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CAPITAL FORMATION : ITS IMPORTANCE AND DETERMINANTS

WILLIAM McD. HERR*

University of New England

Central to recent theories of economic growth are the two variables capital and technology. If we sampled the literature on this subject through time, we would find that the relative roles of these two variables have altered. Domar[1] dramatizes this shift by sketching a historical play which might be entitled, "Banishing Labour and Capital." The plot focuses on growth models and consists of three acts:

> "In the first, labour, supported by an invisible chorus of capital, land and technological progress, holds the stage; in the second, capital and labour exchange roles. Finally, in the third act now being performed, labour, capital (and sometimes land) and technological progress appear on the stage together . . . . . ."

A review of the script written by Australian farm economists indicates that the story unfolds much the same. In the early stages it has generally been recognized that the whole of the annual effort of labour is not devoted to current production but is used for development.

The key role played by capital in later stages of development is well illustrated by the work of Gutman.[2] His study pertaining to the period from 1921 to 1948 shows that net production changes were closely associated with variations in investment but bear little relation to changes in the size of the labour force.

More recent statements altered this setting to include technological advance. For example, Campbell virtually gave the plot away in an early statement describing technological advance "as the dominant factor in determining the direction and rate of growth of aggregate rural output."[3] However, recognition that new technology is often incorporated and brought into fruition through the process of capital formation has been

* The author wishes to acknowledge the helpful comments made on an earlier draft of this paper by W. F. Musgrave, R. A. Pearse, and E. J. Waring and financial assistance provided by the Rural Credits Fund, Reserve Bank of Australia.

[1] Domar, E. D., "On the Measurement of Technological Change," *Economic Journal*, December, 1961.

[2] Gutman, G. O., "Investment and Production in Australian Agriculture," *Review of Marketing and Agricultural Economics*, December 1955, p. 238.

[3] Campbell, K. O., "Current Agricultural Development and Its Implications as regards the Utilization of Resources," *Economic Record*, May, 1956, p. 128.

interpreted by Campbell[4] and Gruen[5] to mean that a continued flow of investment funds into agriculture is a necessary prerequisite to continued production expansion.

This cursory review indicates that the relative roles played by labour, capital and technology have changed through time. However, no decisive statement concerning which factor is largely responsible for growth and development has appeared. The purpose of the following section is to assess the relative roles of capital and technical advance in boosting agricultural productivity. We ask ourselves, especially in the light of certain recent American studies,[6] whether capital formation as an agent boosting farm productivity has been overstated. If technical change deserves top-billing it may be that emphasis on capital and credit problems is misplaced.

I. *The Relative Roles of Technical Change and Capital*

There are a variety of techniques from which to choose for measuring the importance of technological advance.[7] By far the most widely used technique employs indexes of total inputs and outputs. As presumably output must equal total inputs, the "unmeasured" inputs, usually residually obtained, are taken as an estimate of the influence of technical change. Looked at from this broad view the shift to a new production function is due to a variety of factors not rigorously defined which include: improvement in the quality of the work force, improved organization such as economies of size, better management talent, and improvement in technical coefficients. Mostly for want of a better name, the term technical change will be used in this paper to represent these diverse factors which cause the production function to shift.

Another method developed for apportioning the increase in labour productivity to capital and residually to other productivity factors (technical change) was developed by Solow.[8] While some methodological and theoretical questions have been raised concerning this model[9] it does provide a quite simple and direct way to approach the problem.

The Solow Model

The Solow method of estimating technical change can be most clearly seen by referring to Figure 1. Given only two factors of production,

[4] Campbell, K. O., "Some Reflections on Agricultural Investment", *Australian Journal of Agricultural Economics,* December 1958, p. 94.

[5] Gruen, F. H., "Capital Formation in Australian Agriculture", *Review of Marketing and Agricultural Economics,* March-June, 1957, p. 101-102.

[6] Among the studies ascribing a large portion of the rise in total productivity to technical advances are:

1. Solow, Robert, "Technical Change and the Aggregate Production Function," *Review of Economics and Statistics,* August 1956.
2. Lave, L. B., "Empirical Estimates of Technological Change in United States Agriculture, 1850-1958," *Journal of Farm Economics,* November 1962.
3. Kendrick, John, *Productivity Trends in the United States,* N.B.E.R., Princeton University Press, 1961.

[7]. For a discussion and partial appraisal of four methods of estimating technical change see Domar, *op. cit.*

[8] Solow, *op. cit.*

[9] See for example Domar, *op. cit.* and Pasinette, L. L., "On Concepts and Measures of Changes in Productivity". *Review of Economics and Statistics,* August 1959.

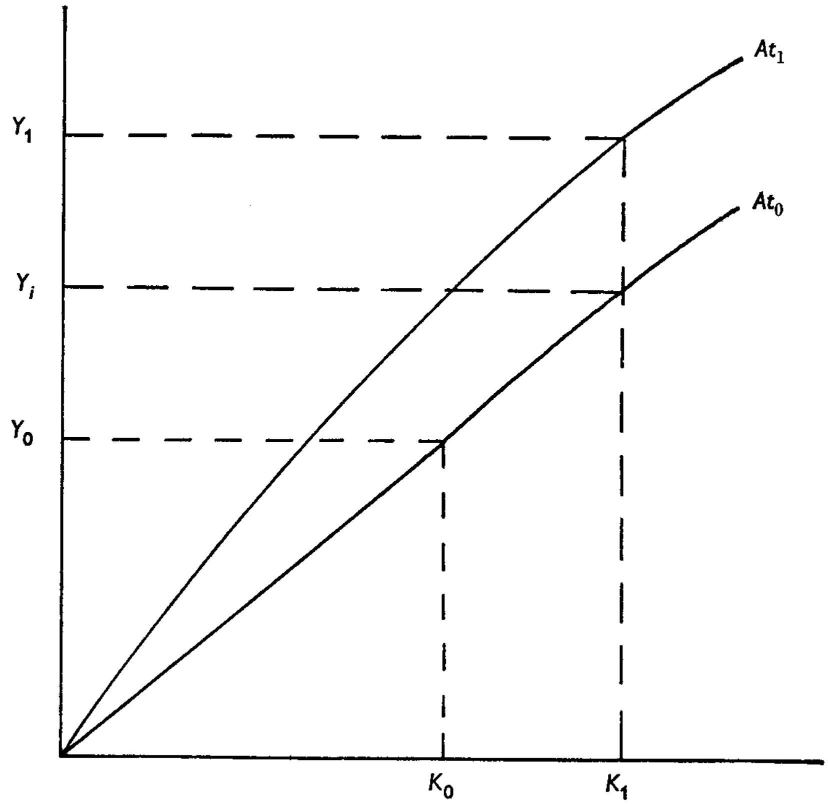

Figure 1

labour (L) and capital (K) with L fixed; a production function such as A in period t_0 is assumed. In t_1 the input of capital is observed to be K_1 and output is Y_1.

A relative shift from Y_0 on At_0 to Y_1 on At_1, $\left(\frac{Y_1 - Y_0}{Y_0}\right)$ is composed of two kinds of changes: (1) an increase in the production function measured at K_1 of $Y_1 - Y_i$ measured as $\left(\frac{\Delta A}{A}\right)$, and (2) an increase in output due to capital measured in terms of output as the difference between Y_i and Y_0, $\left(\frac{Y_i - Y_0}{Y_0}\right)$. Thus the total change in productivity can be written:—

(1) $$\frac{Y_1 - Y_0}{Y_0} = \frac{\Delta A}{A} + \frac{Y_i - Y_0}{Y_0}$$

The first term on the right is due to technical change and the second represents that due to greater capital intensity (ΔK). If an amount representing the additional product due to greater capital intensity $\left(\frac{Y_i - Y_0}{Y}\right)$ can be subtracted from $\left(\frac{Y_1 - Y_0}{Y_0}\right)$ then the remaining change due to technical improvement could be obtained.

A method for estimating $\left(\frac{Y_i - Y_0}{Y}\right)$ is to assume a production function of the Cobb-Douglas type such that constant elasticity exists for each factor. If it is further assumed that each factor is paid according to its marginal productivity then the share of output received by capital will represent capital's contribution to output. Knowing this share and the percentage change in capital use, an estimate of the increased portion of output attributed to the capital increment can be obtained. Thus, if wk is the share of total output received by capital then the portion of the percentage increase in total output $\left(\frac{\triangle Y}{Y}\right)$ which is due to greater capital intensity would be $wk\left(\frac{\triangle K}{K}\right)$.[10] Substituting into equation (1) we obtain:—

$$\frac{\triangle Y}{Y} = \frac{\triangle A}{A} + wk\ \frac{\triangle K}{K} \tag{2}$$

Given satisfactory data for output, labour, invested capital and an estimate of the share of income received by capital, equation (2) can readily be solved for $\frac{\triangle A}{A}$.

Of the information required, the share of income received by capital was the most difficult to identify. Various techniques were considered for estimating wk. One was to estimate labour earnings of the farm work force and subtract this from total income originating in agriculture to obtain capital's share. This method of estimation yielded lower estimates of wk than did other approaches. At the outset it was decided to use these conservative estimates of wk because they would play down the importance of capital and attribute more of the increase in productivity to technical factors. If this estimate of the relative role of technical change and capital shows the latter factor to be important in boosting agricultural productivity it will not be necessary to substitute higher, and perhaps more realistic, values for wk as that conclusion would only be strengthened.

Using the Solow model and the data in Table 1 of the Appendix, the index of technical change shown in Table I is obtained. Because of the assumption regarding wk this index can be viewed as a strong estimate of the role of technical change.[11] In passing it may be noted that this index is well below rates reported by Lave for the same period in the United States but it corresponds reasonably well with those for American agriculture prior to 1940.

The observed change in labour productivity is partitioned as being attributable to either greater capital intensity or to technical change in Table II. The results indicate that in the post-war period a substantial portion of the increase in labour productivity is attributed to greater capital intensity. On the other hand, in the earlier periods capital accounted for less than one-third of the gain in productivity. The small role played by capital in those years may be indicative of the adverse conditions existing for capital formation during the depression and war. At the same time it should be pointed out that if labour worked longer

[10] For a more complete explanation see Solow, *op. cit.* pp. 312-313.

[11] Saxon estimated that net productivity in Australian agriculture increased by 29 per cent between prewar and 1963. The above estimates for a somewhat shorter period indicate a 25 per cent increase between 1940 and 1960. See Saxon, E. A., "Productivity in Australian Rural Industries", *Quarterly Review of Agricultural Economics,* October 1963.

TABLE I

Index of Technological Change in Australian Agriculture Derived from the Solow Model, 1922-59

Year	Percent Change in:[a] Labour Productivity	Capital Labour Ratio	Share of Capital in Output wk[a]	$\frac{\Delta A}{A}$ from Solow Model per cent	Average Annual Change in $\frac{\Delta A}{A}$ (per cent)	Cumulative Technical Change Index 1922 = 100
1922–30	+26	+36	.245	+17	2.1	117
1930–40	+ 9	+10	.200	+ 7	.7	125
1940–47	+ 7	+ 6	.325	+ 5	.7	131
1947–55	+35	+55	.525	+ 6	.8	139
1955–59	+22	+17	.555	+12	3.0	156

a. See Table 2, Appendix.

and harder, such a change would show-up in the technical change index. A shift of the labour input to a man-hour index would minimize this effect.

Judged by this result which places technical change in a favourable light and minimizes the contribution of capital, past emphasis on facilitating capital formation in Australian agriculture does not seem misplaced.

TABLE II

Change in Labour Productivity in Australian Agriculture Attributed to Technical Change and Capital Intensity

Period	Index of Y/L at end of each period	Index of A at end of each period (a)	$Y/L \div A$ (b)	Change in Y/L due to: A (c)	K
	(beginning year of each period = 100)				
1922–30	126	117	108	+18	+ 8
Percent of Y/L attributed to:				69	31
1930–40	109	107	102	+ 7	+ 2
Percent of Y/L attributed to:				78	22
1940–47	107	105	102	+ 5	+ 2
Percent of Y/L attributed to:				71	29
1947–55	135	106	127	+ 8	+27
Percent of Y/L attributed to:				23	77
1955–59	122	112	109	+13	+ 9
Percent of Y/L attributed to:				59	41

(a) From Table I.
(b) $Y/L \div A$ = Increase in labour productivity due to change in capital intensity.
(c) This division assumes that the remaining increase in labour productivity after that due to change in capital intensity is accounted for is imputed to A.

Additional Implications

Whether our model has been able to disentangle technical change from investment depends largely upon the capital stock series. If it is purely a quantity index, which it is intended to be, then all of the changes due to quality and composition of capital are presumably reflected in the technological function along with other changes not embodied in capital. Thus, the capital formation component of the Solow model simply reflects the addition to productivity which would result from adding more investment capital of the variety which is already in existence.[12] The technical change component absorbs the remaining share of the increase in productivity.

Given these aspects of the two sources of increased productivity it is tempting to carry the analysis another step by asking this question:— Is technical change as measured by our derived function largely divorced from farm capital formation or does investment serve as a vehicle for the introduction of technical change?

One possible way to shed some light on this question is to correlate the capital series with the derived technological change function. The regression of A with K for six observations of A shown in Table I yields an R^2 of more than ·9 indicating that over the period investment has been associated with a substantial portion of the technical progress and hence it likely represents an important agent for the introduction of new techniques. It is interesting to note that a similar regression for six observations from 1900 to 1950 for U.S. agriculture using data estimated by Lave yielded an R^2 of ·56.[13] The weaker association of A with K in the United States than in Australia may reflect differences in the type of agriculture, changes in structure, and the relative greater importance of current inputs in American than in Australian agriculture. In any event this additional comparison strengthens the position that capital formation is a prime ingredient of Australian agricultural development.

While the Solow model has some methodological problems and the basic data are subject to questions, fairly substantial changes in the data are believed to be required in order to alter the conclusions. In the light of this finding the next step of examining the factors determining the rate of farm investment becomes more meaningful.

II. *Determinants of Farm Investment*

Studies pertaining to the formation of capital have attracted considerable interest yet relatively little is known about the factors explaining changes in the level of investment. Reflecting on this unsatisfactory state of affairs and on the nature of the farm investment process in Australian agriculture, Campbell proposed a residual funds hypothesis. This view is stated concisely as follows:

"the most plausible formulation would treat investment outlay as a residual,

[12] This aspect indicates an important reason why capital formation often accounts for a minor share of the increase in productivity. As Domar, *op. cit.* (p. 712) points out, "It is the kind of capital accumulation (wooden ploughs piled up on the top of existing wooden ploughs) that contributes so little to economic growth".

[13] Kendrick, *op. cit.* page 215, computed a similar correlation for the manufacturing sector of the United States economy covering the period 1899-1953 and found the association between A and K to be even weaker (36 per cent)

defined as the net income realized from current operations less tax commitments and some conventional allowance for farm family living expenses."[14]

Despite a few voices to the contrary,[15] this type of explanation for changing levels of investment has at times been virtually treated as reality. Widespread acceptance of the explanation, no doubt, reflects its simplicity, its intuitive appeal, and empirical evidence giving credence to the view.[16] Because of its widespread acceptance, implied or otherwise, the residual funds hypothesis is taken as our point of departure for discussing the determinants of investment.

Residual Funds Re-examined

An important question that needs to be answered in any examination of the residual funds hypothesis is the direction of causation expressed by the identity $I = Yd - C$. While it will be argued that the direction of causation runs from income to investment, an argument could be made for the reverse view. Nevertheless, the direction of causation is generally implied by the twin assumption that (1) there exist investment opportunities, and (2) the speed at which investment opportunities are seized depends on internal liquidity. This latter assumption supports the widely held view that capital rationing is common.

Another aspect of the residual funds hypothesis requiring elucidation is the length of the decision-making period to which it applies. That is, in the long-run income must be the source of all investment and consumption outlays. However, when interest focuses on the short-run or on a single year, changes in liquid assets as well as outside funds may be important. This distinction does not alter the main thesis of the residual funds hypothesis, namely that internal liquidity is the determining factor, but it shifts emphasis from spending out of income in the long-run to spending out of balances for short-run decisions.

In this connection it is worth noting that if liquid asset holdings of farmers were known they would undoubtedly exceed net farm income and would exceed annual investment totals several times over. Moreover, data from a limited sample of properties in the north-central part of New South Wales indicate that while internal funds available for personal outlays and investment are dominated by net cash proceeds, changes in liquid assets accounted for as much as one-third of available funds in some years. In this study liquid assets were defined as stocks of feed and materials, livestock inventories, as well as cash and securities.

At first blush, the inclusion of livestock inventories may seem to stretch the definition of liquid assets. However, they were included in the belief that many farmers do not adhere rigidly to any stocking level. Rather, livestock inventories partly fluctuate in response to earnings on alternative uses of funds.

These comments point to a modification in the residual funds hypothesis. In the long-run expression 1 below is likely to be appropriate

[14] Campbell, K. O., "Some Reflections on Agricultural Investment," *Australian Journal of Agricultural Economics,* December 1958, p. 6.

[15] Eisner, Robert, "Investment: Fact and Fancy," *American Economic Review,* May 1963, pp. 237-247 and Kuh, E., "Theory and Institutions in the Study of Investment Behaviour," *Ibid.* pp. 260-268.

[16] See for example, Meyer, J. R. and Kuh, E., *The Investment Decision,* (Cambridge: Harvard Press, 1957).

whereas a relationship such as expressed by 2 is more appropriate in the short-run.

(1) $I = f\ (Yd, C)$

(2) $I = f\ (Yd, C, A_L, D)$ where A_L is liquid assets and D is outstanding debt.

Recognizing these underlying assumptions and modifications, two aspects of the residual funds hypothesis can be tested empirically. First, if the residual funds hypothesis holds then investment functions between time periods, areas and farms should be the same. More specifically, given that internal liquidity determines how rapidly investment opportunities available to the firm are undertaken, it would be expected that a given change in residual funds would result in the same change in investment in different periods, areas, and on different farms. On the other hand, if investment functions differ significantly between periods, areas, and farms, it may be presumed that other factors such as risk, uncertainty and expected returns also play an integral part in investment decisions. A second aspect of the modified residual funds thesis which can be tested empirically is to determine whether the distinction between the short and long-run form of the hypothesis is meaningful.

Some Empirical Results

Data to test these aspects of the residual funds hypothesis require information from both the income statement and the balance sheet. Moreover, data should be avaliable through time so that both long run and time series relationships can be examined. The principal source of information was the B.A.E. sheep survey[17] pertaining to farms in three areas of N.S.W. and for nine consecutive years. While information on investment,[18] income, and interest paid may be regarded as reasonably representative, data for personal outlays and liquid assets are not available from this source.

Despite the limited nature of the information, it was used to throw some light on the long-run version of the hypothesis. Cross section analysis which employs aggregated annual data for each farm can be considered as yielding a long-run investment function from which the effect of changes in liquid assets and debts progressively diminish as the number of years included in each farm observation increases. Moreover, as we are dealing with "lumpy" expenditures and seeking an explanation of long-run behaviour this may be a very appropriate procedure. While the average ratio of personal expenditure (including taxes) to net farm income is not known for each farm, it seems reasonable to presume that it is close to being the same on each farm or the ratio is correlated with the level of net farm income. If either of those situations holds, net income and residual funds will be correlated and hence the long-run form of the hypothesis can be stated by the simple relationship:

(3) $I = f(Y_n)$, where Y_n = net cash income.

[17] The author wishes to express his appreciation for the co-operation received from the Wool Section of the Bureau of Agricultural Economics in making data available.

[18] Gross new investment is defined as the cash expenditure for the purchase of farm assets (both replacement and additions) but excludes land purchases.

Using aggregated data in a cross-sectional analysis of the above form, two propositions were tested: Are investment functions between the relatively prosperous years 1953 through 1957 (Period I) significantly different from the more depressed period 1958-61 (Period II), and are investment functions between areas significantly different from one another?

TABLE III

Summary of Area Regressions by Time Period and Results of Tests for Significance of Difference Between Period Regressions by Areas in Northern New South Wales, 1953-61

	Number of Observations	Value of Constants in Logs A	B	Adjusted Means (in logs)	Correlation Coefficient
Pastoral Area					
Period I	13	2.573	.245	3.668	.30
Period II	13	1.024	.616	3.779	.76†
Significance of Differences		N.S.D.	N.S.D.	N.S.D.	
Wheat-Sheep Area					
Period I	20	.269	.786	3.154	.84†
Period II	20	.463	.754	3.518	.84†
Significance of Differences		N.S.D.	N.S.D.	N.S.D.	
High Rainfall Area					
Period I	13	−2.100	1.335	3.267	.63*
Period II	13	−1.448	1.177	3.282	.72†
Significance of Differences		N.S.D.	N.S.D.	N.S.D.	

N.S.D. = no significant difference
* = significant at 5% level of probability
† = significant at 1% level of probability

The analysis of covariance for differences between time period regression constants and adjusted means within areas shows no significant differences between any of the three values, Table III. The opinion has sometimes been voiced that favourable earnings in the early fifties were retained and invested in later years when income levels were less favourable. If this feature was important it would be expected that the constant would be high and the regression coefficient lower in the second period than in the earlier one. While this tendency is observed in the wheat-sheep and high rainfall areas the differences as judged by statistical criteria are not significant. In the pastoral area the opposite tendency is observed but this is associated with poor correlation in the Period I regression. On the strength of these results the bald formulation of the residual funds hypothesis would appear to hold and period regressions could be pooled to obtain a single regression for each area. These pooled regressions are shown in Table IV.

The same covariance procedure for testing for differences between area regressions yields results which lead to the conclusion that area investment functions are different. Moreover, these differences in behavioural patterns are of a nature that reflect widely held views of differences in risk and uncertainty existing in each of the areas. That is, the results provide a case for believing that as we move from west to east a given percentage change in income boosts investment relatively more. This may be due to the fact that more of any favourable income can be invested in the eastern areas than in the pastoral zone because of the general expectation that next year will not depart very far from the norm. In contrast, farmer behaviour west of the high rainfall zone may be such that a larger portion of any favourable income is retained as a contingency reserve, used for investment in later years, or is used to reduce debt.

TABLE IV

Summary of Area Regressions and Results of Tests for Significance of Differences Between Area Regressions

Area	Number of Observations	Value of Constants in Logs *A*	*B*	Adjusted Mean (logs)	Correlation Coefficients
I. Pastoral Area	26	1.543	.479	3.5378	.59†
II. Wheat-Sheep	40	.391	.764	3.5730	.77†
III. High Rainfall	26	−1.623	1.221	3.4604	.69†
Test of Differences:	Area I with II $t = .86$ Area II with III $t = 1.66$ Area I with III $t = 2.35$*		$F = 3.20$*	$F = 5.10$†	

* = significant at 5% level of probability
† = significant at 1% level of probability

An alternative explanation for the differences in area regressions is that relatively more profitable investment opportunities exist in the pastoral areas than the high rainfall area.[19] This may be reflected in the area regressions by the fact that the constant is high and the regression coefficient low in the western area while the reverse is true as one moves east. A high value of the constant (and a low regression coefficient) can be interpreted as indicating that investment continues at a high level, relatively to other areas, regardless of income.

These two empirical results present conflicting evidence. In two of the three areas, period regressions behave in a way which suggests that economic conditions may affect farmer investment decisions. However, these differences are not significant as judged by usual statistical criteria and hence based on this evidence the residual funds hypothesis is acceptable. Perhaps more to the point, however, is the finding that

[19] This explanation is supported by the findings of Duloy, J. H. See his Ph.D. dissertation entitled: "The Allocation of Resources in the Australian Sheep Industry," University of Sydney, 1963.

residual funds regressions for areas are significantly different from one another. This leads to the view that other factors associated with area differences must be introduced into investment functions. Before examining the implications of this last statement we will look briefly at the short-run form of the residual funds hypothesis.

Short-Run Empirical Results

As argued in an earlier section, the short-run version of the residual funds hypothesis needs to consider the additional variables, liquid assets and debts. While the absence of data for personal outlays and liquid assets prohibits a definitive test of this form of the hypothesis, it may be possible to provide some indication of its worth. For example, if it is argued that C is related to the permanent component of income, C could be presumed to be a function of some past level of income. This line of reasoning suggests that the change in income from some previous level could be used in place of Yd and C without affecting the model much. Having shifted income to a change variable it was also decided to cast the other variables in the same form, hence (2) becomes:—

$$(4) \quad \triangle I = f\,(\triangle Y,\ \triangle A_L,\ \triangle D)$$

However, in this equation $\triangle Y$ and $\triangle A_L$ are likely to be correlated. That is, the immediate impact of an increase in income is an increase in liquid assets and vice-versa. In fact, examination of the change in cash farm income and change in bank deposits of the agricultural sector yields correlation coefficient of 0·81 for the six years between 1957 and 1963. Thus on both intuitive and empirical grounds the variable, $\triangle A_L$, might be omitted which leaves a short-run function of the following type:—

$$(5) \quad \triangle I = f\,(\triangle Y,\ \triangle D)$$

Empirical results for this short-run version of the residual funds hypothesis are shown in Table V. The results leave much to be desired but are largely consistent with previous area regressions.

TABLE V

Time Series Investment Regressions for Three Areas of Northern New South Wales, 1953-1961

Area	Constant "A"	Regression Coefficients D	Regression Coefficients Y	Correlation Coefficients
I Pastoral	1.696	−2.885*	.0799*	.88*
II Wheat-Sheep	−1.546	− .865	−.1880	.61
III High Rainfall	−4.502	− .023	.4073*	.84*

* = significant at 5% level.

The sign representing the change in debt is the same in all three areas though only significant in Area I. The negative coefficient suggests that high debt levels retard investment but more than this they reflect the dual use of internal liquidity, namely for investment and to reduce debt. The significant negative coefficient in Area I for debt lends credence to the view expressed earlier that in the more highly variable income areas, increases in income may be used to reduce debts as well as for boosting investment. This pattern of action in turn yields an investment function which is less responsive to income change than in more stable areas.

The negative coefficient for income in Area II appears to be related to the expansion of crop production in the early fifties. Crop acreage on these farms remained virtually the same between 1953 and 1961 while new investment in plant and equipment generally reached a peak in the early years. It appears that as a group these farms tooled up for high crop production in the early and mid-fifties and in the following years curtailed investment to replacement needs. If this explanation is correct, and it needs further exploration, it suggests that for some amount of investment an acceleration model may be more appropriate than a residual funds hypothesis.

These time series results, based on incomplete data, are perhaps strong enough to indicate that the short-run form of the residual funds hypothesis offers some promise for explaining investment behaviour. A more adequate test requires better quality data.

III. *Summary And Implications*

The view has widely been held that capital formation plays an important role in the development of Australian agriculture. Because of the increasing role ascribed to technical factors as the major force in economic growth and development, it was believed that this view should be examined. An appraisal of this impression indicated that capital formation accounted for a substantial amount of growth in farm productivity. Furthermore, some evidence was presented to show that capital formation serves as a vehicle for the introduction of technical change. These results are interpreted as meaning that capital problems of agriculture deserve our careful and continuous attention.

Given that further capital formation will continue to be an important factor in determining the productivity of Australian agriculture, an understanding of farmer's investment behaviour is required. Some time ago, Professor Campbell proposed a residual funds hypothesis. This hypothesis was submitted in part because profit maximization theories of investment even when flavoured with uncertainty, risk and managerial concepts did not seem to provide a useful guide to entrepreneurial action.

A cursory examination of this hypothesis indicates that certain refinements and modifications are needed if it is to explain short and long-run investment behaviour. But even more important this examination indicates that even with these refinements there are significant differences in investment behaviour between areas and farms which are not explained by the residual funds hypothesis. My interpretation of these results is that if the explanatory power of this hypothesis is to increase we will need to re-introduce into investment functions profit maximization principles interlaced with a generous dose of risk and uncertainty.

Finally, we must not lose sight of the underlying assumption of the residual funds hypothesis. That is, internal funds are regarded as an important determinant of the rate of increase of a firm's capital stock towards some desired level. Accordingly, external financing, risk, uncertainty as well as any capricious desires of management are not explicitly introduced. It is suggested that the explanatory power of the model would all but disappear if we could measure and account for such factors. That is, if we could properly account for risk and uncertainty and the failure to employ outside funds then these, reflected in equity ratios and income variability would become the main determinants of investment and not internal funds. This suggests that while the foregoing empirical results are of some interest we are only mounting a foothill while the main peak remains to be scaled.

APPENDIX TABLE 1

Indexes of Net Production, Employment and Capital Investment in Rural Industries, Australia, 1921-61

Year ending June	Net Production[1] (*Y*) (1937–39 =100)	Farm Labour Force[2] (*L*)	Capital Investment[3] (*K*)
1921	65	87	61
22	65	88	62
23	63	89	63
24	75	90	66
25	73	91	70
26	82	92	72
27	75	93	75
28	82	94	80
29	80	95	85
1930	94	96	91
31	97	97	91
32	101	97	91
33	95	98	91
34	96	99	93
35	91	100	94
36	91	100	96
37	99	100	98
38	94	101	100
39	108	100	103
1940	91	100	104
41	104	96	104
42	109	90	103
43	109	82	101
44	96	82	100
45	102	86	98
46	91	88	98
47	100	89	98
48	96	89	N.A.
49	106	89	N.A.
1950	118	86	N.A.
51	115	85	N.A.
52	108	84	N.A.
53	125	87	N.A.
54	122	87	N.A.
55	126	86	147
56	128	85	N.A.
57	134	85	N.A.
58	124	84	N.A.
59	146	83	N.A.
1960	146	82	164
61	147	81	N.A.

[1] 1921–48 estimates by G. O. Gutman *op. cit.* shifted to 1937–39 base. 1949–61 estimated by deflating Census estimates of gross output and inputs to derive deflated net production.

[2] 1921–48 estimates by G. O. Gutman *op. cit.* shifted to 1937–39 base. 1949–61 estimated from Census data.

[3] 1921–48 estimates by G. O. Gutman *op. cit.* shifted to 1937–39 base. 1955 by J. P. O'Hagan *op. cit.* and 1960 estimated by the author.

APPENDIX TABLE 2

Production and Input Ratios Employed in the Solow Model

Year	Net Production (Y) 3-year Average	Y/L	K/L	Share of Capital in Income Originating wk.[1]
1922	65	73	70	.25
1930	90	93	95	.24
1940	101	101	104	.16
1947	96	108	110	.49
1955	125	146	171	.56
1960	146	178	200	.55

[1] It was assumed that the agricultural work force received the basic wage. The remainder was assumed to represent capital's share of income. In the postwar period this assumption results in a return to capital of 5–7 percent. As estimates of technological change were obtained for time spans representing a number of production periods, a simple average of wk for the beginning and ending year was employed.