AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

FOR AID USE ONLY

1. SUBJECT CLASSIFICATION

A. PRIMARY
Agriculture — AE10-0000-0000

B. SECONDARY
Agricultural economics

2. TITLE AND SUBTITLE
The use of the capital-output ratio in planning agricultural sector investment

3. AUTHOR(S)
Warner,P.D.

4. DOCUMENT DATE	5. NUMBER OF PAGES	6. ARC NUMBER
1967	67p.	ARC 332.71.037b

7. REFERENCE ORGANIZATION NAME AND ADDRESS
Ohio State

8. SUPPLEMENTARY NOTES *(Sponsoring Organization, Publishers, Availability)*
(Thesis M.S.--Ohio State)

9. ABSTRACT

10. CONTROL NUMBER	11. PRICE OF DOCUMENT
PN-RAA-495	
12. DESCRIPTORS	**13. PROJECT NUMBER**
Capacity Capital Investments	**14. CONTRACT NUMBER** CSD-463 Res.
	15. TYPE OF DOCUMENT

AID 590-1 (4-74)

THE USE OF THE CAPITAL-OUTPUT RATIO IN PLANNING AGRICULTURAL SECTOR INVESTMENT

A THESIS

Presented in Partial Fulfillment of the Requirements
for the Degree Master of Science

by

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The Ohio State University
1967

Approved by

Adviser
Department of
Agricultural Economics
and Rural Sociology

ACKNOWLEDGMENTS

The writer wishes to express his sincere gratitude to many persons who have contributed to this study and especially:

To Dr. Raymond A. Bailey, who, as my adviser, gave encouragement, assistance, and guidance;

To Dr. Ted L. Jones and Dr. Norman Rask for their timely counsel and helpful suggestions;

To Herbert J. Roth and S. Thomas Stickley, the writer is grateful for their time and effort spent in help with manipulating the Ecuadorian data;

To John Stitzlein, who, as a fellow graduate student, gave much needed critical and constructive advice of the entire study;

To Mrs. Jeanette White for her typing and editorial assistance; and

To my wife, Ruth, for her faith, assistance, sacrifices, and encouragement which contributed greatly toward making this study a reality.

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CHAPTER I

INTRODUCTION

Economic development refers to ". . . a continuing social process leading to a progressive increase in average output per head among the people in a society."[1] A per capita measure is used because for an increase in output per person to occur, it is necessar for total output to increase faster than population. Belshaw's definition refers to a process because economic development is continuous over time and is not a single improvement. It is social becau there is not only an increase in physical output, but also changes the technical and institutional arrangements of the economic structure of an economy.

Agriculture is an important sector in the development process because in the early stages of development, 60 to 80 per cent of th population is engaged in agriculture and 50 per cent or more of national income is generated in the agricultural sector.[2] Since the majority of the resources of a country lie in the agricultural

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[1]Horace Belshaw, Agricultural Credit in Economically Underdeveloped Countries (Rome: FAO Publication, 1959), p. 5.

[2]John W. Mellor, The Economics of Agricultural Development (Ithaca, New York: Cornell University Press, 1966), pp. 3-17.

sector, the contribution of agriculture toward development is of utmost importance in determining the rate of development of the entire economy.

Inasmuch as increased output is the basic goal of economic development, it is appropriate to state the determinants of the level of output. It is commonly accepted that output is a function of certain input variables.[3] Disagreement begins when an attempt is made to specify these variables. The most common variables considered are labor, capital, natural resources, and technology.

"In the view of many economists, capital occupies the central position in the theory of economic development."[4] Kindleberger quotes many economists who state that capital occupies the "key" role in the development process, but he quotes equally as many who question the importance of capital as a "key" factor in development. It would be deceiving to single out capital and conclude that economic development is the result of only this one variable. Nevertheless the importance of the role of capital in making possible higher productivity and higher incomes per person should not be disregarded. Capital is not only central to the process of development, but it is also a strategic factor in the economic development of an economy.

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[3]For example, see Paul A. Samuelson, Economics, An Introductory Analysis (New York: McGraw-Hill Book Co., 4th Edition, 1958), pp. 501-521; John A. Schumpeter, The Theory of Economic Development (New York: Oxford University Press, 1961), pp. 3-56; and Milton M. Snodgrass and Luther T. Wallace, Agriculture, Economics, and Growth (New York: Appleton-Century-Crofts, 1964), pp. 15-19.

[4]Charles P. Kindleberger, Economic Development (New York: Mc-

It is inherent in the definition of underdeveloped countries that the level of capital use is low when compared with developed countries. Due to the relative scarcity of capital, producers look to credit as a method of obtaining additional capital. Any reference to capital in the remainder of the paper is meant to imply capital made available through the use of credit. Credit is the " . . . ability to command the capital of another in return for a promise to pay at some specific time in the future."[5]

As Hirschman pointed out, "We can now begin to consider one of the most crucial problems in development theory and policy: that of investment choices."[6] The scarce resource capital, in the form of credit must be optimally allocated.

The supply of and demand for credit in agriculture and other sectors of the economy are basic considerations for the development planner. The problem is: given a limited amount of investment resources and various investment alternatives whose total cost exceeds the available resources, how are the best alternatives selected that will make the greatest contribution relative to their cost?[7]

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[5]William G. Murray and Aaron G. Nelson, Agricultural Finance (Ames, Iowa: The Iowa State University Press, 4th Edition, 1960), p. 36.

[6]Albert O. Hirschman, The Strategy of Economic Development (New Haven: Yale University Press, 1959), p. 76.

[7]Ibid.

This basic problem can be stated as an investment decision at three different levels of the economy:

1. At the national level (the total amount of investment to be made out of the current income, or more simply, the per cent of gross national product devoted to gross investment).

2. At the sector level (the distribution of this gross investment among the major sectors of the economy).

3. At the unit level (the distribution of the investment of the sector under consideration among the individual firms that make up the sector).

This study is especially concerned with the agricultural sector of the economy; therefore, most of the consideration will be limited to the second investment decision (at the sector level). Planners must make judgments as to how much additional investment credit is required to obtain a target rate of growth for the agricultural sector. These practical needs of planners have led to the development of investment criteria. The relationship between capital and output is one such criterion that provides planners with a tool which enables them to make decisions as to the investment required to attain a certain rate of growth.

Objectives

The general objective of this study is to develop a technique

level of investment credit necessary to obtain a desired rate of growth in output for the agricultural sector. The more specific objectives are as follows:

1. To further develop and to refine the use of the capital-output relationship for the agricultural sector.

2. To develop methods for treating other variables as modifications of the above capital-output relationship for the agricultural sector.

3. To illustrate the application of the refined capital-output relationship, above, through use of sample data for the agricultural sector of Ecuador.

Procedure

As the first step (Chapter II), through the review of literature on the subject, the role of the capital-output relationship in growth models as currently conceived, is established.

As the second step, reported in Chapter III, the basic capital-output ratio is refined through consideration of various forms of the ratio, their applications, and identification of problems involved in their measurement and use.

The third step, Chapter IV, consists of adjustment of the capital-output ratio for selected primary variables other than capital and output.

As the final step (Chapter V), following refinement and adjustment of the ratio, the application of the ratio will be demonstrated by using data from Ecuador's agricultural sector.

CHAPTER II

THE RELATIONSHIP OF CAPITAL TO OUTPUT IN THE GROWTH MODEL

There has been increased emphasis on the importance of maintaining high growth rates in the economies of underdeveloped countries. Economic growth is intended to mean a physical increase in output,[1] and makes no attempt to evaluate other changes that might accompany this physical increase.

Since this discussion is limited to the interrelationships between capital and output, the primary concern is with growth, or as stated above, a physical increase in output. Even though the primary consideration is with economic growth, it is recognized that growth is a vital part of development and that development involves more than just an increase in physical output.

A Joint Economic Committee of Congress[2] has defined economic growth as "the expansion of a nation's capability to produce goods and services its people want." Recognizing that expansion of a

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[1]The distinction intended here between development and growth is that development includes also the technical and institutional arrangements by which the output is increased; whereas, growth considers only the physical change in output. (Op. cit., Kindleberger, p. 3).

[2]Joint Economic Committee, Congress of the United States, Staff Report on Employment, Growth, and Price Levels, Washington, 1960, p. 1.

nation's capacity to produce takes place over time, economists must be concerned with the nature and problems of the concept of economic growth. It must be recognized that developers are not working with societies that have fixed productive capacities; they are not static models. The theory of economic growth is an attempt to understand and to explain the process of growth. Economists are attempting to identify the determinants of increasing output potential and to analyze the effects of the change.

There have been numerous growth models developed over the past years. These models have been attempts to define variables that define the nature of the process of economic growth. Kindleberger states that the purpose of any economic model . . . "is to illustrate the causal relations among critical variables in the real world, stripped of irrelevant complexity, for the sake of obtaining a clearer understanding of how the economy operates, and in some formations, in order to manipulate it."[3]

Keynesian economics is interested in utilizing fully the labor and capital stock already available to achieve a full-employment equilibrium and spent little time exploring the concept of increasing output capacity through additonal investment.[4] Since that time,

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[3]Kindleberger, op. cit., p. 40.

[4]W. C. Peterson, Income, Employment and Economic Growth (New York: W. W. Norton and Co., 1962), pp. 472-75.

other economists have incorporated the concept of expanded output capacity into the Keynesian model. Harrod[5] and Domar[6] have probably contributed the most toward developing a post-Keynesian growth theory. Harrod and Domar basically agree upon the key role of investment in the growth process. They both emphasize that the size of the capital stock should bear some relationship to output. Polak[7] was the first economist to base policy on the criterion of the capital-output ratio, but the Harrod and Domar models are considered as the origin of the use of the capital-output ratio as a device for the comparison of the relationships between capital and output in a growth theory. Originally they were interested in the business cycle for developed countries, but the concept has been transferred to growth problems in underdeveloped areas.

Domar went beyond the Keynesian assumption of fixed productive capacity and examined the effect of an increase in the quantity of the stock of capital on output. The distinguishing characteristic of Domar's model is that net investment raises productive capacity and thus causes the economy to grow. He then examines the rate at which income must grow if full employment is to be maintained, assuming the

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[5] R. F. Harrod, Towards a Dynamic Economics (New York: Macmillan Book Co., 1949), pp. 63-100.

[6] Eusey D. Domar, Essays in the Theory of Economic Growth (London: Oxford University Press, 1957).

[7] J. J. Polak, "Balance of Payment of Countries Reconstructing with the Help of Foreign Loans," Quarterly Journal of Economics, LVII (February, 1943), pp. 208-40.

capacity-creating impact of net investment.[8] Domar uses the capital-output ratio, or capital coefficient, to represent the ratio of the capital stock of the economy to full production or output. Given an existing level of technology, there will be, on the average, a certain quantity of capital required to obtain a given quantity of output. It should be emphasized that capital is a stock measure, whereas output is a flow measure in Domar's model. The resulting capital-output ratio can then more specifically be called an average capital-output ratio. A further assumption of his model is that the capital-output ratio remains constant over time.[9]

Harrod's approach is basically the same as that of Domar's in his general assumptions. However, there is a major difference in how they view the investment process. Domar stresses the effect of today's net investment on tomorrow's productive potential. Harrod's analysis tends to look at the picture from the opposite side in that he is concerned with whether output has grown sufficiently to induce more investment. His viewpoint is one of a reaction in investment due to past changes in the income level.[10]

The concept that there is some relatively fixed relationship between output and the quantity of capital necessary for the production of that output is basic to both of the above growth models. But

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[8] Eusey D. Domar, "Expansion and Employment," The American Economic Review (March, 1947), pp. 34-55.

[9] Peterson, op. cit., pp. 475-503.

[10] Ibid.

their analyses do not stop with this relationship. They go on to conclude that based on this relationship between capital and output, there is also a relationship between the rate of change in the capita stock and the rate of change in output level. Domar, emphasizing the capacity-creating impact of investment, concludes that the change in output is a function of the rate of change in investment. Conversely Harrod concludes that, due to the accelerator, the change in investment is a function of a change in output. But rather than being overly concerned with which is a function of the other, it is more important that we recognize that a meaningful relationship does exist

In later years economists have used this same approach and have constructed what is called an incremental capital-output ratio. This ratio represents the relationship between changes in the capital stoc and changes in the output level as Harrod and Domar suggested in thei models. Since a change in the capital stock is the same thing as net investment, the incremental capital-output ratio tells us how much added capital or investment is needed to obtain an additional unit of output.

Since the time Harrod and Domar have presented their original theories of growth, there have been a number of reinterpretations of the basic Harrod-Domar model. An important concept that has been added to their model is the concept of a lag period. This idea recognizes the fact that investment in period t might not return all of its output in the same period that the investment took place, but rather that there might be some resulting output in period t + 1,

t + 2, etc., depending upon the length of the lag period. Or, if it is desirable to realize all of the increase in output in period t, then it may be necessary for the investment to be made in period t - 1, t - 2, etc.

More recently, Duesenberry[11] has used the concept of a lag period and has combined it with the principle that growth occurs when the capital-output ratio remains below the optimum ratio so as to induce sufficient investment to keep income growing faster than capital accumulates. He then comes up with two points where capital and income are equal, one being stable equilibrium and one being unstable equilibrium, as compared to the single point presented by Harrod.[12]

As suggested here, growth models are no new concept. But, constructing a model does not make it workable. The above models have made very important contributions toward a theoretical basis for growth. This initial step is necessary in order to point out some of the more important interrelationships in any process. However, after a few of the relationships are recognized, the more urgent task becomes one of reinterpreting the theory into a useable methodology. The basic capital-output ratio has been used as a planning tool since the relationship was first presented by such individuals as Harrod and Domar. Nevertheless, very little work has been done on improving the validity of the ratio by suggesting guidelines for its use.

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[11] J. S. Duesenberry, Business Cycles and Economic Growth (New York: McGraw-Hill Book Co., 1958).

[12] Gardner Ackley, Macroeconomic Theory (New York: The Macmillan Co., 1961), pp. 526-534.

CHAPTER III

FORMS AND MEASUREMENT OF THE BASIC CAPITAL-OUTPUT RATIO

As stated previously, in general, the level of potential output can be assumed to be a function of labor, capital, natural resources, and technology. It is recognized that there are other variables that should be considered, but for purposes of simplification only these four general classifications will be mentioned. Assuming that the other three variables except capital are held constant, it can then be said that output is a function of capital solely.

The simple relationship between capital and output can then be stated. Total output must equal the output per unit of capital times the amount of capital in use. Thus the formula:

$$(1) \quad \text{output} = \frac{(\text{output})}{(\text{capital})} \quad (\text{capital}) \text{ or}$$

$$(2) \quad \text{capital} = \frac{(\text{capital})}{(\text{output})} \quad (\text{output})$$

by definition.

The ratio of capital to output as stated in formula (2) will be referred to as the average capital-output ratio (ACOR). The reason the word "average" is included to identify this ratio is because the ratio represents the relationship between all capital stock invested

in the economy and the flow of output returned in any given period of time. The reciprocal of the ACOR is a measure of the average productivity of the entire capital stock.

The ACOR has been used loosely in the past as a criterion for the projection of the productivity of additional capital investment. However, this ratio is not an accurate measure of what the productivity of new capital will be, due to the change in other variables over time. A more justified and acceptable use of the ACOR is for the purpose of describing the present situation as to the relationship between capital stock and output for the economy; making no attempt to project this ratio as a planning technique.

When the analysis is extended and a growth rate is considered, one considers the change in output as a ratio to the present output. For example, if the present level of production is 100 units and production is increased to 105 units, the rate of growth in production is 5/100 or 5 per cent. Similarly, this can be stated in a formula by definition as:

$$(3)\quad \frac{\text{Increase in output}}{\text{output}} = \frac{(\text{increase in output})}{(\text{increase in capital})} \frac{(\text{increase in capital})}{(\quad \text{output} \quad)}$$

The formula is true not only for increases but also for decreases so more generally, it is stated as:

$$(4)\quad \text{Rate of growth} = \frac{(\text{change in output})}{(\text{change in capital})} \frac{(\text{change in capital})}{(\quad \text{output} \quad)}$$

The change in output as a ratio to the change in capital is recognized as the marginal productivity of capital; the reciprocal of which is the incremental capital-output ratio (ICOR). For example, if

$3 is invested in additional capital and results in a $1 increase in output, then it is said that the marginal productivity of capital is 1/3 and that the incremental capital-output ratio is 3/1 or 3.

Rearranging formula (3) and solving for the change in capital gives:

$$(5)\quad \text{Change in capital} = \frac{(\text{change in capital})}{(\text{change in output})} \quad (\text{change in output})$$

From this relationship it is then possible, given an incremental capital-output ratio and the increase in output desired, to determine the increase in capital or investment required.

For purposes of planning, the ICOR is desired rather than the ACOR. Planners are interested in how much output will increase from an additional amount of investment. As mentioned previously, it cannot be assumed that the ACOR and the ICOR are equal for a certain period unless all other variables are assumed to be constant or unless the resulting affect of changing factors remains the same. Such things as technological changes will alter both the ACOR and the ICOR, but especially the ICOR, because new developments make themselves felt primarily at the time when additions to the capital stock are being made. Furthermore, other variables can raise or lower the ratios by reducing or increasing the amount of capital required to obtain a unit of output.

Leibenstein has made an attempt to define the ICOR more precisely by handling the other variables differently.[1] A net incremental capital-output ratio (NICOR) is used to define the ICOR when all other variables are held constant. An adjusted incremental capital-output ratio (AICOR) then refers to the ratio if other variables are recognized and adjusted by some amount. The NICOR is constructed net of any changes in other variables; whereas, the AICOR is constructed for a given specific change in other factors.

In this study the author will first construct a NICOR. Then something approaching an AICOR will be constructed by adjusting the ratio for selected primary variables. Such factors as weather and price levels are completely unrelated to additions in investment, but they can cause great variations in the output level. Thus, it is necessary for the effects of such variables to be considered in any given situation.

There has been much criticism of the use of the ICOR due to changes in such variables as technology. It is contended that the ICOR is almost useless because of the fact that changes in output due to an accompanying increase in the level of technology are allocated entirely to the increase in capital. However, the author can see no real problem in handling this type of variable. If the use of the ratio is limited to the projection of the output associated with an

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[1] Harvey Leibenstein, Economic Backwardness and Economic Growth (New York: John Wiley and Sons, Inc., 1957), pp. 176-198.

increase in capital, it is not necessary to define the source of the increase in output. But rather, the interest is in the amount of output increase that can be expected to be related to the increase in capital, not that all of the increase is the result of only the variable, capital. As was mentioned earlier, the level of output can be considered to be determined by any one factor, but this does not say that the amount resulting from one factor is not influenced by the level of all of the other factors.

When an attempt is made to actually use the ICOR, some determination has to be made as to the best measures of incremental capital and output. There seem to be two choices as to the measure of capital. They are gross investment and net investment. Investment here refers to additions to the capital stock during some period of time. The difference between gross and net investment is the amount of depreciation and obsolescence or the amount of replacement capital that has to be injected every year. The primary difference that should be recognized here is that net investment makes a contribution toward a permanent increase in capacity, whereas replacement capital makes no contribution toward the expansion of net capacity. The replacement capital bears neither a technical nor a behavioral relationship to net capacity change. This consideration would have no practical significance if the ratio of replacement to net investment were constant over time. But this need not be the case. If changes occur in the amount of net or replacement investment or if the

lifetime of different investments change, there will be a change in the ratio of replacement to net investment.

Measures of output that should be considered are the value of farm product from gross investment, the value of farm product from gross investment minus the value of consumption, the value of farm product from net investment, and the value of farm product from net investment minus consumption. The differences in these four measures are return to either gross or net investment and the value of family consumption. The best measure of output, if a measure of net investment is possible, is the value of farm product from net investment. However, since depreciation or replacement investment is difficult to measure, and it is also difficult to measure only the output that is the result of net investment, the gross measure is accepted as being more accurate than net. When considering whether to use the value of farm product or the value of farm product minus consumption, the important consideration is whether it is possible to accurately evaluate family consumption. If it is felt this estimation can be made accurately, the value of farm product minus consumption would be a superior measure, but if this evaluation enters a significant degree of error, the value of farm product figure can be considered as the next most accurate measure. One of the reasons why the value of farm product data are readily used is because the value of production figure is relatively easy to collect and is usually more accurate. A subjective judgment enters into the value of family consumption figure.

All of the above evaluations are subject to the conditions of any particular situation. For example, if an area is one of basically subsistence agriculture with 75 per cent of the production being consumed and only 25 per cent being marketed, then it is unlikely that the value of farm product is a very accurate measure of output changes. Due to the large proportion that consumption is of total product, in this circumstance, it is necessary that family consumption be evaluated.

Another consideration of measurement that is essential, since these two variables are flow measures, is the time period of the flow. Due to crop cycles and existing standard measures, the appropriate time period for most situations is a one year interval.

An additional decision must be made as to whether time series data or cross sectional data should be used in calculating the ICOR. The time series approach is a set of observations of the same variable taken over a period of time; whereas, the cross sectional approach is one observation at a point in time. Because the ICOR is concerned with an incremental change, it is necessary to have data from at least two observations, at the beginning of the year and at the end of the year, otherwise it is not possible to determine the change over the one-year period of time.

A time series has the two main purposes of estimating trends and of predicting future courses of action.[2] The establishment of trends

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[2]Paul G. Hoel, Elementary Statistics (New York: John Wiley and Sons, Second Edition, 1966), pp. 278-305.

and a projection of these trends into the future as a predictive measure is exactly the intended use of the ICOR. It might, therefore, be concluded that a time series is the best measurement for constructing an ICOR.

A time series helps to cancel out fluctuations in unrelated variables in the specific period under consideration. By averaging figures over an extended period of time, the long-run trends become more stable and are less affected by short-run variations. Three to five year moving averages should "average out" much of the erratic yearly variation. A three year moving average can be calculated as follows:

$$(6) \quad ICOR = \frac{I_t + I_{t+1} + I_{t+2}}{O_{t+3} - O_t}$$

where I_t is investment in period t, and O_t is output in time period t.

It must be recognized that the desirable complete set of time series data is not always available. More often, research projects cover only cross-sectional data for a country, thus including only information for that particular year. With only observations at the beginning and end of any one year, the above formula simplifies into the following:

$$(7) \quad ICOR = \frac{I_t}{O_{t+1} - O_t}$$

Even though it is recognized that only two observations are inferior to a complete set of moving averages, it must also be recognized that a procedure must be developed which can be applied by utilizing the information that is available. In many cases this may be the only information that is available.

There are a number of conditions that apply to the circumstances under which the ICOR is to be used to assure that the ratio is valid. First, it must be assumed that capital is a scarce factor in the system or that other factors are abundant relative to capital. If capital is the predominant scarce element, then it should also reflect the majority of the cost differences. If all other variables are in excess compared with capital, it is assumed that there is no added cost in employing more of these variables as capital increases, or more simply, it is assumed that there is no opportunity cost in the application of other factors. Secondly, the market prices that determine the output level should reflect the social values of different products so as to be a valid aggregation of various products. Thirdly, it must be assumed that the cost structure in the period under consideration remains constant. In other words, the prices of factors of production relative to each other remain unchanged. And finally,[4] constant returns to scale must hold during the period under consideration.

Weaknesses appear in the use of the ICOR when any one of the above restrictive conditions are broken. If capital is not the

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[3]The first three conditions are presented by H. B. Chenery, "Comparative Advantage and Development Policy," American Economic Review, Vol. 51, No. 1 (March, 1961), pp. 18-51.

[4]The last condition is presented by V. W. Ruttan, "Agricultural and Non-agricultural Growth in Output per Unit of Input," Journal of Farm Economics, Vol. 39 (December, 1957), pp. 1566-1976.

limiting element as assumed above, any attempt to calculate the marginal productivity allocates all of the increase in output to the change in capital even though capital is not the predominant scarce element. Kahn[5] pointed out that the opportunity cost of other factors may not be equal to zero. For example, the movement of labor out of over-populated rural areas into industrial centers may develop an opportunity cost that is quite significant. If adequate market conditions are not available for either a particular enterprise or for a particular geographical area, the prices reflected will not be the social values of the products involved. If the price structure changes for factors of production during the period under consideration, the relative use of the factors changes also, consequently changing either the aggregate output level or the capital input required. Breaking the assumption of constant returns to scale in the period being considered makes it necessary to construct more than one ICOR for that period. To facilitate the use of one ratio for a period of time, it must be assumed both that the ratio is constant and that constant returns to scale occur during this period.

Another major shortcoming of the ICOR involves the time element. The ratio overemphasizes liquidity by only considering the rate at which new capital is converted into increased capacity. It fails to consider that a project that maximizes output in the short-run, may have adverse effects in the long-run. This may be the case for such

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[5] A. E. Kahn, "Investment Criteria in Developing Programs," Quarterly Journal of Economics, LXV (February, 1951), pp. 38-61.

longer term investments as cattle and land. These investments may have high ICOR's in the immediate future, but the ratios could be expected to decline in the future.

Various estimates have been made of the ICOR's in developing countries. There seems to be a fairly systematic relationship between investment and changes in production averaged over a number of years for countries at the same stage or similar stages of economic development. A United Nation's report[6] states that for the ten year period ending in 1963, about 70 per cent of the developing countries have an ICOR of between three and four. Table 1 lists the ICOR's of some of these developing countries.

For the ICOR to be useful as a planning technique, it is necessary to understand how the ratio changes during the development process. There are many diverse views as to whether ICOR's increase, decrease, or remain constant as a country becomes more developed economically. Authors such as Bruton,[7] Kaldor,[8] and Solow[9] have made

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[6]United Nations, World Economic Survey, 1965 (New York: 1966), pp. 15-16.

[7]Henry S. Bruton, "Growth Models and Underdeveloped Economies," The Economics of Underdevelopment, A. N. Agarwala and S. P. Singh (eds.) (New York: Oxford University Press, 1963), pp. 219-241.

[8]Nicholas Kaldor, "A Model of Economic Growth," Economic Journal, LXVII (December, 1957), pp. 591-624.

[9]Robert M. Solow, "Technical Progress, Capital Formation, and Economic Growth," American Economic Review, Papers and Proceedings, LII, 2 (May, 1962), pp. 76-86.

TABLE 1

DEVELOPING COUNTRIES: RELATIONSHIP BETWEEN INVESTMENT AND OUTPUT, 1953-1954 TO 1962-1963[a]

Country[b]	Incremental Capital-Output Ratio[c]
United Arab Republic	2
Mexico	2
Sudan	2
Israel	3
Taiwan	3
Thailand	3
Brazil	3
Republic of Korea	3
Ceylon	3
Chile	3
Pakistan	3
Venezuela	4
Ecuador	4
India	4
Burma	4
Ghana	4
Peru	4
Rhodesia and Nyasaland	5
Colombia	5
Kenya	5

[a]United Nations, World Economic Survey, 1965 (New York: 1966), pp. 15-16.

[b]Countries are arranged in ascending order of ICOR.

[c]ICOR's have been calculated by dividing the ratio of gross capital formation by the annual rate of growth in gross domestic product.

Source: Centre for Development Planning, Projections and Policies of the United Nations Secretariat, based on data from the United Nations and from national sources (Yearbook of National Accounts Statistics).

attempts to prove that Harrod and Domar's assumption of a constant ICOR is unjustified. However, in the case of these three economists, they have finally agreed that maybe the ICOR really is constant over time. Leibenstein points out that there are theories both for increasing and decreasing ratios as development progresses. He finally concludes that there is reason to believe that ICOR's decline with development. Paauw[10] quotes the ICOR for the Indonesian development plan as increasing from 2.1 in 1956 to a projected ratio of 3.1 in 1980. Therefore the country's development plan is based on the theory that the ICOR increases with development.

Which of these three theories should be believed? It is very unlikely that conclusions can be drawn to fit all situations. The important thing that can be done is to consider the factors responsible for changes in the ICOR and to attempt to weigh these factors in the environment in which the ratio is to be used. Various authors consider the following factors important in altering the ICOR.

1. Changes in the interest rates can affect the amount of capital in use. With lowering interest rates as development progresses, an upward tendency in the ICOR would be expected.

2. The nature of returns to scale is such that one might expect diminishing returns to set in, thus lowering the effectiveness of capital and increasing the ICOR.

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[10]Douglas S. Paauw, Financing Economic Development (Glencoe, Illinois: The Free Press, 1960), pp. 448-449.

3. The use of technology might be viewed two different ways. Increased efficiency leads to increased output per unit of capital; thus to a lower ratio. At the same time it may be assumed that innovations are capital-using or labor-saving; thus increase the ratio.

4. The nature of changes in the composition of output are such that the productiveness of capital reflects the growth in general, social overhead facilities. The return from any increment of capital increase is greater because these facilities are in existence. This causes a decline in the capital-output ratio.

5. The supply of exhaustible, non-replaceable resources per man will decline as income and population grow, leading to a price rise and an increase in the ICOR.

6. There is a tendency for movement away from the primary industries and toward the tertiary during development. The tertiary industries usually have a lower ICOR than do the primary industries.

7. The quality of the labor force increases with increased education and increased efficiency. This change causes the capacity to increase.

8. In later stages of development external economies become more significant, thus lowering the ratio.[11]

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[11]These factors and others can be found in such sources as Bruton, op. cit., Leibenstein, op. cit., B. Weber and Jones S. J. Handfield, "Variations in the Rate of Economic Growth in the United States of America, 1869-1939," Oxford Economic Papers, VI (June, 1954), pp. 101-131 and others.

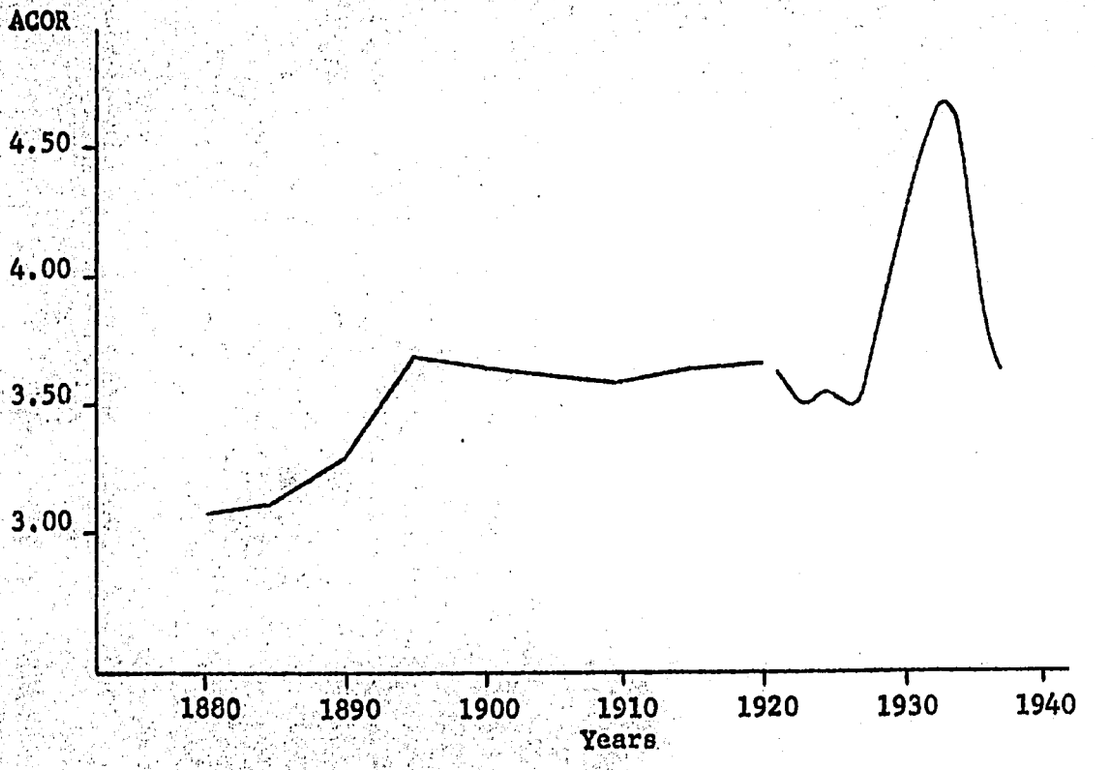
It is recognized from this list of various factors that the alteration as a result of all of the factors would be quite impossible to measure. The authors referred to above have different ideas as to how influential each factor is in altering the ICOR. The endeavor here is not an attempt to evaluate the effect of each of the above factors, but rather to identify the factors so that their influence may be assessed within a particular situation.

It seems likely that historical data from such countries as the United States in its period of development could shed light on the controversy of whether the ICOR increases, decreases, or remains constant during development. ICOR data is not available for the United States for this period, but ACOR's are available. ACOR's do not provide as meaningful a comparison for this study as do ICOR's, but the ACOR's do provide rough indicators of the trend of the average productivity of capital over a longer period of time than is otherwise possible. Figure 1 shows these comparisons for the United States for the period from 1880 to 1937.

If it can be assumed that many developing countries are at about the same stage of development now as the United States was at the beginning of the twentieth century and their development process is similar to what took place in the United States, then from Figure 1, it would be expected that developing countries could expect a relatively constant capital-output ratio for a number of years to come. This period for the United States occurred between the years of 1895

FIGURE 1

U.S.A.: CAPITAL COEFFICIENT
(Ratio of Capital Stock to Flow of Income, 1879-1939)



NOTE: Years 1880 through 1920 were figured every five years, while years 1921 through 1937 are five-year moving averages figured each year. (This causes the wide fluctuations in the ratio after 1920.)

Source: B. Weber and Jones S. J. Handfield, "Variations in the Rate of Economic Growth in the United States of America, 1879-1939," Oxford Economic Papers, VI (June, 1954), pp. 101-131 and others.

and 1920. It should also be pointed out that even with some variation, the ratio over the forty years between 1880 and 1920 only varied from 3.00 to 3.60 or 0.60.

There are two explanations as to why the ratio shows much less stability from 1921 to 1937 than in the previous period. First of all, the method of measurement changed in 1921. After 1921 the ACOR's were calculated each year as a five-year moving average rather than only calculating the ratio every five years. Also this period contains both the "good times" of the 1920's and the depression of the 1930's. These two extreme situations caused the ACOR to also register extreme variations. From observing the direction of extreme movement of the ACOR, the conclusion might be drawn that the ACOR rose in periods of slow growth in income per capita and fell in periods of more rapid growth. This is what would be expected since the ACOR is the inverse of the average productivity of capital.

The evidence presented here for the trend of the ACOR for the United States is not sufficient proof that developing countries will follow the same trend. But it is one bit of evidence that helps to reinforce one of the theories as to the trend of the ACOR in the development process. Since proof of the three theories is very limited, the United States' example could provide very important support of the constant ratio theory. This example is not meant to imply that the ACOR is constant in all other situations, but rather to show evidence of the trend in one situation.

From only this one demonstration of the direction of change of the capital-output ratio, it is unreasonable to generalize this trend for all developing countries. However, recognizing the fact that unquestionable conclusions cannot be drawn from the evidence presented, it is still necessary to utilize what evidence is available so as to suggest a recommended course of action to be used by planners.

The author will assume that the ICOR remains relatively constant over a period of time of up to one decade. This assumption is made, acknowledging the fact that a reevaluation of the ratio should take place at least every decade, but at the same time, it is recognized that a reevaluation usually is not necessary every year. The time period of one decade is an arbitrary judgment, but some stated period of time is necessary to complete the procedure if an appraisal of the ratio is to be made over time.

A planner desiring to use a technique which is based upon the relationship between capital and output must be able to understand the many aspects of its application. He must recognize the appropriate measuring device to satisfy his intended purpose. He must recognize other variables and how they might affect the fundamental relationship. He must recognize the basic assumptions of the technique so as to operate within these assumptions. He must recognize the expected trends of the relationship over a given period of time. And, he must recognize the shortcomings that are basic to the relationship. All of these considerations are necessary if the relationship between capital and output is to be a meaningful investment criterion for planners.

CHAPTER IV

MODIFICATION OF THE BASIC CAPITAL-OUTPUT RATIO

The purpose of this chapter is to improve upon the use of the basic ICOR by providing methods for handling other variables and to point out some of the practical implications of using the ratio. Special consideration will be given to the time variable in the form of lag periods and to "free factors."

Lag Period

Lag periods are used to describe the period of time over which output is realized when this time period differs from the period in which the increase in capital takes place. Methodologically it is assumed that the loan term (length of loan) is equivalent to the period of time over which output response to the capital input is realized; termination of the output response coincides with loan maturity. Given this assumption, in this particular case where credit inputs and product outputs were measured over a period of one year, no adjustment for lag is required for loans with maturities of one year and less. A lag adjustment is only relevant to loans with maturities longer than one year.

If a change in the proportion of intermediate or long term loans takes place over time, the current ICOR should be adjusted to reflect the change in expected future output. Similarly, any output in the present period that is the result of an investment in some past period should be allocated to the past period; thus subtracted from the present period. Since the trend during the development process is usually toward longer term loans, failure to adjust for this tendency would result in an inaccurately high ratio in the present period.

Because each enterprise generally requires a different length loan, it is necessary to consider more than one lag period in a diversified economy. For example, if the average length of cattle loans is four years, chicken loans two years and swine loans three years, the lag period for each type loan has to be treated separately to reflect the difference in their payoff times.

Due to the lag period of return, the change in output in the present period is not a direct reflection of the change in capital in this same period. Since the investment and return may be in separate periods, it is well to identify the output in the present period which is the result of previous investments, as well as to

identify the investment in the present period that will return output in future periods. This concept is demonstrated in the following example:

For a three year lag period, the total change in output in period t can be expected to be the result of investments in periods t, t-1, and t-2.

(t-2) investment
(t-1) investment
(t) investment
⟶ total change in output in period t

Similarly, the investment in period t will contribute to changes in output in these three different periods.

total change in investment in period t ⟶
(t) output
(t + 1) output
(t + 2) output

In order to give a true reflection of change in output from a given change in capital, it is necessary to identify the investment that caused the change in output. In order to reflect the change in output from investments in the present period, contributions in the present period, in one year and in two years should be considered, or in order to identify the investments that cause a change in output in the present period, investments in the present period, one year previous and two years previous should be considered.

FIGURE 2

IDENTIFICATION OF INVESTMENTS THAT MAKE CONTRIBUTIONS TOWARD OUTPUT IN ANY ONE YEAR

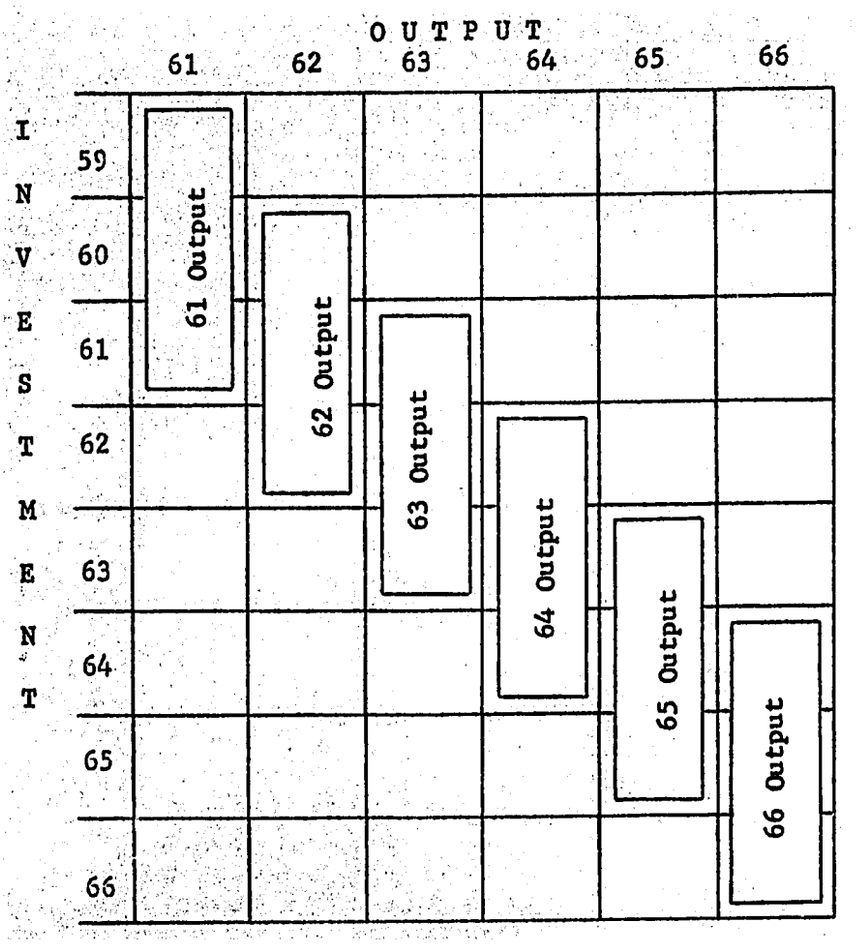
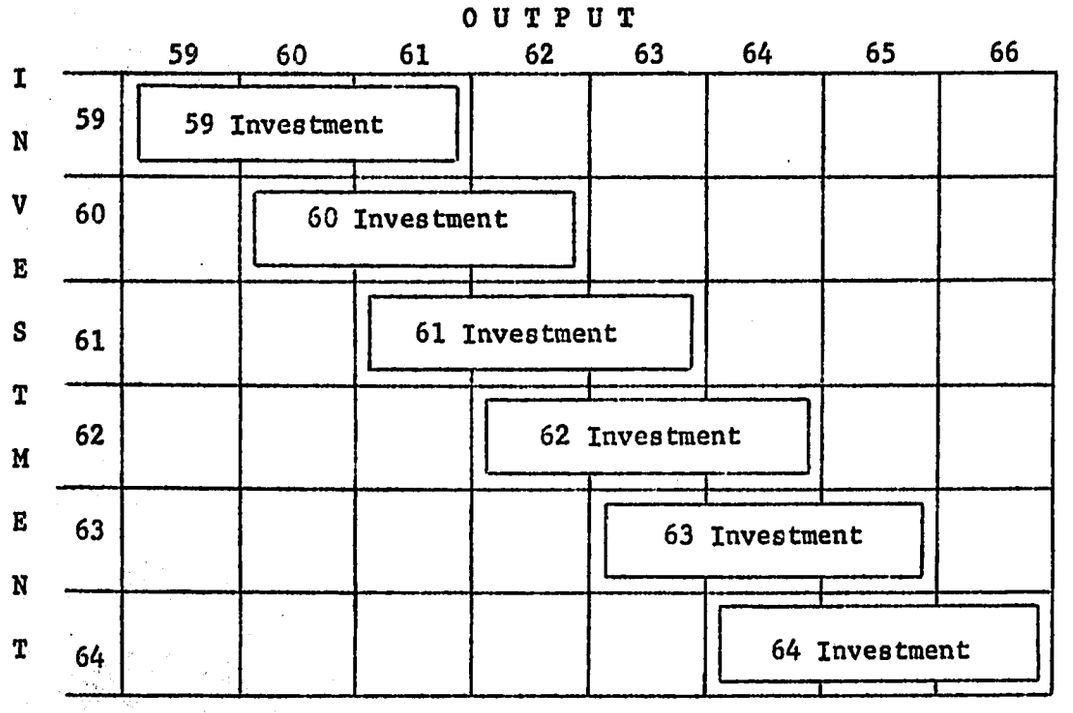


FIGURE 3

IDENTIFICATION OF OUTPUT AS THE RESULT
OF INVESTMENTS MADE IN ANY ONE YEAR



Since it is difficult to project output in future periods and information is available indicating the level of investments in past periods, investments in past periods that cause changes in output in the present period will be considered. If the level of investment has been increasing over the past few years, it would be expected that the measured investment for the present period would be larger than the actual investment that contributed to output in the present period. An adjusted investment level can be arrived at by subtracting investment in the present period and by adding investment from the past periods to the measured investment. Or more simply, as long as the length of the lag period remains constant during the period under consideration, a comparison need only be made between I_t and I_{t-1}, and I_t and I_{t-2}. This may be written as:

(8) $$I_{(adjusted)} = I_{(measured)} - \left[(I_t - I_t) + (I_t - I_{t-1}) + (I_t - I_{t-2})\right],$$

or as

(9) $$I_A = I_M - \left[(I_t - I_{t-1}) + (I_t - I_{t-2})\right]$$

where I_M is measured investment and I_A is adjusted investment. If the level of investment each year is constant, in the above formula, I_t would equal I_{t-1} and I_{t-2}, thus the terms $(I_t - I_{t-1})$ and $(I_t - I_{t-2})$ would equal zero. The adjusted investment would then become equal to the measured investment, $I_A = I_M$.

In order to identify the component parts of the increased output, some evaluation has to be made of the distribution of income over the past years of return. It might be assumed that the return is

distributed evenly over the lag period; however, this is rarely the case. More often the output is distributed more heavily toward the en of the lag period. It is even possible that in some years no output i obtained from an investment, as is commonly the case with tree crops.

For example, a three year loan for swine may return nothing the first year, 30 per cent of the output the second year and 70 per cent of the output the third year. Therefore in a simple static situation, if the change in output in the present period is $1000, $300 can be said to be the result of investments last year and $700 the result of investments two years ago. Once the change in output has been allocated to those years in which the investments were made, expected levels of output can be projected for the investments in the present period. This projection can be made by taking the changes in output in the past periods and correcting these figures for the percentage change in investments between these time periods.

It is assumed that the percentage increase in investment is the same as the percentage increase in output for the period considered. This assumption is justified due to the basic premise that there is a functional relationship between capital increase and output increase for the same period of time. More specifically, this says that the ICOR is constant during the period under consideration (constant returns to scale occurs).

Another important consideration concerning the use of lag periods, is that some evaluation is needed to determine the relative contribution to change in output of each enterprise. For simplicity it

will be assumed that the relative contribution of each enterprise will remain constant during the period of consideration. However, if there has been a definite change in the relative importance of various enterprises, a reevaluation of the component parts of the change in output must be made.

Free Factors

"Free factors" are important variables that affect the level of output but are unrelated to the increase in capital. Two important variables referred to here are the price level and climatic conditions.

The price level probably is correlated to an increase in output to the extent that increased capital increases output, but the price level reflects much more than just an increase in output from a capital injection. Price is affected by many other supply factors such as drought conditions and cyclical trends, and by demand factors such as income levels and growth in population. So it would be expected that there would be wider price fluctuations than would result from a change in capital supplied; thus much of the effect of a price change is unrelated to capital use.

The other important variable is climatic conditions. The level of output is directly related to the weather conditions for a particular year. A severe drought, a flood or a frost can drastically affect the production level. None of these conditions are correlated with an increase in capital, but all three reflect directly into the

ICOR. To prevent arriving at misleading conclusions, adjustments should be made in the ICOR for these unrelated climatic conditions.

Measurement of these two "free factors" is necessary in order to modify the ICOR. Wholesale price indices of farm products are available as indicators of price changes at the farm level and they permit a comparison of prices on a common base period. However, when attempting to measure the effect of climatic condition there is no such distinct indicator. Annual rainfall may be assumed to be an indicator in some instances, but it completely neglects all other climatic factors. Even if the level of rainfall were chosen, still there remains the task of establishing the relationship between the level of rainfall and the level of output.

Because of the difficulty of determining the above relationship and the fact that climatic conditions are usually reflected in the level of production, it will be assumed that the price is the best available indicator of the climatic conditions. Due to the fact that climatic conditions would already be incorporated in the price level, any attempt to set up a relationship between climatic conditions and output could actually produce a larger bias by double counting of the weather factor.

Adjustment by the price index is easily made because of the direct relationship between price and value of output. Any percentage change in the price index gives an equal percentage change in value of output at a given output level. The use of a lag period complicates this relationship somewhat. Since the lag period is concerned with a

projected output in a future period, there are no price indices for these periods. Therefore, it is necessary to either assume the price levels are constant in these future periods and equal to their levels in the present period, or to estimate the expected trends in an attempt to establish future price levels.

Further Implications

Besides considering these additional variables that affect the ICOR, an attempt will be made in the remainder of this chapter to point out a few of the practical implications in the use of the ratio. These additional observations could very possibly be more important in certain situations than the refinements as presented in these past chapters. However, it is hoped that they might provide further insight into the use of the ICOR, especially in those situations where one or more of the above assumptions do not hold.

The use of any form of the capital-output ratio is based on the assumption that a relationship exists between capital and output. Any use of the ICOR then further assumes that there is a relationship between additions to the capital stock and the resulting output. Attempts in this paper are made to trace this relationship back to fundamental definitions and to point out how this relationship is basic to some of the first growth theories. But if it can be proved that no meaningful relationship exists, the whole technique is useless.

Very early in the above presentation, the assumption was made that capital is scarce in underdeveloped countries, and that the method of obtaining any additional capital is credit. This assumption equates new capital with credit for an individual producer under those circumstances. If this is not the case, it is inaccurate to establish a relationship between additions to output and loan input. This relationship can only be valid if the predominant means of acquiring additional capital is credit. An alternative to equating new capital with credit is that of stipulating a given proportion of new capital that is obtained through credit, recognizing that there are other sources of new capital present, i.e., savings.

An assumption that has gone unstated until now is that loans must be made for a productive purpose. It is essential to the basic relationship that loans made for productive purposes be separated out from those made for non-productive purposes. Failure to do so gives an unrealistically high indicated level of loan input in comparison to the increase in output. Part of the problem arises from the fact that in a subsistence agriculture it is often very difficult to separate the productive from the non-productive loans; therefore, this point is of major importance in underdeveloped countries.

When gross figures are used to measure output, there is no reflection of differences between intermediate products and final products. This measure commonly leads to double counting by including the sale of intermediate products rather than just final products. If intrasector reallocation takes place with no increase in production,

as for example in some livestock loans, there is no increase in the total output for the sector. This transaction may benefit a certain individual, but the transaction does not increase the output of the sector. If increasing the output of the agricultural sector is the primary consideration, then loans should be made only for increasing production with intrasector reallocation or for intersector allocation into agriculture.

The statement was made earlier that the length of a loan is the best indicator that is available to suggest the period of return of a loan. This assumption often places too much emphasis on liquidity and does not consider returns for the full life of the investment. It is easily possible that there might be indirect effects as well as some continuing direct affects on the output level long after a loan is paid off. Measurement of these effects creates a problem, thus the reason for the length of loan being chosen as a more convenient indicator.

CHAPTER V

ILLUSTRATION OF THE REFINED ICOR AS APPLIED TO ECUADOR

An attempt will be made in this chapter to apply the methodology as previously presented by employing data from Ecuador's agricultural sector. This demonstration of the technique is important because of the originality of some of the manipulations; however, the approach does not depend upon the success of this one application. The Ecuadorian example can only provide an indication of the appropriateness of this type of measuring device for this given environment. To be able to statistically test the technique involved, many more examples of similar data would be required.

Description of Situation

A brief discussion of the setting from which the data were taken is helpful in understanding the implications of the environment upon the use of the technique. Ecuador has a land area covering 111,168 square miles; of the South American countries, only Uruguay is smaller.[1] The country offers many contrasts in topography with the

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[1] Lilo Linke, Ecuador, Country of Contrasts (London: Oxford University Press, 1954), pp. 1-5.

Andean Mountains delineating three distinct geographical regions: the coast, the mountains, and the interior.

The coast consists of a fertile alluvial plain producing nearly all of the export crops and is increasingly becoming more important as a center of commercial food production for the country. Like the coast, the mountains cover about a quarter of the land area of Ecuador. Nearly all agricultural products that are adapted to a temperate climate are grown in this area and almost all for home consumption. The interior area, consisting of roughly half of the land area, is largely undeveloped and accounts for only a small portion of the national income. The major agricultural commodity from this area is livestock and livestock products.

Ecuador had a per capita gross domestic product (GDP) in 1965 equivalent to US $215 at 1963 prices.[2] The GDP growth rate for 1960-1965 was 4.2 per cent per year at 1960 prices. Considering the 3.2 per cent population growth rate, per capita GDP during 1960-1965 increased only 1 per cent annually.

Agriculture accounted for 34 per cent of the GDP in 1965, compared with 37 per cent in 1960. The growth in agriculture averaged only 2.7 per cent annually during 1960-1965 at constant prices, with an increase of less than 1 per cent in 1963 and only 2.2 per cent in 1964.

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[2]These figures and other basic data in this and the next paragraph have been taken from: Inter-American Development Bank, Socio-Economic Progress in Latin America (Washington, D.C.: Social Progress Trust Fund, Sixth Annual Report, 1966), pp. 197-199.

In 1954 the National Planning and Economic Coordination Board was organized to coordinate the economic activities at the national, regional and local levels and to prepare a development program for the country. This group prepared an immediate action program for 1962-1963 and a more comprehensive plan for 1964-1973. The plan calls for an overall goal of 6.5 per cent annual increase in GDP. With a continuation of the 3.2 per cent annual population growth, this is equal to about a 3.3 per cent increase in annual per capita product.[3]

Source of Data

The source of the Ecuadorian data used in the illustration of the methodology is taken from a cross sectional survey of the agricultural situation of 1062 Ecuadorian farmers conducted by The Ohio State University Agricultural Finance Center in 1966. The techniques in sampling were such that the sample should be representative of the agricultural sector of Ecuador. The sample of 1062 farmers was selected in proportion to the number of farmers in each of the three geographical regions (284 farmers in the coast, 270 in the interior, and 508 in the mountains), thus representing the many types of farming and credit needs of all three geographical regions.

Of the 1062 farmers sampled, 221 or 20.81 per cent are present users of an institutional source of credit (Table 2). These 221

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[3] Ibid., pp. 207-208.

farmers are of special interest to planners of investment decisions, because the main channel through which planners can influence the output level is through sources of institutional credit. For Ecuador, these institutional sources are the Banco Nacional de Fomento (BNF), private banks and the Central Bank. Noninstitutional sources of credit are recognized as another important source of credit (see Table 2), but planners have no direct control over this source, thus it is of little use as a planning tool. Emphasis, therefore, will be given the capital-output relationship of the 221 farmers using institutional sources of credit. Also this will limit the consideration to only productive loans as viewed by the institutional source, because their policy is to give loans only for productive purposes.

TABLE 2

NUMBER AND PERCENTAGE OF SAMPLE FARMERS USING AGRICULTURAL CREDIT

	Number of Farmers	Percentage of 1062 Users	Percentage of 523 Users
Present institutional users	221	20.81	42.26
Present noninstitutional users	147	13.84	28.11
Users of both institutional and noninstitutional	26	2.45	4.97
Past users	129	12.15	24.67
Nonusers	539	50.75	
		100.00	100.00

The Basic ICOR

By utilizing formula (7) to be used for cross sectional data as presented in Chapter III, it is possible to arrive at a basic ICOR for the sample of 221 farmers. ICOR's can also be computed for crops and livestock separately, rather than only as a combined ratio, if it is desirable for planning purposes. The 1964 and 1965 outputs for crops, livestock, and total output are presented in Table 3. The value of farm products from gross investment is accepted as the best measure of output available for the farmers involved. Formula (7) is stated as:

$$ICOR = \frac{I_t}{O_{t+1} - O_t}$$

For this particular situation the formula becomes:

$$ICOR = \frac{I_{64}}{O_{65} - O_{64}}$$

TABLE 3

CHANGE IN OUTPUT FOR 221 INSTITUTIONAL USERS OF AGRICULTURAL CREDIT SAMPLED (sucres)[a]

	1964	1965	Change
Crops	4,786,997	5,629,700	842,703
Livestock	2,909,978[b]	3,300,232	390,254
Value of farm product	7,696,975	8,929,932	1,232,957

[a]In 1965 the official exchange rate was 18.18 sucres = US $ 1.

[b]Due to insufficient data for livestock output in 1964 for the coast and the interior, these figures were projected from those available for the mountains.

From the values in Tables 3 and 4, ratios can be calculated for crops, livestock, and for a combined total figure.

$$\text{ICOR (crops)} = \frac{\text{S/. } 1,269,325}{\text{S/. } 842,703} = \frac{1.506}{1}$$

$$\text{ICOR (livestock)} = \frac{\text{S/. } 1,464,131}{\text{S/. } 390,254} = \frac{3.752}{1}$$

$$\text{ICOR (combined)} = \frac{\text{S/. } 2,735,278}{\text{S/. } 1,232,957} = \frac{2.218}{1}$$

These ratios describe the relationship between investment in any one year and the increase in output in that same period of time for the 221 institutional users of credit. For example, the combined ICOR states that approximately $2.22 must be invested to return a change in output of $1. As might be expected, more investment is required in livestock ($3.75) than in crops ($1.51) to return a $1 increase in output. This can primarily be explained by the lower intensity of labor and land use in livestock production when compared with crop production.

TABLE 4

OUTSTANDING LOANS OF THE 221 INSTITUTIONAL USERS OF AGRICULTURAL CREDIT SAMPLED
(sucres)

	1964[a]	1965
Crops	1,269,418	1,353,100
Livestock	1,464,149	1,694,000
Total	2,735,278	3,047,100

[a]Figures for 1964 are projected from actual 1965 figures based

Lag Period

The basic ICOR as applied on the preceding page can then be adjusted for lag periods and price level changes. Crop loans in Ecuador are almost always made for one production season, thus not longer than one year with the output being realized in the same period the investment is made. Therefore, no lag period is required for these loans. Livestock loans include those made for dairy, beef, work animals, and a few chicken loans. With this assortment of varying types of loans, the periods of return of these loans will also vary considerably. Recognizing this variation, the author will assume the average length of livestock loans is four years with the returns being distributed 10 per cent the first year, 20 per cent the second, 30 per cent the third, and 40 per cent the fourth.

As shown in Table 5, loans by the Banco Nacional de Fomento for livestock purposes decreased about 12 per cent in 1962 and increased about 16 per cent in 1963 and 1964. It will be assumed that this trend of 16 per cent increase continued into 1965. By knowing the level of investment in past periods, it is possible to construct a weighted lag period for livestock loans. Such a lag period shows the difference between the investment measured in the present period and the investment utilized in this same period; recalling from Chapter IV that a difference may exist between these two measures.

TABLE 5

BANCO NACIONAL DE FOMENTO: LOANS OUTSTANDING IN AGRICULTURE AND PERCENTAGE CHANGES
(Thousands of Sucres)

	1961	Percentage Change 1961-1962	1962	Percentage Change 1962-1963	1963	Percentage Change 1963-1964	1964	Percentage Change 1964-1965	1965[a]
Crops	112,315.8	-16.7	93,534.4	- 6.1	87,821.8	+ 6.6	93,635.7	+ 6.6	99,815.7
Live-stock	96,003.1	-11.9	84,579.4	+16.1	98,211.6	+15.7	113,631.2	+15.7	130,335.0
TOTAL	208,318.9	-14.5	178,113.8	+ 4.4	186,033.4	+11.4	207,266.9	+11.4	230,150.7

[a]The figures for 1965 were estimated at the same rate of increase as occurred in 1964.

Source: Banco Nacional de Fomento, Informe De Labores del Sistema De Credito De Fomento, 1962 and 1964, Quito, Ecuador, March, 1965; and the same yearly report for 1961.

Formula (8) as shown in the last chapter becomes:

$$I_A = I_M - 1/10 \ (I_t - I_t) + 2/10 \ (I_t - I_{t-1}) + 3/10 \ (I_t - I_{t-2}) + 4/10 \ (I_t - I_{t-3})$$

with a four year lag period distributed 1/10, 2/10, 3/10 and 4/10. From the Banco Nacional de Fomento loans for livestock (Table 5), it is possible to estimate the amount of loans for the sample of 221 farmers by using the same percentage change over the past years and the actual livestock loans outstanding of the sample in 1965 as the basis of the estimates.

TABLE 6

LIVESTOCK LOANS OUTSTANDING FOR THE 221 INSTITUTIONAL BORROWERS (sucres)

1961[a]	1962[a]	1963[a]	1964[a]	1965[b]
1,157,062	1,033,091	1,229,870	1,464,131	1,694,000

[a]Estimated figures based on the same percentage yearly change for livestock loans as the Banco Nacional de Fomento.

[b]Actual value.

Inserting appropriate values, the formula then becomes I (Livestock Adjusted) = S/. 1,464,131 - S/. 298,982 = S/. 1,165,149 with a reduction in the measured investment of S/. 298,982 or an adjusted investment of S/. 1,165,149 as that utilized in the present period.

The ICOR for livestock would therefore be smaller with the lag period considered than without, or

$$\text{ICOR (livestock)} = \frac{\text{S/. } 1,165,149}{\text{S/. } 390,254} = 2.986$$

Price Level

If the price level of products changes during the period of consideration, the value of output will change in the same proportion. The best available measure of a price level change is the wholesale price index for farm products. In Ecuador the wholesale price index was 109 in 1964 and 111 (estimated) in 1965. At 1964 prices the 1965 value of output should be reduced by 1.80 per cent. Reducing the 1965 value of output by this amount, gives new ICOR's for this period.

$$\text{ICOR (crops)} = \frac{\text{S/. } 1,269,325}{741,368} = \frac{1.712}{1}$$

$$\text{ICOR (livestock)} = \frac{\text{S/. } 1,464,131}{\text{S/. } 330,850} = \frac{4.425}{1}$$

$$\text{ICOR (combined)} = \frac{\text{S/. } 2,735,278}{\text{S/. } 1,072,218} = \frac{2.551}{1}$$

This adjustment increases the combined ratio from 2.218 to 2.551, thus requiring about $.33 more investment to get the same $1 increase in output.

A combination of the effects of both the lag period and the price level gives the following modified ICOR's:

$$\text{ICOR (crops)} = \frac{\text{S/. } 1,269,325}{\text{S/. } 741,368} = \frac{1.712}{1}$$

$$\text{ICOR (livestock)} = \frac{\text{S/. } 1,165,139}{\text{S/. } 330,850} = \frac{3.522}{1}$$

$$\text{ICOR (combined)} = \frac{\text{S/. } 2,434,464}{\text{S/. } 1,072,218} = \frac{2.270}{1}$$

Projection to Agricultural Sector

After modifying the basic ICOR, it can then be used to project the investment required to obtain a desired growth rate for the agricultural sector. In 1965 the sample of farmers (1062) had a total value of farm product of S/. 27,425,041. This sample of 1062 farmers represents .2655 per cent of the total farmers in Ecuador.[4] Projecting the sample to the entire agricultural sector gives a total product of the agricultural sector of S/. 10,329,582,290.[5] According

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[4]This is based on an estimate of 400,000 farm families in Ecuador published by The Ohio State University Agricultural Finance Center, An Appraisal of the Banco Nacional de Fomento Relative to Agricultural Credit in Ecuador (Columbus, Ohio, September 1, 1965), p. 2.

[5]This calculated figure of total product for the agricultural sector differs from published figures of the gross domestic product for the sector because (1) the calculated figure includes returns from export as well as from domestic products, (2) published figures include only sales through the formal market channels, whereas the sample measurement was at the farm level and include all sales, formal and informal, and (3) the definition of a farmer most likely differed. The definition of a farmer used in conducting the survey was any person engaged in agriculture who has decision-making responsibilities of the overall operations of a farm.

TABLE 7

INCOMES, CHANGE AND PERCENTAGE OF THE CHANGE FOR THE SAMPLE OF 1062 FARMERS

Group of Farmers	1964 (sucres)	1965 (sucres)	Change (sucres)	Per cent of Total Change
Present institutional users	8,098,710	9,331,667	1,232,957	55.26
Present noninstitutional users	1,223,113	1,330,894	108,681	4.87
Users of both institutional and noninstitutional	453,540	685,000	231,460	10.37
Past users	5,197,809	5,402,330	204,521	9.17
Nonusers	10,193,962	10,675,250	453,460	20.32
Total	25,193,962	27,425,041	2,231,079	99.99

TABLE 8

LOANS OUTSTANDING OF MAJOR INSTITUTIONAL SOURCES OF AGRICULTURAL CREDIT
(millions of sucres)

Year	Central Bank[a]	Private Banks[b]	BNF	Total
1963	26.1	86.5	186.0	298.6
1964	25.2	100.2	207.3	332.7
1965	33.3	107.1	231.3[c]	371.3

[a]Central Bank figures were obtained from Junta Nacional de Planificacion y Coordinacion Economica, Indicadores Economicas, Ecuador, Vol. I, No. 1 (April, 1966), p. 15. Figures available for credit given rather than credit outstanding so these figures we decreased by 75 per cent. (Direct loans to farmers given by the Central Bank are usually for no longer than 90 days.)

[b]The information available in Indicadores Economicas for private banks shows a very large increase in loans in 1964 and 1965; however, the author attributes much of this increase to a reclassification of present loans to conform to an existing law that requires 15 per cent of their loan funds be made in agriculture. Rather than accept published figures available, figures for the private banks have been reduced to more realistically reflect the actual increase in lending. Together the Central Bank and private bank loans are commonly referred to as commercial bank loans, in the sample, commercial bank loans made up 37.7 per cent of total institutional loans by volume; this same proportion is assumed constant in 1963 and 1964. The new values obtained are then reduced by 50 per cent to reflect loans outstanding rather than loans given during the year. (Loans made by private banks are usually not for longer than six months, except for land loans, and none were included in the sample.)

[c]The 1965 figure is estimated based on the 1964 rate of increase.

to the national plan, a 6.5 per cent annual increase in gross domestic product is desired in future years. Assuming the 6.5 per cent growth rate is therefore the goal of the agricultural sector, there must be S/. 67,142,285 increase in the gross product in 1966. As shown in Table 7, the institutional borrowers contributed 55.26 per cent of the change in output in the 1964-65 period considered. This same group would also be assumed to contribute 55.26 per cent of the 6.5 per cent increase or S/. 37,102,827.

At a basic ICOR of 2.218 to 1, there must be 2.218 times as much investment increase as output or S/. 82,094,070 (2.218 times S/. 37,102,827). In 1965 institutional sources of agricultural credit had outstanding loans equalling S/. 371,300,000 (see Table 8), therefore, to obtain this increase of S/. 82,294,070, they must increase their loan funds by 22.16 per cent.

With a modified ratio of 2.270 there must be a S/. 84,223,417 increase in investment. This is a 22.68 per cent increase over the 1965 level.

Table 9 is an example of how these projections can be extended into future periods. In order to make these projections it must be assumed that in the period being considered the target rate of growth remains at 6.5 per cent, the institutional users continue to contribute 55.26 per cent toward the change in total product and that the ICOR remains constant.

TABLE 9

PROJECTION OF FUTURE REQUIRED INVESTMENT

	1966	1967	1968
(1) Gross product for the agricultural sector (sucres)	10,329,582,285	10,396,724,575	10,464,303,285
(2) Desired increase in gross product (1) x 6.5% (sucres)	67,142,285	67,578,710	68,017,971
(3) Amount contributed by institutional users (2) x 55.26% (sucres)	37,102,827	37,343,995	37,586,731
(4) Amount of investment required (3) x 2.270 (sucres)	84,223,417	84,770,869	85,321,879
(5) Previous investment level (sucres)	371,300,000	455,523,417	540,294,286
(6) Percentage increase in investment required (5) ÷ (4)	22.68	18.61	15.79

CHAPTER VI

SUMMARY AND CONCLUSIONS

The objective of this study was to improve upon the technique which utilizes the relationship between capital and output as an investment criterion. The investigation was carried out in the following manner. First, a review of the existing utilization of the capital-output relationship in the context of growth models was performed. Most writers on this subject find the bases for their approach in the growth models developed by Harrod and Domar.

Second, the basic ratio between capital and output was examined. Starting with the definitions of the concepts involved, the derivation of the capital-output ratio was achieved. Various forms of the capital-output ratio were identified, as well as the appropriate use of each. At this point, further consideration was limited to the incremental capital-output ratio (ICOR) as the appropriate investment criterion. The different measuring devices of capital and output were regarded, with the problems involved in their use. Basic assumptions and shortcomings of the technique were presented to insure accurate use of the relationship. The analysis was then carried one step further by discussing the factors which cause variation in the ICOR

and by supporting the theory that the ICOR remains relatively constant during the process of development.

Third, the basic ICOR was modified to reflect the effect of lag periods and "free factors." Lag periods refer to those loans which do not realize all of their return in the same period in which the loan was made. "Free factors" are those variables that alter the level of output but are unrelated to the change in capital use. The major "free factor" considered was the price level.

Fourth, the application of the refined and modified ICOR was illustrated by utilizing sample data from Ecuador's agricultural sector. The results of the application of the refined ratio, as well as modifications of the ratio, proved to be quite meaningful with the Ecuadorian example. The final ratio of 2.270 is very much in line with what might be expected. The adjustments for the lag period and the price level were almost offsetting in this particular case, but proved to be very important adjustments. Even though it is impossible to statistically test the accuracy of the developed technique, the outcome of this one demonstration of the approach looks promising for future use.

The results of this study provide an improved methodology for determining the level of investment required to achieve a determined rate of growth in an economy. Because the methodology is macro in scope, it is impossible to test the acceptability of the approach with the limited amount of data available; however, it seems

possible to conclude that whenever new, meaningful variables are identified and utilized in attempting to understand a relationship, measurement of that relationship has become more accurate.

Ecuadorian sample data are utilized as an illustration of the methodology developed. It is impossible to precisely evaluate the outcome of this one application of the technique due to the lack of results from alternative approaches with which to make comparisons. The only real "test" of the resulting outcome is a rough comparison with what few existing ratios are available for Ecuador and for other countries in a similar stage of development. However, since the developed methodology does consider additional variables, the final ratio might be expected to differ somewhat from other published ratios, thus further complicating evaluation.

The technique presented considers the investment required by the agricultural sector, but it does not consider the allocation of the investment within the sector. Nor, does it consider how the credit is to be administered. These are investment decisions that must be made with other types of investment criteria and are not meant to be included in this study.

As stated in Chapter III, there has been much criticism of the use of the capital-output ratio as a tool of developmental planning, but the important point is that the tool <u>is</u> being used. And, if it is going to continue to be used as a major investment criterion, attempts should be made to improve upon its use. This study makes one such attempt.

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