in the post-war years which experienced an unprecedented increase in the total number of commercial vehicles in use in Australia. For the years 1920 to 1943 the ratio of one-third was consequently adopted. For the purposes of the index of volume of investment vehicles were valued at £250, this being a rough average of the price of motor trucks and utilities during the base period of our indices (1923-24 to 1927-28). In order to obtain value figures the index figures were inflated by the series (employed earlier) for the price of agricultural machinery.

(c) Livestock.

Next to agricultural improvements, livestock constitutes (in value terms) the most important form of capital investment in agriculture. For the major varieties of farm livestock published figures are both continuous for a long period and reasonably uniform. A number of minor adjustments in the figures were required for the present purpose in order to overcome inconsistencies arising from changes in the annual census date for livestock on farms. As regards the minor types of livestock, i.e., in the main, poultry, records are less complete and estimates had to be derived for part of the period covered on the basis of the data for those States (New South Wales, Western Australia, South Australia) for which continuous published data are accessible.

The figures for numbers of livestock on farms each year which were thus arrived at, may be regarded as comprehensive and reliable. In constructing on the basis of these figures an index of investment two special problems arise, however, which must now be considered in some detail.

The first of these problems is in effect, largely an index number problem of the orthodox variety. The question to be answered is, on what basis to combine the various heterogeneous types of livestock into one single index. To do this by simple addition would make the index meaningless, for it is clearly improper to give one sheep (let alone a hen) the same weight as is given to a cow or bullock.

In dealing with agricultural problems it is not unusual to convert different types of livestock into standard stock units on the basis of their feed requirements as reflected in the carrying capacity of land; thus it is generally held that an area of land capable of carrying one bullock will (alternatively) support five dry sheep, and sheep consequently are converted into standard stock units with the aid of this ratio. Very broadly speaking it may be said that this method of weighting the various types of livestock proceeds on the basis of their respective cost of production (including in this term the cost of maintenance).

The method of weighting, therefore, seems an attractive one to employ for the purpose of constructing an index of the volume of investment. The assumption involved, however, that the cost of producing and maintaining an animal can be quantitatively measured by the amount of feed consumed, is rather too sweeping. Animal nutrition is a complex matter and qualitative factors as well as quantitative ones have to be taken into consideration. Largely because of the difficulties associated with this, there is a considerable diversity of opinion as to the conversion ratio appropriate to the various types of livestock. Moreover, both the economic structure of the livestock industry and the methods of animal production are apt to vary considerably from region to region and this presents further obstacles to any attempt to define a single conversion ratio applicable throughout the livestock industry.

For these reasons a more conventional approach was preferred and average prices during the base period (1923-24 to 1927-28) were employed as weights. The implications of this procedure are similar to those discussed earlier in reviewing the problems associated with the fixed weight aggregate index of agricultural production.

The principal assumption involved in constructing an index of the investment in livestock on this basis is that changes occurring during the period in the relative prices of the various types of livestock do not reflect significant movements in the amounts of investment embodied in them. This assumption, of course, is present wherever base-period prices are used as weights either directly or indirectly by means of deflating a value series.

It must be pointed out, however, that there are some grounds for supposing that the assumption is somewhat less soundly based in the case of the livestock index than in some others to which it has been applied. One reason is that the quality of animals in the Australian livestock herd has improved substantially over the period considered. Productivity of the herd has increased both as regards quantity (e.g., wool per sheep) and as regards quality (e.g., larger percentage of first-grade beef per bullock) as a result of more selective breeding and improved nutritional and other practices.

Again, there have been, over the period, substantial changes in the relative prices of the various types of livestock and also in the prices of livestock relative to those of other commodities. To the extent that such changes are merely indicative of fluctuations in the prices of the various primary products obtainable from the different types of animals their effect is rightly excluded from the index. For their inclusion would in effect amount to arriving at the value of investment by capitalizing the value of the product derived from it and this would involve us in circular reasoning in our subsequent attempt of explaining movements in production by reference to those in investment. A similar difficulty, it may be recalled, was encountered in discussing the capitalization method of determining land values.

Nevertheless the possibility cannot be dismissed that the price changes referred to do, to some extent, reflect real changes in the cost and thereby in the volume of the investment in livestock. Inasmuch as this factor has been operative over the period under consideration the index presented must therefore involve an understatement.

In order to improve, within these limitations, the accuracy of the index an attempt was made to sub-divide, as far as possible the major varieties of livestock, and value separately each of the sub-groups. Thus the cattle population was split into dairy and beef herds and again within the beef herds separate estimates were made for the number of calves, bullocks, etc. Statistics for these sub-groupings are somewhat sketchy and estimates had to be relied on for much of the period. The position regarding prices is even less satisfactory owing largely to the remoteness of the base period and estimates frequently had to be based upon rather scanty information. Even so, however, it is considered that the usefulness of the series was materially increased by introducing the refinement of sub-dividing the index.

Once the index number problem is disposed of another rather more perplexing difficulty remains to be tackled. The difficulty is present to some extent in the case of most livestock production but it is most apparent in the case of the cattle population and the subsequent remarks will therefore be confined to this.

In the cattle industry as in other livestock industries, the distinction between capital on the one hand and production on the other is very much less clearly defined than is the case in other industries. The possibility of confusion is directly due to the peculiar nature of animal production. For, in the livestock industries, the animal, especially the female, is both a unit of investment and a unit of output, i.e., it can be used either directly for the production of meat or by being invested, i.e., added to the breeding herd, it can be used for the production of further animals; but naturally it can be used only for one of these purposes at a time.

Unlike producers in most other industries, livestock producers cannot increase their investment and at the same time maintain their production, the two courses being strictly alternative.[26] It follows that in the cattle industry an increase in output may result either from investment during previous seasons or from disinvestment during the present season. As units of "product" and "investment" are largely identical and are traded in the same market it follows that considerable instability will result in the industry.

Periodic fluctuations, familiar as the cattle cycle, are in fact, characteristic of the industry and it may be appropriate in this context to look briefly at the factors which determine the course of this cycle.

Faced with a rise in the price of his product, the cattle producer has the alternative of either increasing his present income by disposing of the maximum number of animals for slaughter or of saving the females to increase his herd to augment future production. His first reaction is likely to be an attempt to increase present marketings. This may be done by encroaching on the stock of saleable animals which would not normally have been disposed of for some weeks or perhaps, months,

The scope for this type of adjustment is generally limited. But once the higher price has been established for some time, the tendency is for producers to presume that it will continue in the future and adjustments aimed at increasing future supplies will become a predominant feature. In this second phase of the cycle, the retention of breeding stock for the herd, i.e., investment, will reduce supplies for slaughter. This is likely to stimulate a further price advance which in turn will encourage further investment, and the upward movement thus tends to become cumulative.

The period that must elapse before increased production becomes available from the addition to the breeding herd is governed by the technological factors of animal production, i.e., mainly the gestation and fattening periods needed for the production of marketable animals. Thus it will be about four years before the initial investment results in an increased supply of slaughterable stock. In the subsequent seasons this supply will expand at an increasing rate as a result of the cumulative nature of the initial investment.

A downward pressure on prices is therefore the characteristic of the third phase of the cycle. The first reaction of producers at this stage is to withhold stock from market in the hope that the decline will be only temporary and also in order to prevent a further decline. However, as the volume of marketable stock tends to grow at an accelerated pace, it becomes more difficult to postpone marketings; the cost in lost condition, overstocking and supplementary feed mounts up and the investment becomes excessively risky. Investment will thus come to a standstill and production (i.e., slaughterings) will increase sharply.

---

[26] This refers, of course, to the livestock industry as a whole—individual producers can buy livestock and thus increase their investment without reducing their production.

It will, however, be some time before producers decide upon substantial reductions in their breeding herds which constitute a productive asset that it will eventually take several years to replace. Nevertheless, the final stage of the cycle will witness greatly increased slaughterings especially of female animals, as a result of a partial liquidation of the breeding herd, i.e., disinvestment on a considerable scale.

It may be added that fluctuations in the cattle industry can well be generated by exogenous factors. These may be either economic, such as changes in the tariff levels of export markets or physical, such as droughts, floods, etc. Empirical investigation, however, suggests that an explanation of the fluctuations that have actually occurred in the industry, can be provided—largely without reference to those factors—in the terms of the self-sustaining cyclical movement outlined above.

From what has been said, it appears, that it is not possible to ascertain accurately the total amount of investment in livestock by paying attention only to the total number of animals included in the herd each year; for animals shortly to be slaughtered and turned out as "production" comprise part of that number, and unless, in some way they are excluded, the indices for production and investment are bound to overlap. This would not necessarily lead to serious error in either series, if it could be assumed that the proportion of "production" to total cattle numbers (as on census day each year) is reasonably stable. In fact, however, as the preceding discussion has shown, so far from being stable, that proportion may be expected to fluctuate violently. This poses the question of how to distinguish the capital component from the production one in the livestock herd.

The "ideal" solution to this problem would be to obtain each year the total number of animals in the breeding herd and confine the index of investment to these alone. This would have the additional advantage of excluding from the index the large number of animals at various stages of maturity, being got ready for slaughtering, which may be regarded as goods-in-process and (according to our definition) should not be included in the index for investment.

Shortcomings in the available statistics make it impossible to follow out this counsel of perfection. Records of the breeding herd are obtainable only for recent years and are not sufficient to allow projections to be made for the remainder of the period. The method adopted for the purpose of the present estimates was, therefore, to accept annual figures for slaughterings as an indicator of production and to deduct the number of animals slaughtered each year from total cattle numbers in order to obtain the investment component.

This method is not altogether satisfactory, for the final figure arrived at will sometimes contain in addition to the effective breeding herd animals held as reserve stocks (using that term in the commercial sense) as well as a considerable number which must be regarded as goods-in-process. The latter probably bear a fairly constant relation to the breeding herd proper, as their quantity is largely determined by the technological factors of breeding and fattening; the distortion arising from this source is therefore not likely to be large. As regards variations in the stocks of "produced" animals these will tend to distort the distribution over time of production as reflected in our series, but taken over a period of years this effect, too, is not likely to be very serious.

TABLE VIII.

Australian Livestock Numbers and Values.

Year.	Beef Cattle.		Dairy Cattle.		Sheep.		Horses.		Pigs.		Poultry.		Total. Value.
	Number*	Value.	Number.	Value.	Number*	Value.	Number.	Value.	Number.	Value.	Number.	Value.	
	m. head.	£m.	m. head.	£m.	m. head.	£m.	m. head.	£m.	m. head.	£m.	m. head.	£m.	£m.
1920	8·7	44	3·2	32	69·4	87	2·4	24	·70	1·4	10·6	2·1	190
1921	8·9	45	3·6	36	71·3	89	2·4	24	·77	1·5	10·7	2·1	198
1922	8·6	43	3·7	37	72·3	90	2·4	24	·96	1·9	11·7	2·3	198
1923	7·4	37	3·5	35	74·8	94	2·3	23	·99	2·0	11·7	2·3	193
1924	7·1	36	3·8	38	82·2	103	2·3	23	·90	1·8	12·0	2·4	204
1925	7·4	37	3·7	37	90·7	113	2·2	22	·98	2·0	12·9	2·6	214
1926	6·1	31	3·7	37	91·5	114	2·1	21	1·13	2·2	13·0	2·6	208
1927	5·9	30	3·5	35	87·3	109	2·0	20	·99	2·0	12·8	2·6	199
1928	5·9	30	3·6	36	87·5	109	1·9	19	·88	1·8	12·8	2·6	198
1929	5·8	29	3·6	36	88·2	110	1·8	18	·91	1·8	12·7	2·5	197
1930	5·8	29	3·9	39	93·4	117	1·8	18	1·02	2·0	12·8	2·6	208
1931	6·0	30	4·3	43	91·6	114	1·8	18	1·07	2·1	14·0	2·8	210
1932	6·0	30	4·6	46	93·7	117	1·8	18	1·17	2·3	15·4	3·1	216
1933	6·0	30	4·8	48	91·1	114	1·8	18	1·16	2·3	15·8	3·2	216
1934	6·0	30	5·0	50	95·1	119	1·8	18	1·05	2·1	16·5	3·3	222
1935	5·9	30	5·1	51	90·4	113	1·8	18	1·16	2·3	17·0	3·4	218
1936	5·3	27	4·9	49	90·9	114	1·8	18	1·30	2·6	17·0	3·4	214
1937	4·8	24	4·9	49	94·5	118	1·7	17	1·20	2·4	16·7	3·3	214
1938	4·6	23	4·9	49	92·1	115	1·7	17	1·10	2·2	16·5	3·3	210
1939	4·6	23	5·0	50	97·5	122	1·7	17	1·16	2·3	16·7	3·3	218
1940	5·0	25	5·0	50	100·4	126	1·7	17	1·46	2·9	17·4	3·5	224
1941	5·1	26	5·0	50	99·6	125	1·6	16	1·80	3·6	17·7	3·5	224
1942	5·3	27	5·0	50	98·0	123	1·5	15	1·48	3·0	18·3	3·7	222
1943	5·9	30	4·9	49	98·0	123	1·4	14	1·56	3·1	19·5	3·9	223
1944	6·2	31	4·8	48	88·4	111	1·4	14	1·75	3·5	23·0	4·6	212
1945	6·6	33	4·6	46	78·5	98	1·3	13	1·63	3·3	27·7	5·5	199
1946	6·1	31	4·6	46	79·1	99	1·2	12	1·43	2·9	25·6	5·1	196
1947	5·4	27	4·7	47	84·3	105	1·2	12	1·27	2·5	24·8	5·0	199
1948	5·6	28	4·9	49	88·3	110	...	...	1·26	2·5	...	...	...

* Adjusted for Slaughterings.

What has been said above about the causes of periodical fluctuations in cattle production applies with modification also to the sheep and pig population. In the case of sheep the production period is considerably shorter than for cattle and partly because of this and partly because of the importance of wool production the cyclical fluctuations are less clearly marked and exogenous factors more prominent. The determination of the investment component in the sheep flock is greatly complicated by the relation between wool and meat production.

There is no need in this context to trace out the problems of joint supply raised by this complication. The adjustments undertaken in order to arrive at an estimate for the investment component were similar to those made in connection with cattle numbers. Because of the factors mentioned, the accuracy of these adjustments is probably somewhat less than in the case of cattle, but as the relative significance of the adjustments needed was also considerably less, the resulting error is unlikely to be significant.

In the pig-raising industry the production period is considerably shorter than one year and as a result the figure for annual slaughterings is generally in excess of the total number of animals recorded in the annual census. It is thus not possible to obtain a basis for making adjustments similar to those applied in the case of the sheep and cattle industries, and the method that had to be adopted was that of looking upon the whole of the herd as an investment. In view of the relative insignificance of the industry no serious distortion is likely to result from this procedure.

(d) Irrigation Works.

The inclusion of this item in our index of investment is to some extent open to questioning. It could be argued that irrigation works are in a rather different category from farm machinery and improvements as regards their contribution to agricultural output. Unlike those other types of rural capital they are generally the result of public rather than private investment and their contribution to the total rural product is achieved in a rather more roundabout fashion.

In some ways therefore, they are comparable to other forms of public investment of which agricultural production is a major beneficiary, such as roads or public transport. Improvements of these latter types, it will be recalled, are to be classed among external economies and to these may be imputed that part of the increase in agricultural output which is not capable of being accounted for by the increased employment of capital and labour within agriculture.

One reason for the decision to make a separate estimate for irrigation works was the fact that some important individual works are in fact the result of private enterprise (e.g., the First Mildura Irrigation Trust); another was the fact that the benefit from this species of investment accrues almost exclusively to the primary industries and may thus be charged *in toto* to their account; indeed a very considerable proportion of the upkeep and capital charges of these works is actually borne by the primary producers benefiting from them.

Theoretically the volume of investment in irrigation might be measured in a number of ways. A strong case could perhaps be made out for using as an indicator either the total acreage irrigated or the amount of water in acre feet made available. As data for irrigated acreage do not differentiate between the various types and intensities of irrigation involved the second alternative would seem preferable. More particularly so if data could be obtained, referring not to the actual quantity of water delivered (which is liable to fluctuate heavily from season to season) but to the capacity of weirs and storage reservoirs constructed.

The technical difficulties of obtaining (and analysing) data of this sort, however, made necessary once again the resort to value figures or more precisely to figures referring to the cost of constructing irrigation works.

The amount and quality of information on these matters that can be gathered differs considerably from State to State. For Victoria the annual reports of the State Rivers and Water Supply Commission contain capital accounts that give for a long period a wealth of information on investment expenditure incurred in connection with irrigation works in that State, which alone accounts for almost two-thirds of all Australian irrigation development.

As regards New South Wales the position is somewhat less satisfactory but information extracted from the annual reports of the Water Conservation and Irrigation Commission combined with the annual budget estimates enabled a rough series to be constructed. Published information is sketchier still for South Australia. Some details of public investment in irrigation works are given in the report of the Department of Lands, but the significance of capital accounts is somewhat obscured by the deduction of repayments and other credits each year.

Between them the three States just referred to have accounted for from 90 to 95 per cent. of all irrigated acreage in Australia during each of the last 30 years. Because of this dominant importance it was felt that a (time-consuming) study of investment in irrigation works in the remaining States, for which records are very precarious, would not repay in added accuracy the amount of detailed research involved. The assumption was therefore made that irrigation development in those States over the period has varied at roughly the same rate as was recorded for the principal irrigation States. The figure for the amount of investment in irrigation works in the principal irrigation States was consequently inflated each year by means of an index, representing the irrigated acreage in these States as a percentage of total Australian irrigated acreage.

The task remained of deflating the series which refers to actual cost at current prices incurred in the construction of the works. Each annual increment in this value series (representing the amount of capital cost incurred during that year) was thus deflated by an index specially constructed for the purpose. The index employed is a simple unweighted average of labour and building materials costs both of which enter in approximately equal proportion into the construction of irrigation works.

TABLE IX.

Estimated Investment in Irrigation Works—Australia.

Year.	Capital Value of Irrigation Works. Victoria. (1)	N.S.W. (2)	South Australia. (3)	Total of Three States. (4)	Annual Increase of (4) (5)	Deflator Series* 1923–24 — 1927–28 average = 1,000† (6)	Deflated Value of Annual Increase. (7)	Deflated Total Value for 3 States. (8)	Index of Irrigated Area (3 States as percentage of Australian Total). (9)	(8) x (9) Deflated Total Value for Australia. (10)
	£m.	£m.	£m.	£m.	£m.		£m.	£m.		£m.
1921 ...	12·3	7·7	4·3	24·3	...	670	...	36·3	106	38·5
1922 ...	13·7	8·8	5·0	27·5	3·2	1,270	2·5	38·8	107	41·5
1923 ...	14·8	9·7	5·8	30·3	2·8	1,053	2·7	41·5	107	44·4
1924 ...	16·2	10·6	6·5	33·3	3·0	1,060	2·9	44·4	107	47·5
1925 ...	17·9	11·3	7·2	36·4	3·1	1,008	3·1	47·5	107	50·8
1926 ...	19·6	12·0	7·5	39·1	2·7	985	2·7	50·2	106	53·2
1927 ...	21·2	12·7	7·7	41·6	2·5	985	2·5	52·7	106	55·9
1928 ...	22·5	13·4	8·0	43·9	2·3	981	2·3	55·0	106	58·3
1929 ...	23·9	14·0	8·2	46·1	2·2	1,021	2·2	57·2	106	60·6
1930 ...	24·5	14·1	8·3	46·9	·8	1,026	·8	58·0	107	62·1
1931 ...	25·0	14·2	8·4	47·6	·7	1,052	·7	58·7	107	62·8
1932 ...	25·5	14·3	8·4	48·2	·6	1,045	·6	59·3	108	64·0
1933 ...	25·9	14·4	8·4	48·7	·5	1,071	·5	59·8	108	64·6
1934 ...	26·2	14·4	8·5	49·1	·4	1,012	·4	60·2	109	65·6
1935 ...	26·8	14·5	8·6	49·9	·8	1,000	·8	61·0	109	66·5
1936 ...	27·2	14·9	8·6	50·7	·8	991	·8	61·8	109	67·4
1937 ...	27·5	15·2	8·7	51·4	·7	1,000	·7	62·5	109	68·1
1938 ...	28·0	16·4	8·7	53·1	1·7	1,150	1·5	64·0	109	69·8
1939 ...	28·5	17·6	8·7	54·8	1·7	1,120	1·5	65·5	109	71·4
1940 ...	28·9	18·3	8·8	56·0	1·2	1,127	1·1	66·6	109	72·6
1941 ...	29·2	19·0	8·8	57·0	1·0	1,331	·8	67·4	109	73·5
1942 ...	29·3	19·4	8·8	57·5	·5	1,430	·3	67·7	109	73·8
1943 ...	29·4	19·8	8·8	58·0	·5	1,553	·3	68·0	109	74·1
1944 ...	29·7	20·3	8·8	58·8	·8	1,698	·5	68·5	109	74·7
1945 ...	30·4	20·5	8·8	59·7	·9	1,701	·6	69·1	109	75·3
1946 ...	31·9	21·0	8·8	61·7	2·0	1,706	1·2	70·3	109	76·6
1947 ...	33·8	21·5	8·8	64·1	2·4	1,743	1·4	71·7	109	78·2

* Average movement in cost of building material (Melbourne Wholesale Price Index) and labour (average male weekly wage).

† For deflating base period value 1900–1920 average of deflator series is used.

For the purpose of the index, labour costs were measured by the Commonwealth Statistician's weighted average male weekly wage index, while the Melbourne Wholesale price index of building materials was regarded as indicative of movements in that item.

As regards the figure for 1921, the base year of the present investigation, it would obviously have been misleading to deflate it by the value of the index for that year. The assumption was consequently made that construction prior to 1921 had been proceeding at an even rate since the beginning of the century and an unweighted average of the index over that period was used as a deflator for that year.

4. THE INDEX OF RURAL EMPLOYMENT.

In the field of employment statistics difficulties are encountered not only because of the almost total absence of published and reliable figures but because of the unavailability of any data which would allow of conclusions to be drawn or checked as to the actual trends in the size of the rural labour force during the period under review.

Published records for employment in Australian agriculture are confined almost exclusively to data referring to workers permanently employed in agricultural pursuits. For New South Wales alone some sketchy information is available on other than permanent labour (or rather on the total amount of wages paid to such labour annually) but this is insufficient for the building up of a reliable series.[27]

The employment figures here used (Tables X and XI) are, therefore, not based on published statistics; they have been obtained by the courtesy of officers of the Commonwealth Bureau of Census and Statistics, by whom they have been compiled from a variety of sources. Of these the most important are the census returns (1921, 1933 and 1947), returns from the 1939 National Register and the 1945 Occupation Survey.

For years for which other information was unavailable (i.e., for sixteen years out of the nineteen-year period, 1921-1939) figures were based on interpolation. The only additional source from which some guidance could be obtained for the process of interpolation was the annual Agricultural and Pastoral Returns which contain some sketchy information on labour permanently engaged in agriculture. It is generally agreed, however, that the margin of error of these data is wide. Moreover, to base estimates of the total rural labour force on data for permanent employees is likely to be seriously misleading, in view of the changing structure of the rural economy and the divergent trends in individual rural industries which must affect the proportion of seasonal and temporary workers in agriculture as a whole. It is very probable that fluctuations in the rural labour force will largely be confined to the number of temporary employees. When the number of the latter is estimated on the basis of that of permanent workers the degree of fluctuation in the total labour force is liable to be severly understated for that reason.

[27] New South Wales *Statistical Register*.

TABLE X.

Estimated Average Number Engaged in Primary Industries, Manufactures, and Other Industries.

A. Males.

Year.	Mining and Quarrying.	Forestry.	Fishing, Trapping.	Agriculture, Grazing, etc.	Manufacture.*	All Other.	Unemployed.	Defence Forces.†	Total Labour Force.
	'000.	'000.	'000.	'000.	'000.	'000.	'000.	'000.	
1920–21 ...	53·5	28·6	10·7	443·0	277·1	831·7	120·0	......	1,764·6
1921–22 ...	51·5	28·3	10·0	447·5	281·2	847·1	136·0	......	1,801·6
1922–23 ...	52·5	28·5	10·3	453·0	293·0	879·9	123·0	......	1,840·2
1923–24 ...	53·7	32·0	10·4	457·4	310·8	910·8	107·0	......	1,882·1
1924–25 ...	53·8	30·7	10·7	461·8	322·7	913·0	134·0	......	1,926·7
1925–26 ...	54·1	36·9	11·8	467·2	328·8	932·4	139·0	......	1,970·2
1926–27 ...	52·6	32·1	11·5	471·6	337·4	976·0	133·0	......	2,014·2
1927–28 ...	48·9	31·6	11·1	476·0	334·9	988·2	170·0	......	2,060·7
1928–29 ...	43·2	27·3	11·8	480·0	333·1	1,021·5	182·0	......	2,098·9
1929–30 ...	41·1	27·6	13·0	485·0	308·2	982·9	269·0	......	2,126·8
1930–31 ...	43·8	16·9	13·9	490·0	245·9	923·8	413·0	......	2,147·3
1931–32 ...	46·6	14·9	14·8	491·0	237·9	872·0	489·0	......	2,166·2
1932–33 ...	49·4	23·5	13·5	492·0	261·5	860·7	487·0	......	2,187·6
1933–34 ...	55·3	22·7	12·5	498·0	289·2	908·1	424·0	......	2,209·8
1934–35 ...	62·0	27·1	12·5	501·0	322·5	932·5	375·0	......	2,232·6
1935–36 ...	65·0	26·5	11·0	501·0	356·6	991·7	308·0	......	2,259·8
1936–37 ...	67·4	29·1	11·4	503·0	381·4	1,034·6	264·0	......	2,290·9
1937–38 ...	67·9	31·5	11·2	508·0	408·6	1,059·2	236·0	......	2,322·4
1938–39 ...	66·6	28·5	11·7	502·0	412·6	1,086·7	246·1	......	2,354·2
1939–40 ...	64·4	28·7	12·3	503·7	426·9	1,030·2	250·7	64·1	2,381·0
1940–41 ...	60·7	29·0	12·8	483·4	473·1	957·3	155·8	254·9	2,427·0
1941–42 ...	56·0	29·3	10·5	445·7	524·4	898·3	54·6	474·9	2,493·7
1942–43 ...	49·5	29·9	10·7	398·5	535·6	803·1	22·4	662·3	2,512·0
1943–44 ...	47·1	30·2	10·7	393·9	539·1	801·1	28·2	673·4	2,523·7
1944–45 ...	46·9	31·0	12·4	411·7	535·9	833·3	37·6	625·9	2,534·7
1945–46 ...	49·2	30·4	14·0	424·0	548·9	954·4	138·0	364·1	2,523·0
1946–47 ...	54·3	35·2	15·7	437·0	604·3	1,147·3	128·0	76·2	2,498·0
1947–48 ...	56·8	37·0	17·0	439·0	633·9	1,234·3	51·0	42·0	2,511·0

* Average for year—derived from annual factory production census.

† Prior to 1939–40 included in "All Other".

Table XI

Estimated Average Number Engaged in Primary Industries, Manufactures, and Other Industries.

B. Females.

Year.	Mining and Quarrying.	Forestry.	Fishing, Trapping.	Agriculture, Grazing, etc.	Manu-facture.*	All Other.	Unemployed.	Defence Forces.†	Total Labour Force.
	'000.	'000.	'000.	'000.	'000.	'000.	'000.	'000.	
1920–21 ...	0·2	0·1	......	9·8	90·1	325·4	18·0	......	443·6
1921–22 ...	0·2	0·1	......	10·6	97·3	327·8	19·0	......	455·0
1922–23 ...	0·2	0·1	......	11·4	102·6	335·7	18·0	......	468·0
1923–24 ...	0·2	0·1	......	12·2	103·3	350·2	16·0	......	482·0
1924–25 ...	0·2	0·1	......	13·0	105·3	358·4	20·0	......	497·0
1925–26 ...	0·2	0·1	......	13·8	107·5	370·4	20·0	......	512·0
1926–27 ...	0·2	0·1	......	14·6	114·8	380·3	19·0	......	529·0
1927–28 ...	0·2	0·1	......	15·4	114·8	390·5	26·0	......	547·0
1928–29 ...	0·2	0·1	......	16·2	117·4	400·1	31·0	......	565·0
1929–30 ...	0·2	0·1	......	17·0	111·0	392·7	60·0	......	581·0
1930–31 ...	0·2	0·1	......	17·7	92·9	390·1	94·0	......	595·0
1931–32 ...	0·2	0·1	......	18·4	98·7	379·6	111·0	......	608·0
1932–33 ...	0·2	0·1	......	19·0	109·2	380·5	111·0	......	620·0
1933–34 ...	0·2	0·1	......	19·2	116·7	410·8	84·0	......	631·0
1934–35 ...	0·2	0·1	......	19·4	127·1	429·2	66·0	......	642·0
1935–36 ...	0·2	0·1	......	19·6	136·2	445·9	51·0	......	653·0
1936–37 ...	0·3	0·1	......	19·8	142·5	468·3	35·0	......	666·0
1937–38 ...	0·3	0·1	......	20·0	150·6	476·0	31·0	......	678·0
1938–39 ...	0·3	0·1	......	20·3	152·6	483·7	33·0	......	690·0
1939–40 ...	0·3	0·1	......	19·2	160·8	488·0	30·5	0·1	699·0
1940–41 ...	0·4	0·1	......	19·1	177·0	510·0	23·5	0·9	731·0
1941–42 ...	0·5	0·1	......	24·0	201·0	532·4	12·1	6·9	777·0
1942–43 ...	0·6	0·1	......	34·0	223·5	515·8	10·0	33·1	817·1
1943–44 ...	0·5	0·1	......	39·9	227·4	492·1	11·0	47·9	818·9
1944–45 ...	0·5	0·1	......	39·9	214·7	498·2	15·0	46·7	815·1
1945–46 ...	0·5	0·1	......	36·0	196·4	493·7	26·0	28·6	788·0
1946–47 ...	0·5	0·1	......	29·0	200·4	511·6	22·0	4·0	767·6
1947–48 ...	0·6	0·1	......	......	......	......	17·0	0·6	782·7

* Average for year—derived from annual factory production census.

† Prior to 1939–40 included in " All Other ".

Although for this reason the year-to-year variations in the figures may be of little significance, the series is useful in charting in broad terms the approximate size of the rural labour force during the period.

These figures are given separately for male and female labour; the latter have been converted for the purposes of the index to male equivalents at the customary factor of 50 per cent. The justification for this procedure lies both in the lower efficiency of female workers in rural occupations and the fact that a considerable proportion of them is presumed to be engaged for part of their working time in domestic occupations.

The most unsatisfactory feature of the figures apart from the deficiences mentioned is that they refer to average annual employment, i.e., to man-years. As conditions of employment and working hours are known to have varied over the period, data giving man-hours would naturally have been much more appropriate to a study concerned with productivity. Such data, if they were available, might throw light on at least two relevant problems. One of these relates to the depression years for which our figures record a rise in rural employment. As unemployment was high in other industries during that period it seems possible that the rural figures include among the labour force a certain amount of "concealed" unemployment which, no doubt, would be made explicit if the data were available on a weekly (or hourly) basis.

The other point concerns the war years which were marked by a substantial drop in agricultural employment. As production showed a rise during the war the obvious conclusion would be that productivity must have increased materially during the period. It is, of course, known that this conclusion would be considerably weakened if hours of work could be taken into account.

Another point that may be noted in this connection is that by no means the whole of the annual labour effort is devoted to current production. A proportion of it, and possibly quite a significant one is applied to the maintenance of capital equipment (structures, improvements, machinery and implements) and to a lesser extent to the construction of additional improvements. It seems highly probable that during the war (and early post-war) years the amount of labour effort expended in this direction was substantially curtailed and that consequently the reduction in the labour force would be reflected in the decline of rural investment rather than of rural production. The series presented above, for rural investment and production seems certainly wholly consistent with such a hypothesis.

It may be added that a considerable amount of research was undertaken with the object of securing a split-up of the agricultural labour force as between the major rural industries. The main obstacle there is, of course, the scarcity of statistical information already referred to. This is further aggravated by the vagueness of the Census classification which results in a majority of farmers and rural employees describing themselves as "farmers", "agriculturalists", "primary producers", etc., thus making it necessary to resort to roundabout processes of estimation in order to obtain an approximate split up.

As it is not here intended to give a detailed analysis of individual primary industries, it will not be necesary at this stage to give details of the nature of these estimates.

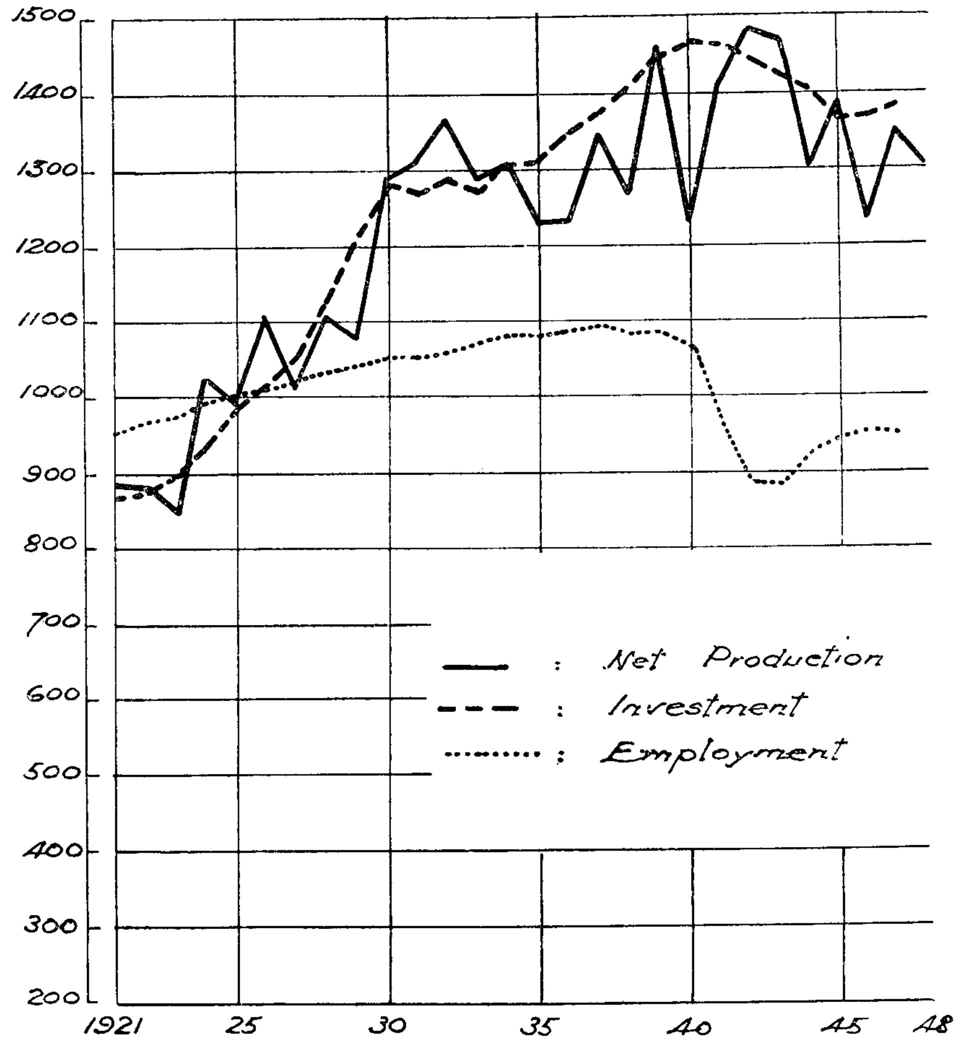

Fig. 2.—Indices of Agricultural Production, Investment and Employment (1923-24 to 1927-28 Average = 1,000).

5. INTERPRETATION.

The three series for investment, production and employment which we set out to obtain, have now been derived (Tables XII and XIII) and an attempt may be made to reach some provisional conclusions about the inter-relation during the period covered of the variables which they represent.

At the outset the tentative nature of such inferences needs stressing. No generalization is worth more than the observations on which it is based. The many limitations of the data here employed have for this reason been discussed in detail in the preceding sections and do not need to be recapitulated.

The high degree of aggregation involved in obtaining each of the three series has, no doubt, to some extent reduced bias and is in part responsible for the comparative stability of the figures over the period. On the other hand aggregation has certainly obscured some interesting and possibly significant inter-relations between the variables represented by the sub-groups of the various indices. Further analysis of these may well yield worthwhile results, but is beyond the scope of the present paper.

In exploring the provisional answers that can be given on the basis of these indices to the questions raised at the outset of this enquiry, we may begin by re-stating those questions in a somewhat more concrete form as follows:—

(1) Has there been a consistent relation between investment, employment and production during the period?

(2) What has been the nature of the relation and what light does it throw on the problems of—

   (*a*) diminishing (or constant or increasing) returns in agriculture?

   (*b*) the relative importance of labour and capital in agricultural production?

TABLE XII.

Indices of Production, Investment and Employment.
(Five-Year Moving Average.)

(1923-24 — 1927-28 average = 1,000.)

Year.	Production.	Investment.	Employment.
1923...	926	909	980
1924...	973	941	989
1925...	1,000	976	1,000
1926...	1,055	1,022	1,010
1927...	1,065	1,077	1,021
1928...	1,124	1,136	1,032
1929...	1,164	1,187	1,041
1930...	1,234	1,232	1,049
1931...	1,268	1,263	1,057
1932...	1,314	1,284	1,065
1933...	1,305	1,292	1,070
1934...	1,289	1,306	1,076
1935...	1,283	1,324	1,083
1936...	1,279	1,349	1,085
1937...	1,310	1,377	1,086
1938...	1,309	1,408	1,082
1939...	1,344	1,431	1,059
1940...	1,373	1,446	1,018
1941...	1,415	1,450	978
1942...	1,382	1,441	945
1943...	1,412	1,422	921
1944...	1,376	1,405	919
1945...	1,351	1,392	932
1946...	1,317	......	......

TABLE XIII.

Investment Indices.

(1923-24 — 1927-28 average = 1,000.)

Year.	Livestock.	Machinery and Implements.	Permanent Improvements.	Irrigation Works.	All Investment.
1921 ...	971	685	842	750	861
1922 ...	971	722	858	808	877
1923 ...	946	796	880	846	891
1924 ...	1,000	870	904	923	932
1925 ...	1,049	963	951	981	984
1926 ...	1,020	1,037	1,016	1,019	1,019
1927 ...	975	1,130	1,093	1,038	1,056
1928 ...	971	1,241	1,186	1,115	1,120
1929 ...	966	1,278	1,331	1,173	1,204
1930 ...	1,020	1,315	1,432	1,192	1,280
1931 ...	1,029	1,241	1,426	1,212	1,275
1932 ...	1,059	1,222	1,423	1,231	1,283
1933 ...	1,059	1,204	1,410	1,250	1,275
1934 ...	1,088	1,222	1,448	1,267	1,308
1935 ...	1,069	1,241	1,470	1,288	1,317
1936 ...	1,049	1,352	1,519	1,288	1,346
1937 ...	1,049	1,444	1,555	1,308	1,374
1938 ...	1,029	1,537	1,598	1,346	1,402
1939 ...	1,069	1,630	1,645	1,365	1,448
1940 ...	1,098	1,685	1,653	1,404	1,469
1941 ...	1,098	1,764	1,639	1,404	1,463
1942 ...	1,088	1,741	1,609	1,423	1,448
1943 ...	1,093	1,778	1,552	1,423	1,422
1944 ...	1,039	1,815	1,541	1,442	1,404
1945 ...	975	1,889	1,511	1,442	1,374
1946 ...	961	1,963	1,505	1,481	1,376
1947 ...	975	2,037	1,497	1,500	1,383

The general trend in the three indices is evident from Tables XII and XIII and Figure 2. In view of the familiar year-to-year instability of agricultural production, this index is most conveniently presented in terms of its five-year moving average and the other indices, in order to preserve comparability, were put into similar form.

The procedure employed for analysing these figures were in the main those of graphic representation and of correlation analysis by the method of least squares. It is clear, of course, that the former method can be no more than suggestive of conclusions; as regards the least square approach it, too, has been employed with considerable hesitation, since recent work undertaken by the econometricians has emphasized its shortcomings for the purpose of handling multiple correlation problems, especially when involving time series.[28] The new techniques that have been developed are not, however, easily accessible and require an amount of detailed computations which makes their use impracticable except in a setting where economic research is carried on with vast resources in manpower and mechanical equipment.

The first hypothesis to be tested against the data assembled is that of a production function of the Cobb-Douglas type. A brief outline of the meaning of such a function will therefore be in place.

A production function is defined as a functional relationship between the quantity of production on the one hand and the quantity of factors used to obtain it on the other.

A good deal of research has been undertaken by economists and statisticians in deriving production functions of various types for a variety of countries and industries and over diverse periods for the purpose of shedding light on the nature (or existence) of laws of production and/or distribution.

There has been a marked division of opinion on the value of the production function as a tool of analysis and complete unanimity has not been reached.[29] The weight of the evidence suggests strongly, however, that interesting and empirically significant generalizations can be obtained from these functions especially on the question of the marginal productivity of factors of production. We must therefore review briefly some of the more important views that have been advanced on the subject.

Extreme critics who refuse to concede validity to the production function as an analytical tool appear to base their view on three principal arguments. In the first place, they say, it is not possible to speak of marginal productivity unless account is taken of the price of factors and products and if these are expressed in value terms the function will be purely tautological, telling us nothing except that the value of the product is equal to the sum of the values of the factors.[30]

As against this it may be urged that it is permissible for the purpose for which production functions are usually constructed to abstract from price changes and by handling the problem by means of index numbers to obtain meaningful results.

---

[28] No attempt was made to survey fully this complex subject for the purpose of this thesis. For confirmation of the view expressed in the text and fuller bibliography see, however, H. T. Davis, *The Analysis of Economic Time Series* (Cowles Commission Monograph No. 6, Bloomington, Indiana, Principia Press, 1941) T. Haavelmo, "The Probability Approach in Econometrics" (*Econometrica,* Supplement, July, 1944), and D. Cochrane, "Measurement of Economic Relationships" *Economic Record,* Vol. 25, No. 49 (December, 1949). See also, G. Tintner, "An Application of the Variate Difference Method of Multiple Regression", *Econometrica,* Vol. 12 (April, 1944) for a discussion of the problem of the direction of minimization with reference to an agricultural production function.

[29] See M. Bronfenbrenner "Production Functions: Cobb-Douglas, Interfirm, Intrafirm" *Econometrica,* vol. 12, 1944, pp. 35-44, for reference to the rather inconclusive state of this debate.

[30] See G. Cassel *On Quantitative Thinking in Economics* (London; Oxford University Press, 1935), Chapter VI. Mention must also be made here of Joan Robinson, "The Production Function and the Theory of Capital", *Review of Economic Studies,* Vol XXI (2), No. 55 (1953-54), and "A Comment" by D.G. Champernowne in the same journal.

The second argument against production functions depends on the existence of indivisibilities which often make continuous variation of factor quantities impracticable. For this reason production functions may be discontinuous and cannot be differentiated.

While this may in some cases be formally true, it is rarely a serious practical obstacle, especially where production functions refer (as they generally do) not to individual firms but to larger aggregates such as industries as a whole. In other cases it would still be possible to consider marginal productivities as difference quotients without specific limits.[31]

The third main line of attack (which seems the weightiest) alleges that the functional relationships governing production are in a continuous state of flux as a result of changes in the nature and volume of productive factors and processes and that for this reason an attempt to derive economic parameters from statistical data, especially time series by the method of least squares is doomed to failure.[32]

Part of this argument seems directed specifically not against production functions as such but against a particular type, viz., those which do not allow changes in the absolute or relative proportions of factors to influence the value of the marginal product. Again, the fact of continuous change need not necessarily invalidate a production function derived by the method of least squares, though a fluctuating rate of change would probably have that effect.[33] The impact of such fluctuations, however, may well have been over-rated by the more severe critics. Their view, in any case, is contradicted by a body of empirical evidence of impressive consistency.[34]

The modern pioneer work in the field of prodution functions was undertaken by Professor P. Douglas who first put forward (working in collaboration with Professor Cobb) the so-called Cobb-Douglas[35] function which has served as the basis for most subsequent investigations. The Cobb-Douglas function represents production as a function, linear in logarithms, of capital invested and labour employed, of the form—

$$P = aI^k \times E^m$$

Where *a* is a constant. I and E represent Investment and Employment respectively.

---

[31] See D. Durand, "Some Thoughts of Marginal Productivity, with Special Reference to Professor's Douglas' Analysis", *Journal of Political Economy,* 1937.

[32] G. Cassel, *op. cit.* p. 127 *et seq.*

[33] Durand, *op. cit.*, produces some evidence of excessive short-term instability in the parameters; but a rather unusual type of production function was used.

[34] See especially T. Marschak & W. H. Andrews "The Theory of Production," *Econometrica,* Vol. 12, Nos. 3 and 4 (July-October, 1944) for details of results, also Colin Clark, *Conditions of Economic Progress* (2nd Edition, London; Macmillan, 1951).

[35] See especially P. Douglas, *The Theory of Wages.* (New York, Macmillan, 1934) also Cobb & Douglas, "A Theory of Production" *American Economic Review,* Vol. 18, Supplement (March, 1928). Pp. 139-165.

In determining the parameters of this function for manufacturing industries in U.S.A., Australia and elsewhere, Douglas and his many collaborators have attempted to throw light not only on the process of production but also on the laws of distribution. The results of the investigations relating to distribution though of considerable interest are somewhat doubtful and (being beyond the scope of this thesis) will not be discussed here.

A number of specific criticisms have been raised against the Cobb-Douglas function to which reference must briefly be made.[36] The function has been applied by Douglas and his associates to two types of aggregates:

(*a*) "Temporal" (i.e. time-series) data for all manufacturing industries in a given region combined over a period of years (e.g., N.S.W. 1901-27); and

(*b*) "Cross-Section" data, i.e., data for individual manufacturing industries during the same period (e.g., Australia 1936-37). It has been shown that the result of cross-section studies are difficult to interpret theoretically and indeed that the procedure for deriving them as used by Douglas may not be appropriate.[37] As it is not possible to obtain data necessary for cross-section studies of Australian agriculture, the production function here presented will be of the time-series type and the implications of the cross-section approach need not be fully entered into.

In much of his earlier work Douglas insisted, when fitting the equation ($P = aI^k E^m$) to his data, on imposing the special condition of $k + m = 1$.

The reason for this procedure is of some interest. It is evident that from the Cobb-Douglas function the marginal product of the factors of production can easily be derived by partial differentiation: thus

$$\frac{\delta P}{\delta E} = a\, m\, I^k\, E^{m-1} \text{ and } \frac{\delta P}{\delta E} = m\, \frac{P}{E}$$

and similarly

$$\frac{\delta P}{\delta I} = k\frac{P}{I}.$$

This, of course, means that the marginal product is proportionate to the average product, *i.e.*, it is a function of the ratio of the factors of production. Production here is a homogeneous function of Investment and Employment of degree ($k + m$) which means that an increase of

$$\frac{b + 100}{100}$$

in the amount of each factor of production will yield an increase of

$$\left(\frac{\cdot + 100}{100}\right) \times (k + m)$$

in the amount of P. It further follows (from Euler's theorem[38]) that—

$$I\,\frac{\delta P}{\delta I} + E\,\frac{\delta P}{\delta E} = (k + m)\ P.$$

[36] For more complete discussion see H. Mendershausen, "Professor Douglas' Production Function", *Econometrica*, 1938.

[37] See M. W. Reder, "An Alternative Interpretation of the Cobb-Douglas Function", *Econometrica*, 1943, also, J. Williams, "Professor Douglas' Production Function", *Economic Record*, 1945, and M. Bronfenbrenner, *op. cit.*

It is clear that if $k+m = 1$, then Production is equal to the sum of I and E multiplied by their respective marginal products. This is the state of affairs that may be expected to prevail under perfect competition and when returns to scale are constant.

The assumption of constant returns to scale (for that is what Douglas' condition $m+k = 1$ amounts to) was not based so much on empirical evidence, as made by Douglas in order to allow conclusions to be drawn from the production function about the distribution of the net product between Labour and Capital. With increasing or decreasing returns the total product would be greater or smaller than the sum of the amounts of the factors multiplied by their respective marginal products.

Douglas mistakenly considered that such a situation would mean that the problem of distribution would necessarily become indeterminate and industrial chaos inevitable.[39] Actually it implies merely that no valid conclusions about the distribution of the product can be drawn from the Cobb-Douglas function unaided by additional information (about the degree of monopoly, etc.). This hardly seems to constitute sufficient ground for imposing the condition $m + k = 1$; this condition has consequently been abandoned for the purpose of the agricultural production function presented below.

A further point of criticism that has been advanced against Douglas' results is that his classification of factors is insufficiently complete. This criticism carried some weight when aimed at Douglas' data for capital which are frequently based on Census results with long periods of interpolation and inadequate allowance for the effects of replacement and of the varying intensity of utilization of capital. As the data for the production function for Australian agriculture had to be derived from different sources altogether, these points (with the exception of the one relating to idle capital) will not arise.

Of considerably greater moment is the fact that the Cobb-Douglas function makes no allowance for the contribution made to production by new inventions and the general effects of the spread of technological knowledge. In the absence of such allowance the contribution of these factors must be reflected in higher values of m and k; and where the sum of these is equal to unity it must be concluded that the returns to Labour and Capital alone (unaided by those other factors) would be declining.

The best way of bringing to account these intangible (and unmeasurable) factors of production, is evidently by representing them in the equation as a constant trend over time and this has consequently been done in the equation presented below by adding an additional term c^T to the usual Cobb-Douglas function. The Cobb-Douglas function for Australian agriculture which has been derived from the indices presented above is of the following form:—

$$P = 5{\cdot}406\ (0{\cdot}989)^T\ I^{1.221}\ E^{-0.453}.$$

[38] For proof and also for more rigorous definition of homogeneous functions see R. G. D. Allen, *Mathematical Analysis for Economists* (London, Macmillan, 1938), p. 315, *et. seq.*

[39] For an excellent discussion of this problem see Marschak & Andrews *op. cit.* p. 182, *et. seq.*

The most striking feature of the function is the negative exponent for the factor "Labour" (E). The implication of this is that over the period covered by the indices there has been an inverse relation between the numbers employed and the net output in rural industries. This finding (which is statistically significant) that agricultural production can be increased by a reduction of the labour force is, of course, contrary to common experience and cannot therefore be accepted. The unsatisfactory result may be largely ascribable to the inadequacy of the employment series to which reference has previously been made. It was found, then, that the most serious deficiencies in this series are likely to be found during the war years and this period was therefore omitted and a production function computed covering the period 1921-38 only which was found to be of the following form:—

$$P = 8{\cdot}331\ (0{\cdot}987)^{T}\ I^{1.299}\ E^{-0.593}.$$

The relation is similar to the previous one and the exponent of E is again negative. The result is of some interest for the reason that in this case the value of the exponent of E was shown to be without statistical significance.

We are thus forced to the conclusion that it is not possible with the help of the data available to derive a meaningful function of the Cobb-Douglas type for Australian agriculture. Another line of approach will therefore be needed to test the applicability of Schultz' thesis to Australian conditions. To develop such an approach would lead well beyond the intended scope of this paper. The remaining remarks will merely aim at exploring some implications of the data derived in the previous sections.

TABLE XIV.

Annual Variations of the Indices.

(Three-year moving average.)

Year.	Production.	Investment.	Employment.
1924...	42	38	11
1925...	30	46	11
1926...	41	53	11
1927...	37	55	11
1928...	55	52	10
1929...	47	42	9
1930...	48	32	8
1931...	21	20	8
1932...	5	14	7
1933...	— 12	13	6
1934...	— 10	19	6
1935...	7	24	5
1936...	9	28	2
1937...	23	27	0
1938...	21	22	— 8
1939...	34	14	— 22
1940...	12	3	— 35
1941...	13	— 8	— 38
1942...	— 13	— 15	— 36
1943...	— 10	— 16	— 20
1944...	— 32	...	— 4

There are certain difficulties involved in an attempt to explain with the help of the three indices the significance of their year to year variations which are naturally very small in relation to the totals. This means that the degree of auto-correlation of the original series is high and suggests that they can be analysed most appropriately in terms of their first differences.[40]

One advantage of this procedure is that the annual variations in the investment index correspond, of course, to the amount of annual investment which is a rather more familiar and manageable economic variable than is "total capital invested".

The relation of the aggregates and their annual differences are shown in Figures 2 and 3. These differences were derived in the first place from the five-year moving average of the indices (Table XII). Considerable year-to-year fluctuations were still exhibited, however, by the differences of the production index, even though the trend was very clearly apparent.

A further smoothing process was therefore applied to these data by taking a three-year moving average. This is shown in Table XIV. While the effect of the smoothing process is insignificant in the case of the variations in investment, in the case of the variations in production it succeeds in reducing the random element to a considerable degree.[41]

On the basis of these data a simple linear function of the type $\Delta P = a + b\Delta I + c\Delta E$ was fitted. The regression equation was found to be of the form—

$$(1)\ \Delta P = -19{\cdot}93 + 1{\cdot}55\ \Delta I - 1{\cdot}12\ \Delta E$$

again indicating a negative relation between variations in employment and production.

In order to further explore the relation betwen these two variables a simple regression equation was fitted, representing variations in production as a linear function of variations in employment. The co-efficient of correlation was found to be low (.47) and of only doubtful statistical significance.

Precise quantitative inferences from these results cannot be drawn because of the limitations already adverted to, to which the index of employment is subject. It is unlikely, however, that these imperfections vitiate the broad outline of the conclusion that emerges, viz.—that increases in agricultural production over the period reviewed have as often as not been associated with decreases in rural employment. This

[40] The subject of serial correlation (or auto-correlation) in time series and its effect on statistical analysis is a highly technical one. M. Ezekiel, *Methods of Correlation Analysis* (2nd Edition, New York; Wiley, 1941, p. 352) states: "This problem is one of the greatest unsolved questions in the whole field of modern statistical methods". For justification of the procedure used in the text see G. Tintner, *The Variate Difference Method* (Indiana, Bloomington Press, 1940), especially p. 156 *et. seq.*, also H. T. Davis, *op. cit.* and D. Cochrane *op. cit.*, especially p. 16.

[41] To verify the point that the trend of the data was not disturbed by the further smoothing process the regressions given below were worked out for both the five-year moving average and the three-year. The results were closely similar as regards regression coefficients and constants while, as expected, correlation coefficients were higher and standard errors lower for the latter series.

does not, of course, prove the existence of a causal relation between declines in employment and increases in production. It may, however, be taken to be corroborative evidence of two familiar tendencies in Australian agriculture: firstly, a rise in production and a decline in employment associated with increases in investment (especially mechanization); secondly, a decline in investment and production during periods of depression when agricultural employment is apt to increase.

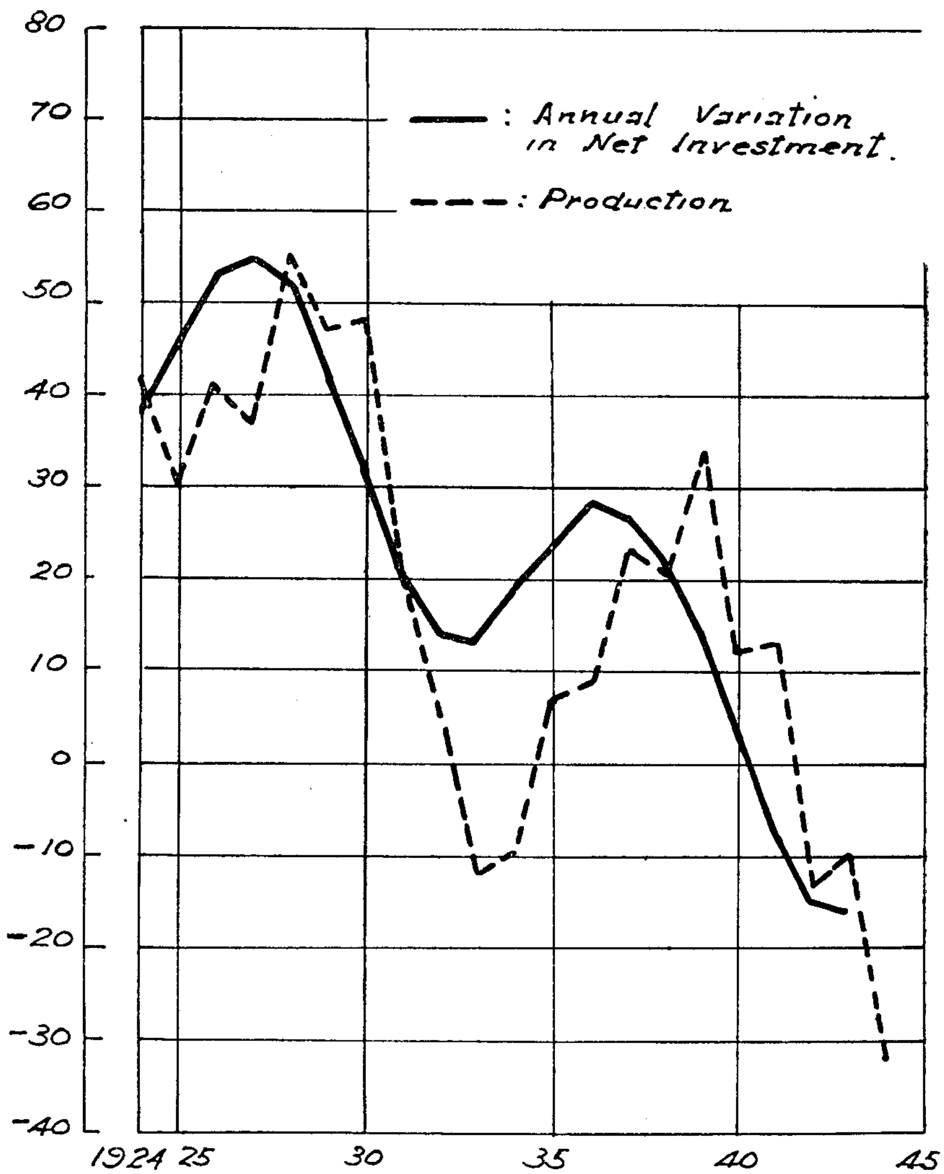

Fig. 3.—Annual Variation in Indices of Net Agricultural Investment and Production. (Derived from Figure 2.)

The general relation reflected in the equation holds true with even greater force in the case of the war period when an unprecendented fall in employment was associated with a rise in production. During that period the major factor probably was a greatly increased labour effort per man employed in the primary industries which more than offset the reduction in the labour force. An extraordinary succession of favourable seasons also played a part.

It appears that recorded variations in rural employment are of little assistance in explaining the changes that have occurred in agricultural production. Further investigation revealed that what variations have occurred in agricultural production over the whole of the period could quite satisfactorily be represented as a function of changes in annual investment.

This alternate simplified approach has consequently been employed for relating both the actual annual variations in production and investment and also these variations expressed in terms of the total indices, i.e., the percentage variations of the two variables.

In Figure 3 a time lag is distinctly apparent between the variations in production and investment which is exactly what one would expect on the basis of common observation (and economic theory) in a functional relation between these two variables. The regression equations presented below were computed, in the first instance, without a lag and also for time lags of one, two and three years. It was found that lags of one and two years yielded closely similar correlation coefficients, significantly higher than those obtained on the basis of the two alternative assumptions. The regressions shown below are consequently calculated on the basis of a one year lag.

Again the hypothesis was explored that the regression lines may have been different during the war-time period than before the war. Separate regressions were therefore worked out for the period between 1921-38 and 1939-47 as well as for the two periods combined.[42] The slopes of the regression lines for the two periods (pre-war and war-time) were found to be similar though the constant was higher (roughly equal to zero) for the later period. Because of the small number of observations available for the war period and the fact that these were largely concentrated in the lower values of agricultural investment, the view was taken that little significance could be attached to the regression of this period considered on its own and the results given below refer solely to the period as a whole.

When production changes were represented as a simple linear function of absolute changes in investment, *i.e.*, $\Delta P = a + b\Delta I$, the following result was obtained :—

$$\Delta P = -7{\cdot}02 + 1{\cdot}01\ \Delta I.$$

The correlation was high (·93). The coefficient of ΔI, of course, measures the change in the annual increment of production attendant upon a unit change in the amount of annual (net) investment. The constant (a) measures the change in production associated with zero-investment. Over the period the value of this constant was negative, indicating that in the absence of investment, production would fall off.

[42] As a result of smoothing (by use of moving averages) and of lagging the actual number of years for which data were available was somewhat reduced.

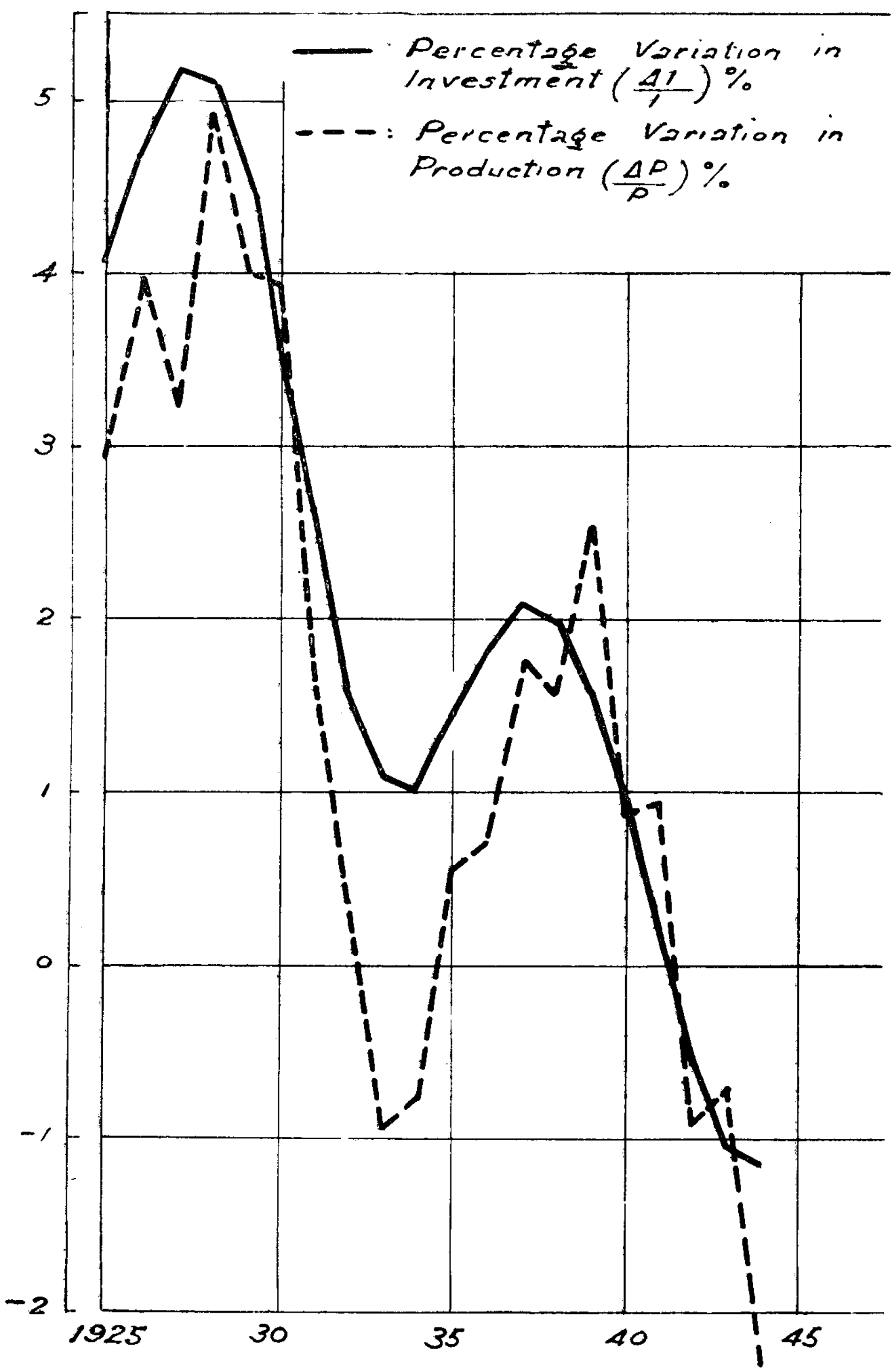

Fig. :.—Percentage Variation in the Indices of Net Agricultural Investment and Production.

The corollary that, during the period, a substantial level of annual net investment was required in order to provent a decline in production is rather a surprising one and it is not easy to formulate a hypothesis about the nature of rural investment which completely accounts for this behaviour of the constant a.

Perhaps the simplest explanation would be that our series for annual investment does not really represent net investment, but contains a gross or replacement component roughly equal in magnitude to the value of constant a. If this were the case, a decline of annual investment below the level of a (i.e., below replacement level) would quite naturally be associated with a decline in production. Nevertheless when account is taken of the manner (previously outlined) in which the investment index has been derived it is difficult to see how a gross (investment) element could have intruded into the figures.

The most likely explanation then is that agricultural production as carried on during the period considered caused a deterioration of irreplaceable wasting assets and that a substantial amount of net investment was needed each year, merely to compensate for the depressing influence that this must have had on production. The constant a in this case must be taken as indicating the amount of "worn-out" natural assets which each year have to be replaced by manufactured capital. The guess may also be hazarded that an analysis (which is not being attempted here) based on a split-up of the investment series into its various components might throw further light on this subject.

We may recall at this point that the series for production and investment were both presented in value terms. The constants a and b of the equation above may therefore be expressed in like manner, i.e., terms of constant 1923-24 to 1927-28 average values, simply by converting the index numbers (or the annual differences between them) back to absolute figures. By multiplying the right hand side of each equation by $\frac{176}{676}$ (the quotient of the base period values of the two indices) we obtain—

$$\Delta P = -1{\cdot}83 + {\cdot}26\ \Delta I.$$

This may be interpreted as implying that for each £1 million invested, production increased by £260,000 annually during the period.

It must be remembered in appraising these figures that they refer to quantum (of production and investment) rather than to pure value; if it were intended to convert them to present day values the production and investment figures in the equation would have to be inflated separately by means of their respective indicator series. Expressed in current values, therefore, the equation would assume a slightly different form. Subject to this reservation the regression equation implies that the marginal efficiency of capital in Australian agriculture averaged 26 per cent. during the period considered.[43]

[43] This compares with a figure of about 15 per cent. found for United States agriculture by D. Gale Johnson, "Contribution of Price Policy to the Income and Resource Problem in Agriculture", *Journal of Farm Economics,* Vol. XXVI, No. 4 (November, 1944).

In conclusion we may turn away from this discussion of the relation between absolute changes in the amounts of investment and production and briefly consider the relation between their relative variations. Using again the least-square method a trend was fitted to the data and the following regression equation was obtained—

$$\frac{\Delta P}{P} = -\cdot 49 + \cdot 94 \frac{\Delta I}{I}.$$

A second degree parabola was also fitted to the data; the non-linear nature of the data was not considered sufficiently marked to merit fuller discussion of their implications.

The constant *a* in the equation is indicative of the rate of annual investment necessary to prevent a drop in production,[44] and raises problems similar to those already considered when discussing the implications of the earlier equation relating absolute increments in investment and production.

The constant *b* measures the percentage increase in production associated with an increase of 1 per cent. in investment.

The regression equation suggests that over the period considered Australian agriculture has yielded returns to investment of slightly below unity. This, of course, is something quite different from an assertion that Australian agriculture as a whole is subject to diminishing returns. In fact the regression points strongly to the contrary conclusion, as it is evident that (if we accept the finding) the returns to capital and labour combined, will be in excess of unity even granted the fact that labour earns a much lower return in Australian agriculture than does capital. On the other hand the high marginal productivity of capital reflected in the figure (.94) is not so surprising if it is remembered that the definition of capital used is a very wide one, including (in the form of irrigation works) even a factor which from some points of view might be ranked among external economies.

The reasonableness or otherwise of our correlation must, for the present, at least, remain speculative in the absence of reliable data on marginal productivities in agriculture elsewhere.[45]

---

[44] Thus with $\frac{\Delta P}{P} = 0$, $\frac{\Delta I}{I} = \cdot 5$; *i.e.*, investment at the rate of ·5 per cent. of p.a. is needed to keep production stationary. It may be noted that a similar conclusion is implicit in the Cobb-Douglas function presented above. The time trend obtained in the equation was of the order ·989 which means that in the absence of net investment production would decline at the annual rate of 1·10 per cent.

[45] G. Tintner, in "An Application of the Variate Difference Method to Multiple Regression", *op. cit.*, derives a Cobb-Douglas function for United States agricuture of the form:—

$$\log P = 2.773 \log E + .902 \log I + .0087T - .264$$

According to this the marginal productivity of capital in United States agriculture would be almost identical with the one here derived for Australia by a widely different method. Tintner's regression, however, implies that the marginal productivity of labour is three times that of capital. Though this conclusion appears to be accepted by Colin Clark, *op. cit.* p. 210, it is here regarded as too inconsistent with Schultz' finding, *op. cit.*, to carry conviction.

Statistical correlations, no matter how successfully they stand up to the various tests of significance, do not warrant functional dependence. The general nature of the function and the particular independent variables represented must more or less be assumed at the outset. Some scope exists for rejecting variables or functions which do not appear to perform satisfactorily and recourse was had to this procedure, as will be recalled, at various stages of the present enquiry. But there is no way of demonstrating (and in fact, no reason for supposing) that other and more complex models will not give a truer picture of the forces that determine production.

Thus our result is not entirely inconsistent with the hypothesis that agricultural investment does, in fact, yield steeply diminishing returns, but that during the periods investigated this tendency was more than compensated for by the steady growth of external economies or by the beneficial effect of "inventions" in a broad sense of this term. These may have taken the form of improved cultural methods, new advances in pest control, new and more efficient types (rather than larger quantities) of farm machinery, changes in tenure leading to farms more closely approaching the optimum size, etc.

Some light might have been shed on the importance of these influences had it been possible to add an exponential time trend as a second independent variable to the linear regression shown above, in the same way as was done for the Cobb-Douglas function; but it is not possible to determine such a trend (in combination with linear data) by the method of least squares.[46]

In conclusion attention may be directed to an inference that becomes apparent when production and investment over the period are related to relative price movement. Figure 5 shows the time series of annual investment and production changes in conjunction with an index of relative agricultural prices.

The conclusion seems also completely at variance with evidence from Cobb-Douglas functions which have been fitted to two samples of Iowa farms which show a coefficient for labour of .24 and .26 respectively, i.e., a value of less than 10 per cent. of the one quoted by Tintner.

For the two studies referred to see: Tintner and Brownlee "Production Functions from Farm Records", *Journal of Farm Economics*, Volume XXVI, No. 3, (August, 1944) and G. Tintner "A Note on the Derivation of Production Functions from Farm Records", *Econometrica*, Volume 12 (January, 1944). Both these studies use the cross-section approach which, as was noted above, is open to certain objections.

For a production function yielding very high values for coefficients of both labour and capital see D. Gale Johnson, "Contribution of Price Policy to the Income and Resource Problem in Agriculture", *op cit.* Though adequate quantitative data are not available, many valuable qualitative and analytical studies of the problem have appeared during recent years, see esp. T. W. Schultz, *Production and Welfare in Agriculture* (New York; Macmillan, 1950) also Pei-kang Chang, *Agriculture and Industralization* (Cambridge, Mass.; Harvard University Press, 1949).

[46] A linear time trend was fitted to these data but yielded no statistically significant results.

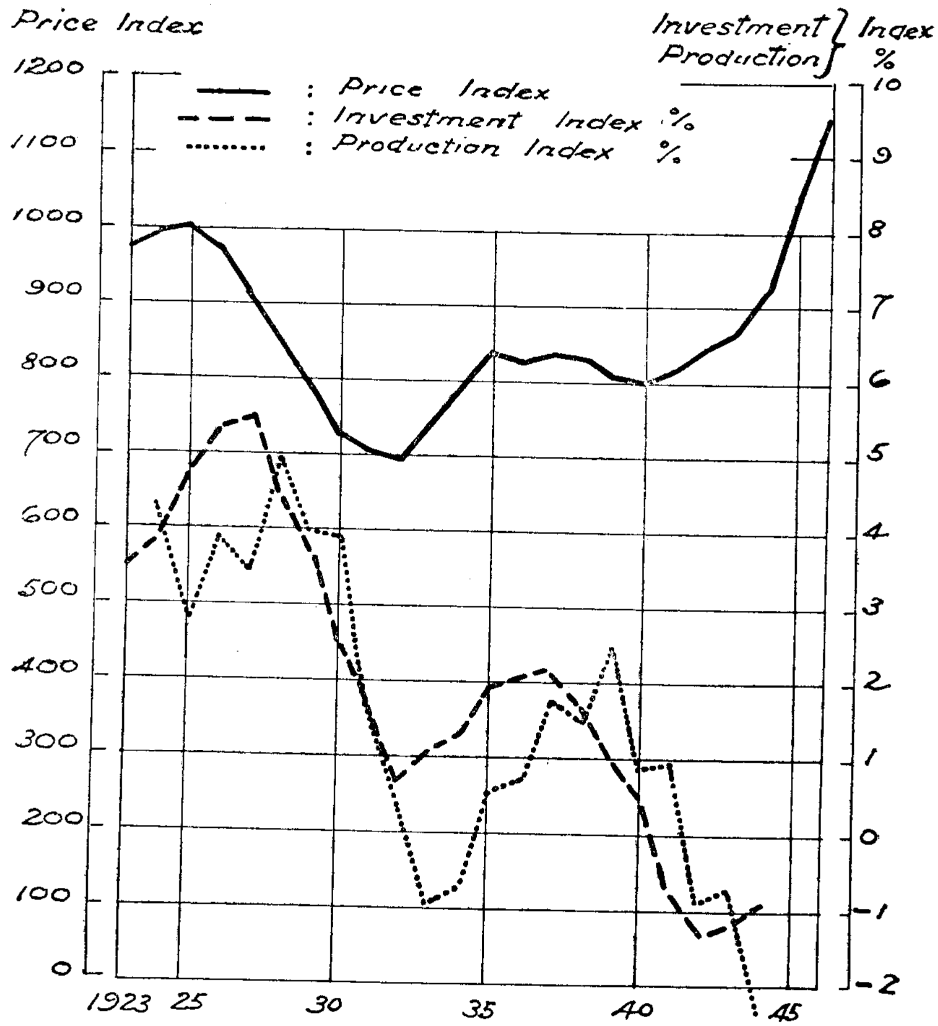

Fig. 5.—Variations in Farm Prices, Investment and Production.

This index of prices is based on the series of farm prices published by the Commonwealth Statistician which, for the present purpose, was deflated by the Statistician's C-Series Index. The C-Series was used as the best available measure of fluctuations in the value of money; the resulting index shows the movement of farm prices relatively to the general price level and gives a rough indication of the varying levels of profitability of agricultural production as against non-agricultural.

A cyclical movement is quite clearly discernable in each of the three indexes. Starting from high levels, *prices* declined steeply during the late 1920's and remained at a low level before rising again during the mid-1930's. This decline in relative prices was followed, with a lag of two seasons or so, by a decline in investment which dropped from a record level of almost 6 per cent. in the 1920's to somewhat less than 1 per cent. in the early 1930's.

After a period of recovery during the mid-1930's, prices again weakened and *investment,* which had reached a level of 2 per cent., declined, passing the zero mark early in the war and continuing below zero for a period of several years. The decline in investment, due to the unattractive price relations was, no doubt, aggravated by the physical shortages of capital goods and materials during the war years and also by the manpower shortage, which made difficult the construction and even the maintenance of improvements, most of which have a high labour component.

A negative level of investment, such as seems to have prevailed during the war years, implies, of course, that instead of net investment taking place, Australian agriculture was consuming its capital during the period. Further evidence, in fact, suggests that this process was not reversed until about 1947.

During the late 1920's rural *production* expanded at a rapid rate. This rate declined during the early 1930's, and reached its low point a little later than did prices and investment and by the end of the depression the trend in rural production was pointing downwards. During the mid-1930's, production again expanded at an increasing rate, reaching a peak shortly before the war, when prices and investment were once more on the decline; and during the later war years production was still dropping off after a decided upturn had occurred in prices, and when investment, although still below zero, had passed its low-water mark.

A steeper fall in agricultural production might, perhaps, have been expected during the war years in the face of four or five years of continued disinvestment. Intensified labour efforts of farmers during those years may have partly offset the deterioration of capital assets, and technical progress (e.g., the considerable increase in tractor numbers) may have further assisted.

It has sometimes been suggested that the level of rural production in Australia is strongly influenced by non-economic factors and that remarkable increases can be produced at will (perhaps in response to Government exhortations) in times of economic crises.

In the very short run this may be true. But applied to a longer period this view conflicts with the trend reflected in these data. They show that both during the depression and during the war agricultural progress was severely checked. They suggest that production rises only after investment has risen, and declines when investment is falling off. This movement, of course, will be influenced in the short run by seasonal conditions and may be hastened by technical innovations, some of which may make investment on an exceptionally heavy scale profitable, while others may reduce the amount of investment needed to obtain a given increase in output.

Price incentives, as a rule, will after a lapse of time, show their effect through promoting increased investment and it is this which will lift production to a permanently higher level.

APPENDIX.

A Note on Capitalization Rates.

Let us consider the imposition of a rate on a property which yields a net return of £1,000 and at a current rate of capitalization (C) of 5 per cent. has an unimproved value (V) of £20,000. (To simplify matters it is assumed that no improvements exist.) If now a rate (T) is struck, at 2.4 pence in the pound (or 1 per cent.) annual net returns to the owner will be reduced by £200 to £800 and the capitalized value, i.e., (approximately) the market value of the land will fall to £16,000. But matters do not end here; for at this reduced capital value the amount of rate payable will be only £160 and in consequence the unimproved value in the second year after the rate has first been levied will rise slightly to £16,800 and will again be reduced slightly in the subsequent year. Theoretically, this process once set in motion would have to continue ad infinitum, with oscillations of ever-decreasing amplitude occurring around a target value, which is ever more closely approached but never quite reached.

In practice, no doubt, these fluctuations would cease after a number of years, land valuations not being sensitive to very small changes in returns. But where the rate changes frequently, it will call forth a pattern of continuous fluctuations in unimproved values the effects of which will not be easy to disentangle. The value (V^0) toward which the market price of land will at any time tend, will be given as can easily be shown by

$$V^0 = V \times \frac{C}{C + T}.$$

This follows because the annual revenue accruing to the owner after the imposition of the rate will be equal to the difference between his income before the tax was imposed and the amount of tax actually payable. Thus,

$$\frac{V^0 \times C}{100} = \frac{V \times C}{100} - \frac{V^0 \times T}{100}$$

and

$$\frac{V^0 (C + T)}{100} = \frac{V \times C}{100}$$

$$V^0 = V \times \frac{C}{C + T} \qquad \ldots\ldots\ldots\ldots (1)$$

Owing to changes in the rate and discounted expectations of future changes it may often not be possible to gauge with complete accuracy the actual value of the land (as previously defined) as against the market value where published valuations are based on the latter.

It is clear that where sufficient time is not allowed to intervene for the unimproved value to reach its equilibrium level as determined by equation (1) other formulae will apply. For example in the year subsequent to the one in which the tax has first been levied, the unimproved value will be lower than the final equilibrium level; it will be defined by the equation:

$$V^0_1 = V \times \frac{C - T}{C} \qquad \ldots\ldots\ldots (2)$$

The yield of the rate during the second year of its imposition will then be given by:

$$Y = \frac{T}{100} \times V \times \frac{C - T}{C} = \frac{V}{100} \times \frac{TC - T^2}{C}.$$

If, for any reason, it were intended to levy a rate such as to maximize the yield from it during the second year of its imposition, the rate would have to be struck at half the rate at which net returns are being capitalized. For the problem would be to make Y a maximum, *thus*

$$\frac{dy}{dT} = O$$

and

$$\frac{d\left(\frac{V}{100} \times \frac{TC - T^2}{C}\right)}{dT} = O \text{ and differentiating}$$

$$C - 2T = O$$

$$T = \frac{C}{2}.$$

In practice the maximum and minimum rates of assessment are as a rule fixed by statute and these may be regarded as setting the limits within which land values will move as a result of this type of impost.

It was noted when discussing progressive land taxes that these give an inducement to reduce the size of the holding below the economic optimum. The extent of this inducement may be briefly indicated.

To make sub-division worthwhile, the various parts of the fragmented holding must yield (combined) a net income after taxation no smaller than could have been obtained from the undivided estate. Calling this minimal yield Y_m and using symbols as previously defined and making use of the equation established above—

(1) $V^0 = \frac{V \times C}{C + T}$ it follows that V^0 is merely the capitalized value of Y_m. Thus,

(2) $Y_m = \frac{V^0 \times C}{100}$ and substituting—

(3) $Y_m = \frac{C^2 V}{100\,(C + T)}$. This may be written as—

(4) $\frac{V}{100} \times \frac{C^2}{C + T}$ and as $C > T$ it follows that Y_m is an increasing function of C; similarly, it follows that it must be a decreasing function of T. It may be expedient to look upon T in equation (4) not as a flat rate, but rather as the difference between the two rates before and after sub-division. In that case, Y_m becomes the difference in yield (before taxation) of the land before and after sub-division.

The inducement will then be the stronger, the higher the rate of tax and the lower the rate of capitalization of net returns.

Theoretical considerations clearly suggest that the annual cost of rates will ordinarily be capitalized and that the sum thereby obtained will operate as a deduction from unimproved value. This hypothesis was used as a basis for the recalculation of unimproved value figures for New South Wales and Queensland (see Table II), two States for which fairly full data for local rates levied are available. The formula employed for the purpose of this calculation was the one derived above, viz:

$$V^0 = V\frac{C - T}{C}$$

where V^0 is the unimproved land value which would prevail in the absence of local rating; V is the unimproved land value as actually recorded; C is the rate of capitalization of net returns and T is the percentage in the pound at which local rates are levied.

Computations on this basis, and on the assumption of a capitalization rate of 5 per cent., suggest that in the absence of changes in the level of local rates, unimproved values in New South Wales would have risen by more than 20 per cent. during the period from 1936 to 1947, as against a rise of only 10 per cent. as reflected in the published figures. In Queensland where the recorded increase during those years was only about 6 per cent., unimproved values would have risen by no less than 75 per cent., had rates remained constant over the period. This estimate assumes a capitalization of 5 per cent. for Queensland, which may be rather low in view of the highly variable conditions under which agriculture is carried on in many regions of the State. But even if a capitalization rate of 8 per cent. is assumed, the increase in unimproved values that would have occurred in the absence of changes in local rates is still found to be of the order of 30 per cent.

The complexity of the factors determining unimproved values makes it impossible to draw other than tentative inference from the data presented above. A fuller analysis making allowance for the effects of State and Commonwealth land taxation and other factors involved, will be necessary before more definite statements can be formulated; meanwhile, the facts, set out above, may be taken to corroborate the conclusion previously reached, that unimproved land values as recorded can give us little guidance in the quest after a measure of unimproved land regarded as a capital item for use in primary production.