# An Analysis of Capital-Output Ratios

# with special reference to South Africa

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CONTENTS

It is known that an increase in the National Income per capita is usually the most evident manifestation of economic development. Such a symptom, however, is not in itself the most suitable measure of the trend and intensity of development; that is, of the "nature and causes" of the development of the wealth of nations. Since capital is indeed one of the factors on which economic growth depends, it is important to consider, in addition, how the quantity of available capital and especially its productivity vary in any country.

An index used for the purpose of illuminating the role of capital in the development process is the capital-output ratio. The statement that the capital-output ratio measures the productivity of capital is intended to convey that such a ratio can provide an indication of the physical productivity of investment and not of its marginal efficiency. The two concepts should not be confused. Physical productivity involves a technical relationship existing between stock of capital and flow of output. In any period of time, the economic system is endowed with a given complex of investment goods and enjoys a certain flow of output. The ratio between flow of output and stock of capital shows how many units of product can be expected, as an average, from each unit of capital. It is therefore a matter of statistical measurement relating to quantities actually realized. The marginal efficiency of capital, as defined by Keynes, and as it is generally accepted in economic writing, consists of a relation between the expected return from the application of one additional unit of capital and the cost of that unit of capital.

The marginal efficiency of capital, to quote Keynes, is defined: "... in terms of the expectation of yield and of the current supply price of the capital-asset. It depends on the rate of return expected to be obtainable on money if it were invested in a newly produced asset; not on the historical result of what an investment has yielded on its original cost if we look back on its record after its life is over",(1)

The marginal efficiency of capital implies a psychological element; it does not depend exclusively on quantitative returns actually realized (ex post) but also on expected returns (ex ante). The productivity of capital is measured by the ratio P/K, (where P = product and K = capital), an ex post relationship; the marginal efficiency of capital is an ex ante relationship; one is concerned with past results, the other with future expectations. The marginal efficiency of capital is subject to short term variations which are not reflected in the trend of the capital-output ratio. The latter includes changes in the physical productivity of capital and does not necessarily reflect all the cyclical variations which offset future expectations.

It is no part of the design of this thesis to investigate all the factors which influence investment decisions; which make expectations of future flows of income resulting from new investment vary with the current stage of the business cycle; and, through the acceleration principle of derived demand, make the expectations the more volatile the longer the returns from the investment are likely to take. The capital-output ratio is employed for the elucidation of different problems.

Even so, the measurement of the capital output ratio involves considerable difficulties. As a whole series of studies have made clear, the measurement of capital presents considerable statistical difficulties. For example, should it be estimated at first cost or at depreciated values; if the latter, how should the depreciation be reckoned? Since capital is always being added to or consumed, must it be reckoned at historical cost (giving to a heterogenous combination of historical values the guise of a homogenous current capital stock)? If reduced to a constant price level, how can this procedure genuinely be carried through? The measurement of output is subject to similar, if less formidable, difficulties. It is thus obvious that the calculation of capital-output ratios over any considerable period of time encounters serious statistical obstacles. Moreover, excluding such fundamental statistical problems as are inherent in the measurement of capital and output, one cannot ignore such additional complications as arise from the facts that:

i) the utilisation of investment goods varies from time to time;

ii) the composition of capital and income is subject to change;

iii) as a result of technical change, the volume of output may increase without there having been a corresponding increase in the amount of capital employed. This is, indeed, a mainspring of economic growth; and is a major reason for a study of capital output ratios.

In spite of such undeniable limitations, it may be argued that the trend of the capital-output ratio reflects trends in the

productivity of capital, in particular if the measurement refers to long periods of time. In the long term, successive variations offset each other, disequilibria are compensated by contrary movements. Therefore measurements relating to long periods may present a more realistic picture than can be obtained from investigations limited to short periods.

What is the productivity of capital? Estimates of the Incremental Capital-output Ratio (ICOR) made by a number of scholars[2] show particular agreement on two points: first, that in industrialised countries the ICOR appears not to be subject to marked variations; second, that such a ratio varies between 3 to 1 and 4 to 1. This means, for example, that an investment of R100 (or an increment of capital of R100) brings about an increment of Gross National Product (GNP) of between R25 and R33, or that an increase of 3% in GNP is due to an investment varying between 9% and 12%; even if the real amount of GNP invested by such countries (i.e. the rate of accumulation) varies from 15% to 20%.

In mathematical terms, the ratio between the stock of capital and output (i.e. the average ratio, as distinct from the marginal ratio) is simply a function of the amount, which is in turn a function of the proportion of national product invested, of the average "life" of investment goods and of the rate of growth of output. Assuming the average "life" of investment goods to be given, the capital-output ratio is determined by that part of output annually invested. Assuming this to be the case, one may deduce that the capital-output ratio is much lower in underdeveloped countries, because the rate of accumulation of

capital is considerably lower than the developed countries. According to some scholars(3), on the other hand, the capital-output ratio is higher in underdeveloped countries because of the relative inefficiency of those industries producing investment goods, the considerable wastage of capital and the slower extension of technical knowledge: elements which render capital less productive and therefore make the capital-output ratio higher.

There are other scholars(4) who argue that the capital-output ratio is lower because in developing countries unused natural resources are exploited, because there is more rapid population growth, different weight is given to agriculture, industry and services, and there are greater incentives to use less capital-intensive methods of production.

Those who hold the former opinion regarding relative inefficiency in the production of investment goods believe that the cost of capital must be higher in the less developed countries, which are more efficient in the production of consumer goods than of investment goods, in comparison with more advanced nations. There is little doubt that wastage of capital would tend to raise the capital-output ratio in underdeveloped countries. Such wastes are due to the fact that there is more malinvestment due to ignorance of effective possibilities within the economy, which gives rise to considerable wastage. Although such malinvestment is not peculiar to the less developed countries, there are greater obstacles to a just appreciation and a rapid seizure of such opportunities as exist, by an entrepreneural class with both the means and the knowledge to make effective investments. Such entrepreneurs are scarcer in less developed countries. When, again through ignorance, or through traditions or institutions less conducive to change, capital does not move so

freely away from accustomed but less productive sectors, with consequent over-investment in some activities - and those among the less productive - and under-investment in others, the capital-output ratio may be pushed up. But capital is also wasted where capital goods are not used or maintained with the same skilled attention as may be expected in more advanced countries; the labour force is less accustomed to the handling of machinery and so is less proficient in its use, and the work tends to be performed with less speed and less accuracy.

If, therefore, a higher capital-output ratio in some less developed countries may be explained by the slow acquisition of technical skills, this means that the frequent use of capital investment to bring about the introduction and spread of new and more productive techniques also involves a higher capital output ratio (because a deficient technology involves the reaping of lower returns from such capital), nevertheless it opens up possibilities of suddenly moving rapidly towards a declining ratio. The problem may have arisen originally because of a lack of appreciation of the need for balanced investment in the two complementary spheres of instrumental capital and "human capital", or may even have been inevitable because of the unavoidably long "gestation period" of investment in human beings. A factory fully equipped with the most modern machinery can be erected with far greater ease and speed than a generation of operatives or artisans fully trained to the use of the machines can be created. This may help to explain the rapid - indeed at times appearing almost miraculous - progress which from time to time has emerged, when investment in improving the powers of adaptation of the population to a more advanced technology, or investment in the

"infrastructure" which removes such obstacles as inadequate and expensive communications, comes to fruition at an appropriate period. It might almost be said that the overcoming of technological backwardness through necessary investments in the fields particularly of education and technical training, when massive investment in physical capital takes place concurrently, may bring about rapid economic progress accompanied by low capital-output ratios. This might explain the notably fast rates of growth experienced by some countries which were late starters, such as the USSR, Italy, or perhaps even more strikingly, Japan.

Unfortunately, it is rarely possible to obtain statistical data of sufficient reliability, covering a long enough period, to calculate acceptable capital-output ratios of countries which have as yet hardly entered the modern economy. That is indeed why it is still possible to have hypothetical explanations of a fact which, empirically, is as yet insufficiently well-established, namely that the less developed countries tend to have either above-average or below-average capital-output ratios.

Let us turn now to an analysis of the arguments mentioned above, which, according to some, explain why the capital-output ratio is lower in underdeveloped countries than in the more advanced ones. Just as capital is more productive when utilised for the introduction of techniques which are economically an improvement upon those already existing, so indeed it would be if such capital were used to exploit unused natural resources rather than those already in use. Consequently, underdeveloped countries, at least those adequately endowed with natural resources, should be able to use capital more productively. The

validity of this argument is not striking: it is the expectation of profit which generally induces investment, and profit does not only depend on the potential yield from the investment in itself, but also on the economic environment in which such investment is made.

With regard to population growth it might be argued that the capital-output ratio should be higher in those countries where population increases slowly than in those where it increases at a faster rate. Because of the "law of diminishing returns" capital will yield a greater output when coupled with an increasing amount of labour. However, it is not necessarily true that the economically active population grows more rapidly in under-developed countries. Moreover, if population growth is slow, less capital is required for housing, a sector which has a very high capital-output ratio.

However, it appears that the most effective way of approaching the argument as to whether the capital-output ratio is lower in under-developed countries lies in a consideration of the different importance, and therefore different weight, given to productive sectors in every economy. One of the consequences of industrialisation is mechanisation of agriculture, a characteristic which makes of the agricultural sector one of the most intensely capitalistic. Moreover, if one considers the importance which heavy industry and public services assume in developed economies, one can more readily maintain that the highest levels of the capital-output ratio are in fact found in the latter. Then again, capital may not be so essential in backward countries (in the sense that an increment of output requires a smaller amount of

capital than it would in more advanced states). For example, an increment of output in the agricultural sector in backward countries can be obtained by using different agricultural techniques such as the use of fertilisers, insecticides, crop rotation etc., rather than employing capital by way of mechanisation. In addition one should not forget the problem of the employment of the labour force. Some time ago, it was estimated that in India the agricultural sector supported a population greater by a fourth than that required for cultivation even with existing techniques and implements. Consequently, under such circumstances, the use of capital to substitute manpower would merely be a waste, since production was already too capital-intensive.

It can therefore be deduced that there can be valid a priori reasons for hypothesising either that the productivity of capital is lower in under-developed countries or that it is higher. At this stage, however, it becomes all the more essential to be in possession of accurate and comparable statistics so as to justify following one or other body of opinion.

Before describing the framework of the present analysis, I would like to stress certain factors which can generally influence and therefore can cause variations in the productivity of capital.

The productivity of capital can be influenced by particular trends in technical progress; inventions can alter the productivity of capital, resulting in a greater or lesser use of capital even if all other conditions within the economy remain constant. Productivity of capital can also be affected by

variations in the degree of monopoly of the various undertakings; to the extent that capitalistic entrepreneurs enjoy monopolistic advantages, the reward of capital is greater than its marginal productivity: this means greater profits and therefore incentive to invest. Moreover, the productivity of capital can be affected by variations in the scarcity or abundance of non-permanent natural resources (such as mineral deposits); if, during the course of economic development, the availability of such natural resources varies, so will real costs of production of capital goods and therefore the productivity of investment will also be subject to change.

Finally, the productivity of capital may vary with every variation in the elasticity of demand: inelasticity in the demand for a product, which means that average and marginal revenues fall as capital investment in production increases, may bring about diminishing returns to capital invested in that sector of the economy; this is, indeed, what limits the extent of investment in the sector and diverts new investment into other channels. These arguments are intended to underline the importance which may be attached to estimates of the capital-output ratio as a measure of the productivity of capital. Investigations of this nature are evoking increasing interest and appear all the more worthy of attention in that the results obtained are capable of manifold applications, all of great value both in theory and in practice. If, for example, the average capital-output ratio is known, it is possible to deduce the increase in income that will flow from a given investment, or alternatively, the investment which, with the labour of a given number of workers and within a given framework, will be necessary to produce the desired increase in income.

From a broader point of view, the estimate of interconnected relationships between capital and product can serve as a basis for the construction of the production function as well as for the verification of the operation of the acceleration principle. Finally, once the historical trend of the capital-output ratio has been traced, the statistical material necessary to test the validity of certain theories, such as the stagnation hypothesis, can be obtained. Moreover, at the root of every historical enquiry lies the consideration that a "better knowledge of the past" can serve as a guide for present decisions, once it is realised that from past trends can be deduced such elements as will assist in the prediction of future developments.

The purpose of this work is an analysis of the capital-output ratio in South Africa during the period 1950-1969. I will attempt to describe, on the basis of theoretical considerations, the trends in and the causes of movements of this ratio. I will attempt to relate theory (Part I and Part II) and reality (Part II). Part III will be devoted to prognostications and a comparison of foreseen data with those of the fourth E.D.P.

# PART I

## A THEORETICAL VIEW OF THE CAPITAL-OUTPUT RATIO.

# CHAPTER I

## Definitions

### I. Different types of capital-output ratio.

When one deals with the capital-output ratio it is possible to refer to two different concepts:

a) One can speak about the Average ratio established between the capital stock existing at a certain moment and the flow of product which comes out of it in a certain interval of time; this is the concept employed, for example, by Kuznets in his well known research concerning the United States,(5) as well as by other American economists, such as Creamer and Borenstein,(6) in some inquiries concerning particular sectors of the American economy.

b) On the other hand one can speak of the marginal ratio established between the increment in the capital stock and the increment in output in a certain interval of time; this second concept has been employed by Fellner in repeated inquiries directed to ascertain the trend of capital productivity in the long run:(7) these coefficients measure the productivity of capital and they can be of considerable utility both to establish the structure of a certain economy and to help orientate investment plans.

If, for example, in the "t" period, I refer to the average capital output ratio, the investment of a certain capital equal to $K_t$ yields an output equal to $Y_t$, their ratio gives the number of units of capital necessary to produce a unit of product. The higher such a "number" is, the lower the productivity of capital, and vice versa.

All this can be explained in another way: let us suppose that in the "t" period such a ratio is equal to "n", this, as has been said, means that n units of capital would be necessary, or that the quantity of capital would reproduce itself in n.t periods; the less time taken, the lower is n and the more productive the capital has been.(8) On the contrary the marginal ratio, better known as "Incremental capital-output ratio" (ICOR) explains how the capital stock has to increase in order to cause an increase of a unit in the product.

If such a coefficient, analytically defined as $\triangle K_t / \triangle Y_t$, is equal to n, it means that in order to obtain a unit more of product, n units of capital must be invested. In fact $\triangle K_t$ is the increase in capital stock which is identically equal to the investment carried out in the period t, and $\triangle Y_t$ is the increase in output which is given by the difference between two values of output over two subsequent periods.

The ICOR may be defined net or gross, depending on whether net investment and output, or gross values are used: similarly, it may be adjusted for labour input by subtracting from the denominator the value of the increase in output attributable to the increased labour force. A.A. Walters has suggested the following formula:(9)

$$ICOR = \frac{\text{investment}}{\triangle Y + w \triangle L \cdot Y}$$

where $\triangle Y$ is the increase in output, w is the share of income going to labour and L is the labour force.

Obviously other definitions are also possible. For example J.S. Sandee suggested the following way of calculating ICOR:[10]

$$ICOR = \frac{\text{investment}}{(Y - Y_o) - w(L - L_o)}$$

Moreover, other authors distinguish three different types of ICORs, i.e.: Actual ICOR (ICOR), net ICOR (NICOR) and adjusted ICOR (ACOR). By NICOR is meant the incremental capital-output ratio as it would be on the assumption that the supplies of all other factors are held constant. By ACOR is meant the incremental capital-output ratio as it would be if it were adjusted to a given increase in the supply of other factors, in order to maintain the optimum combination of them all. In practice, however, neither of these concepts are actually employed. Therefore we shall base our calculations upon the actual incremental capital-output ratio (ICOR), rather than upon NICOR or AICOR, since it is impossible to say a priori whether the increase in output is due only to an increase of capital, other factors remaining constant (NICOR), or to an increase both in capital and, proportionally, in the other inputs (ACOR).

## 2. The difficulty of defining ICOR.

In the calculation of the incremental capital-output ratio several alternatives may present themselves and thus create difficulties. These may relate, for example, to a) the data on which one can base the calculations, b) the duration of the period to be considered in the measurement of the increases of capital and of product, and c) the method of dating the increases so calculated.

As to the first point, i.e. the choice of data on which one can base the calculations, as far as the numerator $\triangle K$ is concerned it is possible to consider gross investment or net investment or only fixed investment by excluding the working capital.

Which of these magnitudes is to be chosen chiefly depends upon the statistical data at our disposal.

Analogously, for the denominator $\triangle Y$ it is possible to consider the value added or the net product. Obviously if net values are considered for the numerator it will also be correct to consider net values for the denominator; however, apart from this need for homogeneity of the magnitudes to be related, the choices can be made with a certain degree of freedom.

Of course such choices also depend upon the use which one wants to make of the capital coefficient; for example, for the purposes of planning it will be certainly more correct to calculate net capital coefficients than gross ones.

The choice of period to be considered is arbitrary. The available data in my case are annual data; it would then be possible to calculate the capital-output ratio (I refer to the incremental one) year by year. But this would not be convenient since the series of the ratios so calculated would inevitably reflect possible fluctuations in investment from one year to another. As what is of interest is not the value achieved by the incremental capital-output ratio year by year, but its trend over a certain period of time, it is necessary to find a method which

smoothes the fluctuations and reflects the general tendency of the phenomenon; for this aim the moving-average method or the interpolation can be used. It is obviously impossible to say a priori, in every particular case, which of these methods will be the best; this is a matter of convenience, but it is also necessary to point out that each one of these calculations will produce different results in absolute value, even if their trends are similar. This is why once the desired result has been obtained a great deal of circumspection is necessary in interpreting it; and although it may be possible to attribute a meaning to the tendency which the data show, it is not true that it is possible to do the same for the value of each datum.

Once the time period to which one wishes to relate the incremental capital-output ratio has been established, and once the relative increments have been calculated, the problem of dating such increments arises.

Here there are at least three possible solutions. One could say that the main function of the investment is the creation of new productive capacity which, in a subsequent period, allows the product to increase; if one uses this point of view one will relate the investment of a certain period to the increase of product obtained in a subsequent period. Since the latter is the consequence of the former, it is reasonable to expect that the latter will only become apparent one or more periods later.

The incremental capital output ratio would assume the following form:

$$k_t = \frac{\triangle K_t}{\triangle Y_{t+n}} \qquad (I)$$

Where $k_t$ is the ICOR at time t, $\triangle K_t$ the increment of capital at time t and $\triangle Y_{t+n}$ the increment of product over a period lasting for time n beyond time t.

But nothing prevents us from adopting the opposite view, that is, considering that the increase of product is the factor which stimulates new investments.

This is the famous "accelerator principle" that by now has become a much used instrument in economic theory. From this point of view, the situation is reversed: it is the increase in output which comes first and yields, in a subsequent period, the increase in capital. Here also it is necessary, in writing the incremental capital-output ratio, to lag the data by a certain period, that is:

$$k_t = \frac{\triangle K_t}{\triangle Y_{t-n}} \qquad \text{(II)}$$

Finally, it is possible not to postulate any causal relation between the investment and increase of product, and to consider them simply as two magnitudes which generally vary in the same direction; in such a case one gives up lagging the data in one direction or in another and directly establishes the ratio between the investment and the increase of product of the same period, that is:

$$k_t = \frac{\triangle K_t}{\triangle Y_t} \qquad \text{(III)}$$

It is impossible to say <u>a priori</u> which of these methods is the more correct: but let us try to analyse them and to find some justifications, both theoretical and statistical, in order

to choose one or other of them. Let us proceed by elimination. The second method is not to be considered here since it is beyond the scope of this work, which bases itself on the calculation of the Incremental capital-output ratio and not on the measurement of the "accelerator principle".

Besides, such two coefficients, even if formally equal, present substantial differences.(11)

The Incremental capital-output ratio is a magnitude of a technical nature, which measures the realised relation between capital and product and therefore it is an "ex post" magnitude; the accelerator, on the contrary, is a behavioural magnitude, which measures the reactions of the entrepreneurs to the variations of national income, and, therefore, it has something of the nature of a "planned" magnitude. One could say, and some have, that the accelerator is a capital-output ratio desired by entrepreneurs, different, then, from the ratio which is actually realised. Such an interpretation, however, is only approximate.

First of all not all investment is determined by increases in demand; there are investments also determined by autonomous pressures such as scientific progress or Government; therefore, even if the expectations of entrepreneurs were fully realised, the capital-output ratio would always be different from the accelerator. Besides, while the capital-output ratio can fluctuate according to the percentage of utilisation of plants, the accelerator is, by its very nature, independent of temporary fluctuations in productive capacity utilised. Let us now consider the other two methods of calculating the ICOR mentioned above. It has been ascertained that every investment always produces

(unless it is an unproductive investment) a double effect: it increases the global demand and the productive capacity, that is, the real supply. But what remains to be determined, for a correct calculation of the ICOR, is to see, or at least to estimate, when that result can be achieved. In other words, what value has to be assumed by n in the denominator ($\triangle Y_{t+n}$) of the incremental capital-output ratio?

If the investment has been productive in the same period in which it was carried out, n will be equal to 0, if after 1 period, n is equal to 1, if after 2 periods n is equal to 2, and so on. (Periods here refer to years).

Therefore, the incremental capital-output ratio will assume the following forms

$$\frac{\triangle K_t}{\triangle Y_t} \quad , \qquad \frac{\triangle K_t}{\triangle Y_{t+1}} \quad , \qquad \frac{\triangle K_t}{\triangle K_{t+2}} \quad , \quad \ldots$$

respectively.

Unfortunately it is impossible to say what time interval must elapse before an investment begins to take effect, but some hypotheses can be made: hypotheses which, if they seem to be valid from a logical point of view, nevertheless could not be verified by economic reality.

In order to attenuate arbitrary assumptions in the choice of one of the above-mentioned solutions, I have used a statistical instrument: the correlation coefficient of Bravais.[12] In other words, the correlation between the series of investments carried out in South Africa during the period 1950-69 and the

increase of product in the same time period has been calculated by assuming a time lag between the investment and the increase of product of 0, 1, and 2 years respectively. More precisely, I have assumed that the investment begins to bring reward in the same period in which it was carried out, or after one year or after two years.

The results obtained are set out below:

AGRICULTURE

| | | |
|---|---|---|
| $I_t$ with $\Delta Y_t$ | r = 0,3071 | (n = 0) |
| $I_t$ with $\Delta Y_{t+1}$ | r = 0,3588 | (n = 1) |
| $I_t$ with $\Delta Y_{t+2}$ | r = 0,37II | (n = 2) |

MINING

| | | |
|---|---|---|
| $I_t$ with $\Delta Y_t$ | r = -0,3215 | (n = 0) |
| $I_t$ with $\Delta Y_{t+1}$ | r = -0,066I | (n = 1) |
| $I_t$ with $\Delta Y_{t+2}$ | r = -0,022I | (n = 2) |

MANUFACTURING

| | | |
|---|---|---|
| $I_t$ with $\Delta Y_t$ | r = 0,6212 | (n = 0) |
| $I_t$ with $\Delta Y_{t+1}$ | r = 0,7710 | (n = 1) |
| $I_t$ with $\Delta Y_{t+2}$ | r = 0,II05 | (n = 2) |

SERVICES

| | | |
|---|---|---|
| $I_t$ with $\Delta Y_t$ | r = 0,6025 | (n = 0) |
| $I_t$ with $\Delta Y_{t+1}$ | r = 0,7549 | (n = 1) |
| $I_t$ with $\Delta Y_{t+2}$ | r = 0,5409 | (n = 2) |

As can be seen, apart from the mining sector, where there is almost indifference between the series (i.e. a correlation coefficient very near to 0), perhaps due to the fact that this sector presents a longer gestation period, the highest correlation is obtained by relating the investments of a certain period to the increases of product of the subsequent period, that is, by considering a time lag between investments and increases of product of 1 year.

Of course, such a correlation coefficient, by its very nature, does not mean that the investment carried out in the period t yields an increase of product after 1 year, but it does mean that the related series have, more or less, varied in the same direction.(13)

The Incremental capital-output ratio can be net or gross, according to whether the magnitudes related are gross investments and gross product or net investments and net product (that is excluding capital depreciation).(14)

According to some(15) the net ratio is more significant than the gross one, since the latter relates investments and product of which a certain part represents wealth consumed during the period. However, considering that the depreciation is not a "consumption" of wealth, but simply a "transformation" of wealth in the sense that the cost of depreciation is one of the elements which make up the cost of production and therefore forms part of the price of the finished article, and considering the uncertainty and arbitrariness by which depreciation is calculated, the use of gross incremental capital output-ratio might be preferable.

This is particularly true in those cases in which one wishes to compare results in different countries. In fact the criteria used in the official statistics for estimating depreciation can be different from one country to another rendering it impossible to compare the net incremental capital-output ratios.

In the following table (Table I) I have collected the data relating to depreciation in eight countries, among them South Africa, and they have been expressed as percentages of gross domestic product - D/Y in the table - and of gross total fixed investments - D/I in the table..

Table I: Percentages of depreciation in eight countries
Average 1963-67

| | U.S.A. | CANADA | BELGIUM | U.K. | GERMANY | ITALY | S.AFR. | NETHERLANDS |
|---|---|---|---|---|---|---|---|---|
| D/I | 57,5 | 45,8 | 43,6 | 41,7 | 41,1 | 41,0 | 35,1 | 35,3 |
| D/Y | 10,3 | 13,1 | 10,5 | 10,3 | 10,5 | 9,8 | 9,6 | 9,8 |

Source: For the basic data see: U.N. Yearbook of National Accounts, 1968.

The data are striking in their uniformity: depreciation in fact, takes about 10% of gross domestic product (the mean of the eight countries being equal to 10,4%) and about 42% of gross total investments (the mean of eight countries is equal to 42,3%). Again, the coefficient of variation $\frac{\sigma}{M}$ (i.e. the ratio between the mean square deviation and the mean) is equal to 0,015 for D/Y and to 0,149 for D/I. (The reader does not have to be reminded that such an index varies between 0 and 1, 0 being the least value and 1 the maximum).

In interpreting the data one must realise that the gross incremental capital-output ratio is always greater than the net ratio. This derives from the structure of the formula, in that, in passing from the gross ratio to the net ratio, in the numerator the whole depreciation of a certain period is deducted, but in the denominator only the increase in this depreciation.

In fact, in this case, the net ICOR is:

$$(\text{net}) \quad \frac{\triangle K_t}{\triangle Y_{t+1}} = \frac{I_t - D_t}{(Y_{t+1} - Y_t) - (D_{t+1} - D_t)} \qquad \text{(IV)}$$

where $D_t$ & $D_{t+1}$ are depreciation in periods t and t+1.

Since depreciation has more influence on the numerator than on the denominator, the greater the depreciation the greater the difference between the net and the gross ICOR. In normal cases, such a difference should be about 30 or 40%.

3. The capital-output ratio at current and constant prices.

When one wishes to relate investment to the product of different periods, it is necessary, in order to eliminate the variations in the purchasing power of money, to value the economic aggregates at constant prices. It is obvious that the capital-output ratio at constant prices is different from the capital-output ratio at current prices; it is however desirable to establish the degree of such a divergence. It becomes apparent that: - the divergence between the capital-output ratio at constant and current prices is greater for the ICOR than for the average capital-output ratio;

- the divergence for the average capital-output ratio is proportional to the difference in prices experienced during the period under consideration; on the contrary, no such proportional connection exists for the incremental capital-output ratio.

This may be briefly demonstrated. Let us call "C" the current ratio (at current prices) and "D" the deflated ratio (at constant prices). Such ratios are equal only in two cases:

1) If the general level of prices is constant;
2) if the capital and product of the same period are related and the same index of prices is used to deflate the series of capital and product.

In the first case (general level of prices constant) the original series coincides with the deflated ohe. Therefore the relative ratios are also equal.

In the second case, the numerator and denominator of the ratio at current prices are multiplied by the same index of prices, therefore the value of the fraction remains unchanged. Obviously these cases are not found very often, and so, generally, the deflated ratio diverges from the current ratio. Let us examine how, starting with the ACOR.. If K is the capital stock, Y the product, $p_k$ and $p_y$ the price indices of investment goods and total output respectively, the deflated ratio will be:

$$D = \frac{K/p_k}{Y/p_y} = \frac{K}{Y} \cdot \frac{P_y}{P_k} \qquad (V)$$

On the contrary the current ratio will be:

$$C = \frac{K}{Y} \qquad \text{(VI)}$$

In order to measure the divergence between the ratios, let us divide one ratio by the other:

$$\frac{C}{D} = \frac{K/Y}{K/Y \cdot \frac{P_y}{p_k}} = \frac{p_k}{p_y} \qquad \text{(VII)}$$

If the price indices are equal (i.e. the same index is used to deflate the series of capital and product) the whole expression is equal to 1 and therefore the current ratio is equal to the constant ratio. On the contrary, if the price indices are different the ratios also will be different; so every divergence between the prices of capital goods and the general level of prices yields a divergence between the current ratio and the deflated one. But, as is apparent from the formula, such a divergence is equal to the ratio between the price indices considered.

If, for example, the price index of capital goods is higher, let us assume by 10%, than the general index of prices, the current capital-output ratio will also be greater than the deflated one to the same extent, i.e. 10%. If, for any reason, a time-lag into the calculation of the capital-output ratio is introduced, the results are very similar.

If $p_{k_1}$ and $p_{y_2}$ are the price indices for capital and product in periods 1 and 2 respectively, the deflated capital-output ratio, calculated with a time lag of one period will be:

$$D = \frac{K_1/p_{k_1}}{Y_2/p_{y_2}} \qquad \text{(VIII)}$$

On the contrary the current ratio will be:

$$C = \frac{K_1}{Y_2} \qquad (IX)$$

and dividing the former by the latter, one obtains, as in the previous case:

$$\frac{D}{C} = \frac{p_{y_2}}{p_{k_1}} \qquad (X)$$

If the price indices of the first period are considered as a base, $p_{k_1}$ is equal to $p_{y_1}$, equal in its turn, to 1, and the formula becomes $D/C = p_{y_2}$. That is, the percentage divergence between the current and deflated capital-output ratios is equal to the percentage variation of the general index of prices.

Let us consider the same for the incremental capital-output ratio. In the calculation of ICOR it is necessary, for definitions, to utilise magnitudes relating to different periods of time. Thus, if I represents investment in period 1 $Y_1$ and $Y_2$ the product in periods 1 and 2 respectively, and $p_{k_1}$, $p_{y_1}$, $p_{y_2}$ the price indices of investment goods and product, the deflated incremental capital-output ratio, calculated with a time lag of 1 period, will be:

$$D = \frac{I/p_{k_1}}{Y_2/p_{y_2} - Y_1/p_{y_1}} \qquad (XI)$$

while the current ratio will be:

$$C = \frac{I}{Y_2 - Y_1} \qquad (XII)$$

By dividing, as before, the latter by the former, we have:

$$\frac{C}{D} = \frac{\frac{I}{Y_2 - Y_1}}{\frac{I/p_k}{Y_2/p_{k_2} - Y_1/p_{y_1}}} = \frac{I}{Y_2 - Y_1} \cdot$$

$$\cdot \frac{Y_2/p_{y_2} - Y_1/p_{y_1}}{I/p_k}$$

summing and deducting $\frac{p_k}{p_{y_1}}$, we have:

$$\frac{C}{D} = \frac{p_k}{Y_2 - Y_1} \cdot \left( \frac{Y_2}{p_{y_2}} - \frac{Y_1}{p_{y_1}} \right) + \frac{p_k}{p_{y_1}} -$$

$$- \frac{p_k}{p_{y_1}} = \frac{p_k}{p_{y_1}} + p_k \left[ - \frac{I}{p_{y_1}} + \frac{I}{Y_2 - Y_1} \cdot \right.$$

$$\left. \cdot \left( \frac{Y_2}{p_{y_2}} - \frac{Y_1}{p_{y_1}} \right) \right]$$

multiplying and dividing by $Y_2 - Y_1$ :

$$\frac{p_k}{p_{y_1}} + p_k \left[ - \frac{Y_2 - Y_1}{p_{y_1}(Y_2 - Y_1)} + \frac{I}{Y_2 - Y_1} \cdot \right.$$

$$\left. \cdot \left( \frac{Y_2}{p_{y_2}} - \frac{Y_1}{p_{y_1}} \right) \right] = \frac{p_k}{p_{y_1}} + p_k \cdot$$

$$\cdot \left[ - \frac{Y_2}{p_{y_2}(Y_2 - Y_1)} + \frac{Y_1}{p_{y_1}(Y_2 - Y_1)} + \right.$$

$$+ \frac{Y_2}{p_{y_2}(Y_2 - Y_1)} - \frac{Y_1}{p_{y_1}(Y_2 - Y_1)} \Bigg] =$$

$$= \frac{p_k}{p_{y_1}} + p_k \left[ \frac{Y_2}{p_{y_2}(Y_2 - Y_1)} - \frac{Y_2}{p_{y_1}(Y_2 - Y_1)} \right]$$

that is

$$\frac{C}{D} = \frac{p_k}{p_{y_1}} + \frac{Y_2}{Y_2 - Y_1} p_k \left[ \frac{1}{p_{y_2}} - \frac{1}{p_{y_1}} \right] \quad \text{(XIII)}$$

from this formula it seems that, if the general level of prices is constant and consequently all the indices are equal to 1, we have

$$\frac{C}{D} = 1 + 0$$

that is

$$C = D,$$

and the current incremental capital-output ratio is equal to the deflated one. But, if the general level of prices varies, there will be a divergence between the current and deflated ratios, and this time such a divergence between the ratios will not be equal to the variation of prices, but will be much higher.

Such a divergence is much clearer if the period 1 is considered as the basis of our price indices, so that one may write $p_k = 1$, $p_{y_1} = 1$; in fact, acting in such a way, we have

$$\frac{C}{D} = 1 + \frac{Y_2}{Y_2 - Y_1} (1/p_{y_2} - 1) \quad \text{(XIV)}$$

From this equation it is clear that if prices are rising (so that $p_{y_2} > 1$), the right side of this equation is less than 1, and then the current ratio will be less than the deflated one. It is also clear that such a divergence between the ratios is higher than the variation in the level of prices, and the bigger it is the bigger is the variation of prices compared with the variation of income-money.

It is then possible to state that, while the choice between the current and deflated ratio has little importance for the calculation of ACOR, it becomes, on the contrary, essential when ICOR is calculated. Again, for the Average capital output ratio such a divergence is more or less of the same size as the variations in the level of prices; for the ICOR, however, even a small variation in the level of prices can produce a noteable difference between the current and the deflated ratio.

## 4. The Average capital-output ratio (K/Y) or the Incremental capital-output ratio ($\triangle K/\triangle Y$)?

It is known that the ratio between product and a factor of production gives us the productivity of that factor. Therefore the Average capital-output ratio (i.e. the inverse of such a ratio) measures the productivity of capital, assuming that the other factors remain in a given combination considered optimum by entrepreneurs. This kind of productivity is usually called the "Average productivity of capital". If, on the contrary, increments are related (in our case the increase in capital and in the product) the ratio gives the marginal productivity of capital, assuming, in this case also, that the other factors remain in a certain combination considered to be the optimum.

The difference between the Average capital-output ratio and the Incremental capital-output ratio has the same nature as that existing between any average and marginal propensity. Now, which is the more representative, or significant or important of these two concepts? I believe the marginal propensity, and thus the Incremental capital-output ratio; since the former (average propensity) is a static concept, and the latter (marginal propensity) is a dynamic concept. The one refers to what has happened, the other to what is happening.

Thus, to measure the productivity of capital, the Incremental capital-output ratio is certainly better than the Average capital-output ratio, mostly because of the greater operational value of the former. In addition, there are formidable difficulties, both theoretical and practical, in measuring the Capital stock.

Can these magnitudes be equal? Statistically it is rather unlikely; analytically, (i.e. in theory), it can happen in every case in which it is possible that the marginal propensity is equal to the average propensity.

If we have a f(x), analytically expressed by $y = ax$, when y is the product and x the capital, then:

$$\frac{y}{x} = a \qquad \text{ACOR}$$

$$\frac{\Delta y}{\Delta x} = a \qquad \text{ICOR}$$

and, so, the ICOR is equal to the ACOR.

However, in practice, the function which it is statistically possible to establish between the product and capital cannot be equal to $y = ax$, since it is by now accepted that capital, at least in statistical enquiries, means reproducible and durable wealth; and the earth, human beings, and so on, are excluded. This means that, even without capital defined in that sense, a certain production, owed to natural resources, like the earth, would be possible.

Such a situation, if we want to represent it analytically and in linear form, will be:

$$y = ax + c$$

and then

$$\frac{y}{x} = a + \frac{c}{x}$$

$$\frac{\triangle y}{\triangle x} = a$$

thus

$$\frac{\triangle K}{\triangle Y} \neq \frac{K}{Y}$$

In practice, the possible equalities between $\frac{\triangle y}{\triangle x}$ and $\frac{y}{x}$ will be mostly casual. However it seems to be interesting to examine the relations which may exist between $\frac{\triangle K}{\triangle Y}$ and $\frac{K}{Y}$, one of them is the following:

$$\frac{\triangle K}{\triangle Y} = \frac{\triangle K}{K} \cdot \left(\frac{\triangle Y}{Y}\right)^{-1} \cdot \frac{K}{Y} \qquad \text{(XV)}$$

This identity can be written in terms of logariths as:

$$\lg\left(\frac{\triangle K}{\triangle Y}\right) = \lg\left(\frac{\triangle K}{K}\right) - \lg\left(\frac{\triangle Y}{Y}\right) + \lg\left(\frac{K}{Y}\right) \qquad \text{(XVI)}^{(16)}$$

This means that the relation between the ICOR, rate of growth, and Average capital-output ratio is linear in logarithms. Furthermore the coefficients are exactly -1 for the logarithm of $\frac{\triangle Y}{Y}$ and + 1 for the logarithm of $\frac{K}{Y}$. In other words, the Incremental capital-output ratio is inversely related to the rate of growth; the higher the rate of growth, the lower the ICOR and vice versa.

Again, the ICOR is positively related to the average capital-output ratio, the higher the Average capital-output ratio, the higher the ICOR and vice versa.

Such a relationship was used to predict investment needs for the United Kingdom by the authors of the National plan.(17) This Study of the National Institute for Economic and Social Research (N.I.E.S.R.) tried to explain variations in ICOR in the industrial sectors by a linear regression on the capital output ratio and on the rate of growth of output.

It was found that:

$$ICOR = 1.\ 70 + 2{,}26\ \frac{K}{Y} - 0{,}71\ \frac{\triangle Y}{Y}$$

$$(R^2 = 0{,}6107)$$

From the knowledge of the growth rate and of the capital-output ratio the future ICOR was predicted. This was then applied to the annual expected growth of output to find annual requirements. The N.I.E.S.R. study also showed that the growth rate was more important than the capital-output ratio as a determinant of ICOR's.

The same regression has been calculated by us for the manufacturing sector of the South African economy, and it has been found that

$$ICOR = -7,5 + 9,65 \frac{K}{Y} - 0,3 \frac{\Delta Y}{Y}$$

$$R^2 = 0,7866$$

As can be seen, here also $\frac{\Delta K}{\Delta Y}$ and $\frac{\Delta Y}{Y}$ are negatively associated, while $\frac{\Delta K}{\Delta Y}$ and $\frac{K}{Y}$ are positively associated. If we consider the fact that $\frac{K}{Y}$ and $\frac{\Delta Y}{Y}$ could never be equal to 0, and the high value of $R^2$, we can say that such a linear regression of ICOR on the average capital-output ratio and on the rate of growth of output in the period 1950-64 is rather significant. Here also it has been found that $\frac{\Delta Y}{Y}$ has much more weight in determining $\frac{\Delta K}{\Delta Y}$ than $\frac{K}{Y}$. In fact the partial correlation coefficient between $\frac{\Delta K}{\Delta Y}$ and $\frac{K}{Y}$ is equal to 0,3445 and between $\frac{\Delta K}{\Delta Y}$ and $\frac{\Delta Y}{Y}$ is equal to -0,6179: in absolute value the latter is bigger than the former, and again, the positive and negative sign of such coefficients points out, as it is before said, the direct relationship between $\frac{\Delta K}{\Delta Y}$ and $\frac{K}{Y}$ and the inverse relationship between $\frac{\Delta K}{\Delta Y}$ and $\frac{\Delta Y}{Y}$.

If we want to give an economic explanation of these results, assuming that $\frac{\Delta K}{\Delta Y}$ represents investment decisions, $\frac{K}{Y}$ the capital intensity and $\frac{\Delta Y}{Y}$ the rate of growth of product, it is possible to state that investment decisions are ruled more by the rate of growth than by the capital intensity existing in a certain economic sector.

In other words, one does not invest on the basis of investments already carried out in a given sector and therefore

of the capital stock existing there, but on the basis of the actual or potential rate of growth of product. This would go to explain why investments in the economic sectors with high capital intensity, such as transports and communications and heavy industries are carried out more by government than by private entrepreneurs.

# CHAPTER II

## Trend and meaning of the capital-output ratio

It has often been affirmed that the capital-output ratio is a suitable index with which to measure the productivity of capital, and also its variations over a period of time.

We want to consider a few theories which try to explain the trend of such a capital coefficient during the process of economic growth. One such theory which, as Khan[18] acknowledges, is a feature of all the contemporaneous approaches to the theory of economic growth, considers the capital coefficient as a constant parameter.

According to this theory the capital coefficient, then, is the result of a constant relation between capital and product and does not undergo variations during economic growth.

Another theory, that accepted by Goldsmith, considers, on the contrary, that the capital coefficient steadily decreases with an increasing rate of growth; that is, it assumes a continuous increase in the productivity of capital. Such a trend was pointed out by different authors, among them Goldsmith[19] who noticed that, during the period 1897-1950, in the U.S.A., the capital coefficient decreased from 3,5 to 2,5.

Even the most recent statistics on the capital coefficient for the whole economy, according to Van der Werde[20] would show a general tendency to decrease, as is apparent from Table 2:

Table 2: Long run variations in the capital coefficient in some countries in Europe and other continents.

| | | | | | |
|---|---|---|---|---|---|
| Belgium | 1916 - 1956 | from | 9,3 | to | 5,4 |
| Germany | 1913 - 1955 | " | 5,4 | " | 3,6 |
| Norway | 1900 - 1955 | " | 4,1 | " | 3,4 |
| Australia | 1903 - 1956 | " | 6,4 | " | 4,0 |
| South Africa | 1917 - 1956 | " | 7,0 | " | 4,5 |
| Colombia | 1925 - 1954 | " | 4,4 | " | 2,9 |
| Argentina | 1917 - 1955 | " | 5,8 | " | 3,4 |

Source: M. di Palma: Il rapporto capitale-prodotto, Boringhieri, Roma 1967, p.12.

According to Leibenstein[21], who tried to give an interpretation of such a phenomenon, the reasons for this general tendency of the capital coefficient to decrease can be found in the reduction which took place in some economic sectors and for some products, in the capital necessary for a unit of production, i.e. the introduction of "capital-saving" processes of production, and in the evolution of the economic structure of production, i.e. an increasing importance within the economy of those sectors with lower capital coefficients as sources of economic growth.

According to a third theory, finally, the capital coefficient during economic development passes through three different phases: it starts at a very low level in the initial stage of economic development, rises to a high level in the second stage and then settles at values somewhat lower than those noted during the preceding period. This is the interpretation accepted by several economists, inter alia, C. Clark, S. Kuznets[22] and more recently R. Bicanic.[23]

According to R. Bicanic, during the phase of "threshold" (i.e. a phase of the economic growth synonymous with Rostow's "Take off") there is an increase in demand for capital goods which determines an increase in the capital coefficients. Such a thesis is not strengthened by Zimmerman's estimates[24] where it appears that a higher level of the capital coefficient does not occur during the "take off" period. The explanations put forward by the defenders of this theory (Bicanic, Clark and Kuznets) nevertheless seem to be sound. In fact it is plausible to assert that the ICOR tends to increase noticeably with the increase in economic development.

Moreover, in the pre-factory economy, capital is a rather scarce factor compared with other factors (labour) which can be, on the contrary, superabundant, therefore the whole economy is characterised by short periods of production (in the sense of Böhm Bawerk).

However, in developed economies, both investments in infrastructures, whose productivity is delayed, and investments in activities whose productive cycle is completed through longer runs than those which are characteristic of pre-factory economies, are rather frequent.

It would then appear that, while in the first case the capital coefficient settles at rather low levels, in the second case, during economic development it will tend to increase progressively. This indicates that the system is moving towards greater long-run efficiency.

When, finally, the economy is over this stage of growth and reaches the stage of maturity, where,with a full exploitation of productive capacity is associated the complete utilisation of economies of scale, lower capital-output ratios will be obtained and the productive system will be highly efficient.

But it is obvious that if one wants to continue with further enlargements of productive capacity or to use new methods of production which need the utilisation of a greater quantity of capital, the incremental capital-output ratio will tend to increase again.

Of these three theories, the nearest to reality would seem to be the third.

The first theory has no statistical-economic importance. It was formulated as a simplifying assumption for the composition of some growth models, like those of Harrod-Domar and Kaldor.

The second, however, may be justified, if explained in a different way. As is known, the economic growth of a country passes through different stages, and since every stage is characterised by different economic conditions, so the parameters that could reflect such conditions will also be different. Thus, the incremental capital-output ratio, which is one of these parameters, will take different values in each stage. According to some, as has been mentioned above, the ICOR would start from low values (about 2) at the beginning of economic growth, and then would increase considerably in the subsequent stage (values

around 5 or 6) and by decreasing again would complete the cycle. If we want to refer to Rostow's stages of economic growth, i.e. the traditional society, the pre-conditions for the take-off, the take-off, the drive to maturity and the age of high mass-consumption, the ICOR would take very low values during the traditional society, chiefly because of the shortage of capital; it would increase considerably during the pre-conditions for the take-off, then it would decrease during the take-off and increase again during the drive to maturity and continue to decrease during the mass consumption.

Professor D.H. Houghton[25] has tried to apply Rostow's five stages of economic growth to the South African economy. He considers the first stage, "South Africa's traditional society" to date from the beginning of time to 1820: the second stage, "The pre-conditions for the take-off", from 1820 to 1933; the third stage, "The take off" from 1933 to 1945; the fourth stage, "The drive to maturity", from 1945 to 1993?, and the fifth stage "The age of high consumption" he takes not to have been reached yet in South Africa.

With the data at my disposal I have been able to calculate capital-output ratio for part of the second stage. The results are as listed below:

| Period | ICOR |
|---|---|
| 1917-1933 | 8,74 |
| 1933-1945 | 3,02 |
| 1945-1964 | 4,16 |

Source: for the basic data till 1950 see: C.J. du Pisanie: Die Bepaling en die Gebruik van Kapitalopbrengsverhoudings : unpublished thesis, University of Pretoria, 1968. pp.41 and 65. For the rest of the period the data on output and capital formation have been provided by the South African Reserve Bank.

According to what has been said above, the ICOR should tend to decrease in the future. A similar trend seems also to be apparent for Italy.(26)

In fact:

| Periods | ICOR |
|---|---|
| 1874-1893 | 5,69 |
| 1894-1940 | 2,40 |
| 1950-1968 | 3,38 |

In conclusion, while it is not possible to state that the trend of ICOR is constant or decreasing during economic growth; it is possible to say that the ICOR shows regular fluctuations during economic growth.

Now, whether the trend of such fluctuations is decreasing (Goldsmith's hypothesis) or increasing, (my opinion) it will be due to the particular circumstances of the growth process of individual countries.

With the data at my disposal, in order to illustrate the trends of ICOR, I have been able to calculate the Incremental capital-output ratio for the 1920-1969 period for South Africa. (See table below)

| Periods | ICOR |
|---|---|
| 1920-1926 | 4,21 |
| 1926-1932 | 7,43 |
| 1932-1938 | 3,16 |
| 1938-1944 | 3,77 |
| 1944-1950 | 4,61 |
| 1950-1956 | 4,67 |
| 1956-1961 | 4,57 |
| 1961-1969 | 3,59 |

Source: C.J. Du Pisanie, op.cit. pp.41 and 65.
South African Reserve Bank.

As can be seen, such values show a trend which is more or less decreasing. The high value taken by ICOR during the period 1926-32 is to be ascribed to the fact that this period was, as has been seen before, a period of transition for the South African economy, and besides, the early part of the period was highly deflationary.

The same calculations carried out for Italy during the period 1874-1968 are quoted below:

| Periods | ICOR |
|---|---|
| 1874-1883 | 5,17 |
| 1884-1893 | 6,27 |
| 1894-1903 | 2,03 |
| 1904-1919 | 2,63 |
| 1920-1929 | 2,34 |
| 1930-1939 | 2,60 |
| 1951-1959 | 3,01 |
| 1960-1968 | 3,86 |

Source: The data on output and capital formation come from: Annali di Statistica, series viii, Vol. 15, ISTAT, Roma, 1965.

Here it is possible to see on the contrary, the increasing trend of the Incremental capital-output ratio in the observed period.

This leads me to reconsider the argument already touched upon in the introduction, as to whether ICOR is likely to be higher or lower in less developed or in mature economies.

I do not deny the validity of the reasons, to which Lewis[27] refers in order to arrive at the conclusion mentioned above, namely that it is not possible to give a categorical answer to

the question. But, if some considerations may work in one direction and some in an opposite direction, it is necessary to see whether it is possible to single out from them those which would be important enough to turn the scale.

Now, this is possible if two characteristic features of the economies of underdeveloped countries are noticed, that is:

a) the fast growth rate of population,

b) the lack of so-called "external economies".

It has been ascertained that in underdeveloped countries the growth rate of population is, on average, higher than that of developed countries.

It would appear that investments in dwelling-houses, which have an extremely low coefficient of productivity (i.e. a very high Incremental-capital output ratio) will absorb in underdeveloped countries a higher percentage of total investments that that absorbed by developed countries. "Probably", Lewis writes, "underdeveloped countries need to assign more than 25% of their total accumulation in dwelling-houses".(28) This proportion, it is true, is less than in the U.S.A. where about $\frac{1}{5}$ of total capital formation pertains to building construction, which is understandable if it is remembered that the growth rate of population in the U.S.A. has also been very high and moreover, the productivity of investment in manufacturing is high, so the ICOR in the U.S.A. is not unduly raised by the large investment in construction of houses.

What can be said about other developed countries? In Great Britain, still according to Lewis, the percentage of total investments in dwelling-houses is about 20%, below the average, therefore, in underdeveloped countries. But what would be the average if we add other developed countries with a very low growth rate of population? We should then have a valid reason for a higher incremental capital-output ratio in under developed countries than in developed ones.

In Table 4 below the annual growth rates of population of a few developed and underdeveloped countries in the period 1958-61 are listed:

Table 4: Annual Growth rates of population in some countries 1958 - 1961

| Developed countries | annual growth rate of population | underdeveloped countries | annual growth rate of population |
|---|---|---|---|
| U.S.A. | 1,7 | COLUMBIA | 2,2 |
| UNITED K. | 0,7 | CHILE | 2,4 |
| GERMANY | -0,4 | BRAZIL | 3,6 |
| ITALY | 0,7 | VENEZUELA | 3,3 |
| JAPAN | 0,9 | MEXICO | 3,1 |
| FRANCE | 1,0 | NIGERIA | 1,9 |
| AUSTRIA | 0,3 | CONGO | 2,4 |
| BELGIUM | 0,5 | REP.C. AFRICA | 1,9 |
| HOLLAND | 1,3 | PAKISTAN | 2,1 |
| CANADA | 2,2 | INDIA | 2,2 |
| SOUTH AFRICA | 2,6 | | |
| AUSTRALIA | 2,2 | | |

Source: Demographic Yearbook, United Nations, New York, 1969.

Coming back to what has been said above, the lack of external economies may be of much more importance in the determination of ICOR in underdeveloped countries. Let us try, above all, to come to an agreement about the meaning of this phrase which has recently undergone many changes and additions compared with the original concept of Marshall.

According to Arndt, the concept of "external economies" in Marshall is different from that used at present. For Marshall they exclusively consist in the benefit which a given firm gets from the expansion of total industrial production, and they occur independently of the particular production of such a firm. The original concept has then undergone several changes, becoming wider and wider: at first in a study of Allyn Young, later thanks to the writings on economic growth.(29)

In order to include the several meanings recently given to the words "external economies" we shall start by saying that they are all those modifications of the surrounding economic background which favourably affect the productivity coefficient of capital invested in a certain economic activity.

It may therefore be assumed that "external economies" are

A. Those economies coming from the mutual relation between industries or economic activities which develop simultaneously. Among these it is possible to distinguish:
   1) "External economies" exploited by a certain firm which develops in an economic sector in a phase of expansion.
   2) "External economies" exploited by an economic activity for the contemporaneous development of other industries.

B. Those economies coming to a certain industry for the estab-

lishment of a system of infrastructures or social fixed capital (i.e. aqueducts, ports, roads, railways etc.).

In short, it is possible to say that the "External economies" are conditioned from one side, by the balanced growth of the economy, and from the other side, by investments in infrastructures. According to Nurkse the incentive to invest is limited by the extent of the market. This may create a vicious circle; the market may be limited because of a shortage of investment - say in improvement of transportation facilities - and yet there is no encouragement to make the necessary investments to overcome this, precisely because the market is limited.(30)

In order to come out of the vicious circle, a simultaneous development of several different industries is necessary, where every one of them offers its own products and, at the same time, demands those of other industries: briefly, every industry would generate "external economies" for all the others.

Of course, however, such balanced growth needs a very strong amount of initial investments, which are not possible in underdeveloped countries because of the shortage of investment funds.

Now, if a shortage of social fixed capital is a characteristic of underdeveloped countries, another characteristic, no less important, is that which is particular to the same

investments in infrastructures: they are indivisible, that is, they cannot be carried out in less than a certain minimum size. Nor, on the other hand, is it possible to carry out investments in activities where the time-lag is very short, i.e. directly productive investments, unless a minimum amount of investment in roads, railways, services etc. has taken place. Thus, investments in infrastructures must precede the achievement of balanced growth.

The classical economists predicted that productive investments would go, under the effect of free competition, towards those areas or countries where the cost of labour was lower; in reality, on the contrary, these investments have gone towards those areas or countries where the "external economies" were such as to allow lower costs even in the presence of relatively high wages.(31)

The error of the classical economists consisted in ignoring the peculiar indivisibility of fixed social capital. It is this indivisibility, as well as the necessity to have this kind of capital before establishing industries, that the classical economists did not see.

This feature is sufficient to explain the non-functioning of the mechanism which, according to the classical economists, ought to lead, under the action of free competition, to the elimination of income inequalities between countries. In fact, even if capital could move freely from one country to another, no private entrepreneurs would be able to set up, in the

underdeveloped countries, that quantity of fixed social capital which would have allowed the execution of standard industrial investments.

Both because of the necessity of devoting a large part of capital formation to infrastructures and because of the lack of "external economies", we can see a number of reasons which combine to explain why the Incremental capital-output ratiomcould be expected to be higher in underdeveloped countries than in developed countries. If to this we add what has been said about the growth rate of population and the consequent necessity of investing in building constructions, such a conclusion becomes still more inevitable.

A very simple conclusion may be derived from this analysis. In order to obtain a certain increase of per-capita real income, the underdeveloped countries would have to make a greater effort at creating capital than the developed countries, firstly because they have a higher capital-output ratio, secondly because they have a higher growth rate of population. Therefore, it is not surprising in such circumstances that differences in economic welfare between underdeveloped and developed countries tend to grow instead of decreasing.

# PART II

## THE CAPITAL-OUTPUT RATIO IN SOUTH AFRICA DURING THE PERIOD 1950-1964, AND SOME REFLECTIONS UPON IT.

# CHAPTER III

## The economic aggregates of Investment, Capital Stock, Product

The difficulties of comparing nominal (or monetary) aggregates over time are well recognised.

The value of a given set of goods can vary both because the real quantity of such goods increases or decreases, and because the prices which have been used for the valuation of these goods, vary.

For a study on the productivity of capital, which is what this work is intended to be, it is necessary that the economic aggregates used are not affected by changes in the purchasing power of money or, in other words by changes in the general level of prices. Therefore I have used, for investments (gross domestic fixed investments), for the capital stock, and for the product (gross domestic product at factor cost or value added) "real values", that is, values at 1958 constant prices. The data have been kindly supplied by the South African Reserve Bank.

The methods used in estimating the aggregates correspond in all cases, with the exception of the value added since 1965, with those employed by Mr. C.J. du Pisanie.(32)

Mr. du Pisanie's estimates of the value added in the main sectors were up-dated to 1965 by means of the following extrapolations. For mining, by the physical volume of

mining production, for manufacturing, by the physical volume of manufacturing production, electricity, gas and water, by electric current generated, and construction, by the value of investment in building and constructions at constant prices. The estimates pertaining to services were derived as a residual.

Before calculating the Capital-output ratio, let us analyse the series of gross fixed investments and gross domestic product with the aim of pointing out possibly significant features.

In Table 5 the percentage composition of gross domestic product by sector of economic activity for the 1950-69 period, has been calculated.

During the period 1950-69, about 13% of total gross domestic product pertains to agriculture, 12,6% to mining, 25% to industry and 49,4% to services.

Naturally the weight of such sectors in the total product has been changing during the period analysed, above all, because the economy has passed from a more or less agricultural stage to a more industrialised one. In fact, in the 1950-59 period, about 14,2% of Gross Domestic Product pertained to agriculture, and about 35% to industrial activities (including mining), while in the 1960-69 period about 11,8% pertained to agriculture and 39,8%to industrial activities (mining included).

Table 5. During the period 1950-1969 percentage distribution of the Gross Domestic Product at factor cost by sectors of economic activity.

Total G.D.P. = 100.

| Years | Agriculture | Mining | Manufacturing | Services |
|---|---|---|---|---|
| 1950 | 14,78 | 10.88 | 22,24 | 52,10 |
| 1951 | 15,28 | 10,65 | 22,57 | 51,50 |
| 1952 | 14,59 | 10,66 | 23,58 | 51,17 |
| 1953 | 15,12 | 10,08 | 23,67 | 51,13 |
| 1954 | 14,83 | 10,79 | 23,79 | 50,59 |
| 1955 | 14,30 | 11,50 | 24,10 | 50,10 |
| 1956 | 14,63 | 12,05 | 23,83 | 49,49 |
| 1957 | 13,45 | 12,79 | 24,09 | 49,67 |
| 1958 | 12,60 | 12,67 | 24,46 | 50,27 |
| 1959 | 13,11 | 13,56 | 24,19 | 49,14 |
| 1960 | 12,83 | 14,02 | 24,15 | 49,00 |
| 1961 | 13,35 | 14,06 | 24,03 | 48,56 |
| 1962 | 13,38 | 14,36 | 24,48 | 47,98 |
| 1963 | 12,27 | 14,10 | 25,57 | 48,06 |
| 1964 | 11,24 | 13,73 | 26,88 | 48,15 |
| 1965 | 10,76 | 13,45 | 27,36 | 48,43 |
| 1966 | 10,82 | 13,46 | 27,79 | 47,93 |
| 1967 | 12,66 | 12,59 | 27,62 | 47,13 |
| 1968 | 10,61 | 12,59 | 27,63 | 49,17 |
| 1969 | 10,99 | 11,97 | 28,65 | 48,39 |
| Mean | 13,02 | 12,59 | 25,00 | 49,39 |
| Period | | | | |
| 1950-59 | 14,30 | 11,56 | 23,63 | 50,51 |
| 1960-69 | 11,89 | 13,43 | 26,11 | 48,27 |

Source: The data on G.D.P. were provided by the South African Reserve Bank.

However, the transformation undergone by the South African economy can be better pointed out by considering the percentage of investments absorbed by different economic sectors.

If we look at Table 6 it is possible to see the gradually decreasing importance of the agricultural and mining sectors.(33) On the contrary the industrial sector shows an increasing tendency during the same period. The fact that this sector has absorbed increasing percentages of investment compared with the other sectors, can be ascribed to the following causes:

1) The particular nature of investment in the primary activities (agriculture);
2) The policy of government towards manufacturing industries;
3) The declining relative importance of gold mining;
4) The growth of services, which permit an enlargement of the market.

On the first point we can say that South Africa over many years had been, first and foremost, an agricultural country (or countries). The level of current investment in more recent years has, as a result of reaping the deferred returns of past investments, been at a lower level in consequence of this. This particular relationship cannot, however, be laid down with any certainty. As was already noted in the introduction, recent changes in the mode of agriculture, which increase the degree of mechanisation, have greatly increased the capital intensitivity of this sector. Yet many of the improvements in the productivity of agriculture - such as the use of selected seeds and improved animal breeds or strains, have been of a capital-saving nature, and income generated in agriculture has not necessarily been re-invested in agriculture. As a result, in the 60's, a greater

Table 6. Percentage distribution of gross fixed investment by sectors of economic activity.

Total fixed investment = 100

| Years | Agriculture | Mining | Manufacturing | Services |
|---|---|---|---|---|
| 1950 | 15,14 | 13,68 | 26,04 | 45,14 |
| 1951 | 15,92 | 14,44 | 26,38 | 43,26 |
| 1952 | 13,71 | 16,62 | 23,48 | 46,19 |
| 1953 | 12,78 | 14,75 | 26,76 | 45,71 |
| 1954 | 12,94 | 15,10 | 26,30 | 45,66 |
| 1955 | 13,00 | 13,03 | 25,45 | 48,52 |
| 1956 | 12,01 | 11,53 | 24,32 | 52,14 |
| 1957 | 11,24 | 10,09 | 23,36 | 55,31 |
| 1958 | 10,05 | 9,19 | 24,29 | 56,57 |
| 1959 | 10,32 | 9,66 | 26,69 | 53,33 |
| 1960 | 9,95 | 12,17 | 24,15 | 53,73 |
| 1961 | 9,86 | 13,21 | 24,84 | 52,09 |
| 1962 | 10,23 | 10,39 | 27,10 | 52,28 |
| 1963 | 9,12 | 8,79 | 30,68 | 51,42 |
| 1964 | 7,97 | 8,88 | 33,27 | 49,88 |
| 1965 | 6,46 | 7,65 | 32,77 | 53,12 |
| 1966 | 6,49 | 7,13 | 35,38 | 51,00 |
| 1967 | 6,68 | 7,76 | 36,17 | 49,39 |
| 1968 | 6,76 | 7,95 | 32,67 | 52,62 |
| 1969 | 6,30 | 7,80 | 29,30 | 56,60 |
| Period | | | | |
| 1950-69 | 10,34 | 10,98 | 27,94 | 50,74 |
| 1950-59 | 12,71 | 12,80 | 25,27 | 49,22 |
| 1960-69 | 7,98 | 9,17 | 30,64 | 52,21 |

Source: The data on gross fixed investment were provided by the South African Reserve Bank.

percentage of product to be invested was at the disposal of the other sectors.

Another factor, which has given an impetus to the investment activity in the industrial sector, has been the particular policy of government towards manufacturing industry. Inter alia, the Viljoen Commission of 1958(34) recognised that the small size of the market was a major impediment to the growth of manufacturing industries, and suggested various measures to be adopted to overcome such a difficulty. Prominent among these were measures designed to give an assured extent of the home market to local producers, in the hope that this would create economies of scale, and greater efficiency in production would thus, after a while, render South African industrial products competitive with imports, even without special measures of protection. Both customs tariffs and import controls have been employed in that way to the utmost extent permitted under G.A.T.T. rules.

The fact that gold had to be sold, throughout this period, at a fixed price of $35 an ounce, despite inflationary increases in the cost of mining, acted as a brake on investments in the mining sector, thus leaving a greater percentage of output to be invested in the industrial sector.

However, I believe that the factor which has more influence on investment activities in the industrial sector has been the development of services.

This last sector, by means of its components (i.e.

Government, financial services, transports and communications) has produced a suitable background for the development of industry. The "external economies" caused by the development of services, such as credit facilities, governmental subsidies, relatively cheaper transport, have improved the private profitability of industrial developments and may thus have made the industrial sector a kind of magnet for investments.

Throughout this period government spending has been growing particularly fast. It would be informative to break down the aggregate for services in Table 6 into some of its component parts, one of which would be government spending. Unfortunately the sources available do not allow of the elaboration of the table in this way.

## CHAPTER IV

## The capital output ratios in South Africa during the period 1950-69.

### I. The incremental capital output ratio (ICOR).

The ICOR has been calculated for the following sectors:

- Agriculture, forestry and fishing;
- Mining;
- Industry (manufacturing, construction, electricity, gas and water);
- Services (i.e. transports and communications, government trade, financial services and fixed property, dwellings and other services);
- The whole economy (i.e. agriculture, mining, industry and services).

The economic aggregates used have been gross fixed investments and gross domestic product at factor costs, both at 1958 constant prices. (South West Africa is excluded). The results obtained are listed in Table 7.

As can be seen, the annual data show considerable fluctuations and so are not very signfficant; such fluctuations are due, above all, to the investment cycle which is a general characteristic of every sector, and also, among other things, due to the fact that the agricultural sector and the mining sector are concerned with climatic situations, which offset the annual output, and with considerations of monetary policy respectively (it is known that about 20% of mining production

Table 7. The ICOR by sectors of economic activity. Period 1950-68 (the empty spaces mean that the ratio has turned out negative).

| Years | Agriculture | Mining | Services | Manufacturing | Total |
|---|---|---|---|---|---|
| 1950 | 2,83 | 10,26 | 5,23 | 4,10 | 4,61 |
| 1951 | - | 8,31 | 6,59 | 3,24 | 6,36 |
| 1952 | 2,54 | - | 4,28 | 4,28 | 4,66 |
| 1953 | 5,16 | 2,76 | 4,44 | 4,28 | 4,10 |
| 1954 | 14,71 | 2,93 | 5,45 | 4,23 | 4,85 |
| 1955 | 2,66 | 2,49 | 5,42 | 5,88 | 4,27 |
| 1956 | - | 1,91 | 4,75 | 3,96 | 4,90 |
| 1957 | - | 10,66 | 6,33 | 5,05 | 8,39 |
| 1958 | 2,13 | 1,43 | 11,96 | 6,62 | 5,12 |
| 1959 | 8,51 | 2,00 | 5,34 | 6,06 | 5,15 |
| 1960 | 1,64 | 3,03 | 4,83 | 4,02 | 3,67 |
| 1961 | 2,65 | 2,49 | 5,30 | 3,24 | 3,77 |
| 1962 | - | 2,58 | 2,74 | 1,58 | 2,57 |
| 1963 | - | 1,97 | 2,29 | 1,62 | 2,18 |
| 1964 | 13,57 | 4,10 | 3,66 | 3,71 | 5,56 |
| 1965 | 2,76 | 2,86 | 7,19 | 4,60 | 5,12 |
| 1966 | 1,58 | - | 4,72 | 4,63 | 3,35 |
| 1967 | 1,01 | 3,57 | 2,95 | 5,77 | 4,88 |
| 1968 | 1,40 | 9,47 | 4,87 | 2,56 | 3,42 |
| Periods | | | | | |
| 1950-68 | 4,53 | 3,38 | 4,50 | 3,67 | 4,03 |
| 1950-56 | 4,53 | 4,43 | 5,09 | 4,25 | 4,67 |
| 1956-62 | 5,45 | 2,37 | 5,90 | 4,55 | 4,77 |
| 1962-68 | 4,00 | 3,84 | 3,75 | 3,24 | 3,59 |

pertains to gold). Although the price of gold in rands remained virtually constant throughout the period, and indeed because of it, the timing of investment in gold mining was affected both by considerations of the current rate of inflation and by changing expectations regarding an eventual revaluation of monetary gold.

In order to smooth such fluctuations and make the ICOR more significant, the moving average over three years has been used. In other words, the Incremental capital-output ratio has been calculated every year on the basis of the following formula:

$$K_t = \frac{\frac{1}{3}\sum_{t=1}^{3} I_t}{\frac{1}{3}\sum_{t=1}^{3} \Delta Y_{t+1}} =$$

$$= \frac{\frac{1}{3}(I_1 + I_2 + I_3)}{\frac{1}{3}(Y_2 + Y_3 + Y_4 - Y_1 - Y_2 - Y_3)} =$$

$$= \frac{I_1 + I_2 + I_3}{Y_4 - Y_1} \qquad \text{(XVII)}$$

Such a method, owing to the technical characteristics of the moving average at 3 terms, excludes the first and the last terms of the series product and investments. Therefore the period gets narrower; and hence the ICOR, in terms of the formula utilised, can only be calculated for the period 1951-67, not for the the whole period 1950-68.

Table 8. The ICOR by sectors of economic activity on the basis of three terms moving average. (The empty space means that the ratio is negative). Period 1951-1967.

| Years | Agriculture | Mining | Manufacturing | Services | Total |
|---|---|---|---|---|---|
| 1951 | 4,30 | - | 3,82 | 5,13 | 5,07 |
| 1952 | 5,54 | 6,25 | 3,90 | 4,81 | 4,78 |
| 1953 | 4,68 | 4,30 | 4,26 | 4,69 | 4,51 |
| 1954 | 4,75 | 2,73 | 4,66 | 5,06 | 4,39 |
| 1955 | - | 2,42 | 4,55 | 5,17 | 4,66 |
| 1956 | - | 2,87 | 4,85 | 5,46 | 5,41 |
| 1957 | - | 2,26 | 5,05 | 6,88 | 5,78 |
| 1958 | 8,00 | 2,31 | 5,88 | 7,43 | 5,85 |
| 1959 | - | 2,02 | 5,34 | 6,63 | 4,54 |
| 1960 | 2,73 | 2,48 | 4,18 | 6,40 | 4,10 |
| 1961 | 3,50 | 2,68 | 2,49 | 3,97 | 3,25 |
| 1962 | - | 2,32 | 1,88 | 2,99 | 2,67 |
| 1963 | - | 2,70 | 2,12 | 2,83 | 2,79 |
| 1964 | 6,78 | 2,79 | 2,96 | 3,80 | 3,49 |
| 1965 | 1,38 | 4,74 | 4,32 | 4,93 | 4,01 |
| 1966 | 3,04 | 4,44 | 4,41 | 4,34 | 4,03 |
| 1967 | 2,21 | 6,95 | 4,16 | 3,97 | 3,95 |

As can be seen from Table 8, the use of a three-year moving average renders the values of the ICOR much less erratic, and therefore more reliable, although fluctuations in the agricultural sector remain. This, however, as mentioned previously, is a particular characteristic of such a sector, with its wide climatic variations, so that some tend to deny any reliability to the Incremental capital-output ratio calculated for this sector, especially when this calculation is concerned with short runs.

Rather high values of ICOR (I refer to the primary sector) have been apparent in 1955-1959 and 1962-64; this is due, above all, to the annual growth rate of output having been very low and sometimes even negative as in 1957-58 and 1963.

From the data in Table 7 it also appears that in the primary sector the incremental capital-output ratio passes through three different stages: in fact, by dividing the period 1950-68 into three sub-periods of seven years each, we get:(35)

| Periods | ICOR |
|---|---|
| 1950-1956 | 4,53 |
| 1956-1962 | 5,45 |
| 1962-1968 | 4,00 |

That is, the productivity of capital in the primary sector decreases in the period 1956-1962 (ICOR = 5,45) and increases during the period 1962-1969 (ICOR = 4,00). Looking at the three periods simultaneously, it is possible to note that productivity during the whole period 1950-1968 has shown an increasing tendency; this is better pointed out by looking for the trend of ICOR in the whole period. The method used has been interpolation with the least squares method.

Table 9. Real and theoretical ICOR's in the agricultural sector.

| Years | Real Value | Theoretical Values (y = a(x-1950)+c) |
|---|---|---|
| 1950 | 2,83 | 5,69 |
| 1951 | - | - |
| 1952 | 2,54 | 5,65 |
| 1953 | 5,16 | 5,59 |
| 1954 | 14,71 | 5,52 |
| 1955 | 2,66 | 5,43 |
| 1956 | - | - |
| 1957 | - | - |
| 1958 | 2,13 | 5,03 |
| 1959 | 8,51 | 4,86 |
| 1960 | 1,64 | 4,65 |
| 1961 | 2,65 | 4,45 |
| 1962 | - | - |
| 1963 | - | - |
| 1964 | 13,57 | 3,68 |
| 1965 | 2,76 | 3,38 |
| 1966 | 1,58 | 3,06 |
| 1967 | 1,01 | 2,72 |
| 1968 | 1,40 | 2,36 |
| Period | | |
| 1950-68 | 4,53 | |

The interpolating function used has been that which, among the following ones, has given the minimum square deviation.(36)

The functions used have been:

| Functions | Square deviation |
|---|---|
| $y = ax + e$ | 4,3056 |
| $\lg y = a \lg x + e$ | 4,6572 |
| $y = a \lg x + e$ | 4,3868 |
| $y = \frac{a}{x} + e$ | 4,3720 |
| $\lg y = \frac{a}{x} + e$ | 4,6424 |
| $y = ax^2 + e$ | 4,2466 |
| $y = ax^{\frac{1}{2}} + e$ | 4,3624 |

It emerges that the best interpolator has been the parabola

$$y = ax^2 + e$$

which has taken the form:

$$y = - 0,0102 (x - 1950) + 5,7014$$

where y is the ICOR, and x time (i.e. x = 1950 , 1951, ....1968).

It seems to be clear (Table 9) that the trend of the ICOR has been decreasing, that is, that the trend of the productivity of capital in the primary sector or agriculture, has been increasing this being the major source of income for such a sector.

The reasons why in this sector capital productivity was increasing can be numerous. The simplest hypothesis is that

people have invested less with no diminution of product. Let us see if this is true. In the period 1950-56 the rate of accumulation was 21,9%, in the period 1956-62 about 16,7% and in the period 1962-68 about 14,5%.

At first sight the hypothesis being tested would appear to fit the facts. But if we notice that in the period 1956-62 the average annual growth rate of product was about 3,7% while in the period 1962-69 it was about 7,4%, we can say that the explanation was just that investment, independently of its amount was more productive. In fact, in quantitative terms the percentage of investment is reduced over time, but speaking of investments only in quantitative terms is not sufficient; their qualitative features must not be forgotten.

Then, the productivity of an investment is not only due to the investment itself, but also to other factors, such as the labour, the techniques utilised and the policy of the government as it affects a certain sector. And I believe it is precisely this last factor which makes capital productivity in the primary sector increase during the period under consideration.

It is not the aim of this study to list and to analyse the work and the results of the several private or governmental commissions set up to introduce into agriculture methods which are more and more scientific and suitable to different agrarian zones. Generally, the primary sector is a sector which escapes to a greater extent the control and planning of men, and for this reason sometimes negative rates of growth of output can

be obtained, rates which, without an adequate agricultural policy, would lead this sector to stagnation and disinvestment. Agricultural policy in South Africa in the last 15-20 years has brought a change from a situation where the productivity of the soil was falling at an alarming rate to one where future productivity is being steadily built up. Unfortunately the same cannot be said of the African reserves,

Looking now at the mining sector, the striking feature apparent from Table 8 is the steadiness shown by ICOR during the analysed period. This steadiness is better pointed out by interpolation of the annual values of the Incremental capital-output ratio. For this interpolation the functions already utilised in the primary sector have been used, to choose that one which has shown the minimum square deviation, that is:

| Functions | Square deviation |
|---|---|
| $y = ax + c$ | 3,0236 |
| $\lg y = a \lg x + c$ | 2,7417 |
| $y = a \lg x + c$ | 2,6577 |
| $y = \frac{a}{x} + c$ | 2,6954 |
| $\lg y = \frac{a}{x} + c$ | 2,7724 |
| $y = ax^2 + c$ | 3,0814 |
| $y = ax^{\frac{1}{2}} + c$ | 2,8822 |

the semi-logarithmic

$$y = a \lg x + c$$

which in this sector takes the following form:

$$y = - 0,476 \lg (x - 1950) + 4,8843$$

where y is the ICOR and x time

$$(x = 1950, 1951, \ldots\ldots 1968).$$

Even in the mining sector, as the angular coefficient of the function states, the Incremental capital-output ratio has shown a decreasing trend. Such a decreasing trend also comes from the smoothed data listed in Table 10.

If we now divide, as has already been done for the agricultural sector, the period 1950-69 into three sub-periods, it is possible to note that the ICOR in the periods 1950-56, 1956-62 and 1962-68 takes the values of 4,43, 2,37 and 3,84 respectively. The very low value of 2,37 and therefore the high productivity of capital, is certainly due to the remarkable rate of growth of product in the same period; it is, in fact, in average of 8%, with maximum points of 10,4% in 1956, of 10,8% in 1957 and 12% in 1959.

From Table 8 it is also clear that the mining sector is the sector which has shown the lowest ICOR, and, therefore, the highest capital productivity during the analysed period: about 30% of total product pertains to the capital factor. All this depends, among other things, on the particular care that this sector has received over time, having been, in fact, the main source of taxation and foreign exchange for the South African economy.

Moreover, if we note that the quasi-totality of the product of mines pertained to gold, we can see more clearly why such a sector has received all that attention which brought it to considerable levels of productivity.(37)

Table 10. Real and theoretical ICOR's in the mining sector.

| Years | Real Values | Theoretical values $y = a \log(x-1950)+c$ |
|---|---|---|
| 1951 | 8,31 | 4,88 |
| 1952 | - | - |
| 1953 | 2,76 | 4,36 |
| 1954 | 2,93 | 4,22 |
| 1955 | 2,49 | 4,11 |
| 1956 | 1,91 | 4,02 |
| 1957 | 10,66 | 3,95 |
| 1958 | 1,43 | 3,89 |
| 1959 | 2,00 | 3,83 |
| 1960 | 3,03 | 3,78 |
| 1961 | 2,49 | 3,74 |
| 1962 | 2,58 | 3,70 |
| 1963 | 1,97 | 3,66 |
| 1964 | 4,10 | 3,63 |
| 1965 | 2,86 | 3,59 |
| 1966 | - | - |
| 1967 | 3,57 | 3,53 |
| 1968 | 9,47 | 3,50 |
| Period | | |
| 1950-68 | 3,38 | |

Gold, besides having all the economic characteristics of any commodity whatever, possesses a greater special importance for the peculiar attributes that it has, both in the national and in the international field. And so, at least while such conditions last, it is more than understandable from the economic point of view, that such a sector should receive the most complete and particular attention. Leaving out the monetary function of gold in the international field, the great influence that it has on the national economy must not be forgotten, such as:

1) It is a provider of foreign exchange. "The possession of an export article, particularly one with the attributes of gold, which all the world wants, is a great advantage to a young country. Gold as the final means of settling international indebtedness can enter through doors which import controls close against other commodities. And hence, from the establishment of Union, South Africa could pay, without undue difficulty, for the capital goods it urgently needed to expand its total national production".(38) Even though some of these advantages have been eroded through inflation since these words were written, others still remain, and no other comparable source of massive supplies of foreign exchange emerged.
2) It is a stabilising factor in the economy. Gold has always exerted a remarkable stabilising effect in the South African economy, owing to the peculiar relationship between its production costs and the price of its end product. The use of gold as the basis of international money makes its price

fixed and, then, there is an infinitely elastic demand for the product at the prevailing price.

During periods of general economic prosperity there will be a tendency for costs to rise, and since in such a sector these cannot be passed on to the consumer, the profit margins contract, On the contrary, during periods of general recession the mining costs tend to fall and the profit margins to rise. Some have shown that in such periods the dividends were maintained and employment, in contrast to the general employment index, expanded in the gold mines.

The facts concerning the gold mining industry just considered may, indeed, have a great deal to do with the increased capital productivity noted for the mining sector. Increased efficiency may form a large part of the explanation, and this, in turn, may have its major origins in the great incentives to reduce costs of production and to offset unavoidable increases in costs of production emanating from other causes. The gold mining industry was not, until very recently, able to pass on higher costs in the form of higher prices. This may well have proved to be a particular stimulus to improvements in productivity. This process, however, has its limits, and the possibility of offsetting the rise in other costs through this means may have become virtually exhausted during the 1962-69 period.

3) It is a brake upon inflation. As a consequence of the relationship between costs and the fixed price of gold mentioned above, the gold-mining industry is particularly sensitive to any factor which tends to increase costs. Thus,

inflationary pressures could have a serious effect upon the profitability and output of one of the major industries of the country.

"Knowledge of this fact has always had a salutary effect upon successive governments and any tendency to take the easy path of inflation has been checked by the realisation of its effects upon South Africa's major export".(39)

However, it is known that any economic growth is normally accompanied by a certain inflation due to demand, viz. internal and external demand for consumption or investment goods, moreover, if we consider the fact that gold is a natural resource, deposits of which are not inexhaustible, and that a major source of demand has been restricted by its decreased importance as international money, we shall realise why in the period 1962-69 the rate of accumulation in the mining sector has decreased by about 18,6% in comparison with the period 1956-62, while the average annual growth rate declined from 8% (1956-62) to 4,2% (1962-69); factors which have caused the productivity of capital to decrease from the exceptionally high level of 42% (1956-62) to 26% (1962-69).

Now let us look at the incremental capital-output ratio in the industrial sector. From the data of Table 8 it seems that such a coefficient assumes values varying from more than 5 to less than 2. The highest values are obtained in the years 1957-1958-1959, that is, 5,05, 5,88 and 5,35 respectively, and the lowest ones in the period 1961-64, when these values

fluctuated around 2. This last period coincides with the depression after Sharpeville and then the recovery of the South African economy; the annual average growth rate was about 9,3%.

In the following years (1966-68) the ICOR increases. Such an increase appears to be due, above all, to the strong expansion of demand during the period of boom which increased the expectations of profit from capital investment in manufacturing industry, even though the extent of new investment brought about a reduction in the production of capital goods. It is known, in fact, that this sector is one of the most elastic to the variations due to the trade cycle (or economic trend), because of shorter planning and supplementation periods, the sector showed the highest rates of accumulation, about 30% in the period 1965-68, while, for the same period, the primary, mining and tertiary sectors showed lower rates of accumulation, about 13,7%, 14% and 25% respectively.

> "The expansion of the private manufacturing sector from relative insignificance in 1911-12 to the largest single component of the national income is undoubtedly the greatest structural change that has taken place in the South African economy during the last years.
>
> Although protective tariffs have played some part in stimulating industrial development, the main cause has undoubtedly been the expansion of the South African market.
>
> Based initially upon the gold mines and the urban population which grew up around them, the manufacturing developments have had an accumulative effect in expanding the market, because each successful phase of industrial expansion generates more income and increases the urban population, and this in turn stimulates further expansion". (40)

If we divide the period 1950-69 into three sub-periods, it can be seen that the ICOR in the period 1950-56 assumes the value of 4,25, in the period 1956-62 of 4,55 and in the period 1962-68 of 3,24. It appears that the capital productivity shows an increasing tendency over the period. This tendency is better demonstrated by interpolating the ICORs calculated for the same period (i.e. 1950-68).

The interpolator used has been the parabola $y = ax^2 - c$, since it has shown the lowest square deviation index compared with the other functions, in fact

| Functions | Square deviation |
|---|---|
| $y = ax^2 + c$ | 1,5243 |
| $\lg y = a \lg x + c$ | 1,5582 |
| $y = a \lg x + c$ | 1,5248 |
| $y = \frac{a}{x} + c$ | 1,5249 |
| $\lg y = \frac{a}{x} + c$ | 1,5561 |
| $y = ax^2 + c$ | 1, 5237 |
| $y = ax^{\frac{1}{2}} + c$ | 1,5254 |

the parabola $y = ax^2 + c$ has taken the following form:

$$y = -0,00072\ (x - 1950)^2 + 4,3657$$

and it has given the following values, which are listed in Table 11.

Table 11. Real and theoretical ICOR's in the manufacturing sector

| Years | Real values | Theoretical values $y = a(x - 1950)^2 + c$ |
|---|---|---|
| 1950 | 4,10 | 4,365 |
| 1951 | 3,24 | 4,365 |
| 1952 | 4,28 | 4,362 |
| 1953 | 4,28 | 4,359 |
| 1954 | 4,23 | 4,354 |
| 1955 | 5,88 | 4,347 |
| 1956 | 3,96 | 4,339 |
| 1957 | 5,05 | 5,330 |
| 1958 | 6,62 | 4,319 |
| 1959 | 6,06 | 4,307 |
| 1960 | 4,02 | 4,293 |
| 1961 | 3,24 | 4,278 |
| 1962 | 1,58 | 4,262 |
| 1963 | 1,62 | 4,243 |
| 1964 | 3,71 | 4,224 |
| 1965 | 4,60 | 4,203 |
| 1966 | 4,63 | 4,181 |
| 1967 | 5,77 | 4,157 |
| 1968 | 2,56 | 4,132 |
| Period | | |
| 1950-68 | 3,67 | |

Both from the negative angular coefficient of the parabola and from the interpolated data the decreasing trend of ICOR's comes out, and, thus, the increasing capital productivity for the industrial sector.

The fact that this sector has shown an increasing productivity of capital (and this has been relatively high in the last years, about 30% in the period 1962-68) may be due to various factors.

I have already mentioned the government policy towards such a sector and the development of services, which had the effect of generating "external economies" for the manufacturing sector. The productivity of capital in this sector may also have been affected by the fact that the exchange rate has been overvalued and protected by comprehensive exchange controls. This has tended to discourage investment in mining and encourage investment and the returns to it in industry. Moreover, if we consider the fact that South Africa is richly endowed with many essential raw materials, we can better realise that the progress of manufacturing industry in South Africa is likely in future to eclipse its present development.

Certainly, there are still many difficulties: above all it is necessary for the domestic market to expand. For some classes of industry, in fact, the domestic market is so small that introduction of the most modern machinery throughout the plant is not worthwhile, and sufficiently long production runs to take full advantage of the economies of scale are not justified. The small domestic market is partly due to the

size of the South African population compared with that of the major industrialised countries.

The limited domestic market is, however, also due to the fact that the majority of the South African population has only a very low level of consumption: mass production methods necessarily imply mass consumption of their products.

> "Difficulties of a different kind also arise from the fact that many factories were originally set up to manufacture consumers' goods out of imported semi-processed or raw materials, and these were allowed in duty free or on rebate with the increasing emphasis on the need to stimulate the use of local raw materials, protective tariffs are being demanded by factories engaged upon the earlier stages of the productive process. This tends to raise costs for the manufacturer at the final stage, and he in turn tends to pass them on in higher prices to the consumer ... The dilemma facing the automobile industry is that factories were established at the ports to assemble vehicles from foreign components.
>
> Now pressure is being brought to bear upon them to use a progressively greater proportion of South African made components, until eventually the whole car will be a local manufacture with the sound basis of an indigenous iron and steel industry: this is probably wise policy in the long run, but it raises great difficulties in costs, location and markets at the present time". (41)

Of course, the inadequacy of the home market might be offset by promoting export trade; this would make possible an increase of demand which could be added to the home demand and, so, a greater market for South African products would develop. Moreover the balance of payments would depend much less upon the production of gold. In view of the ultimate inevitable exhaustion of the gold mines and the uncertainties still facing gold as an international currency, as a long term

aim, and in view of South Africa's industrial potentialities, it might be better to export manufactured goods than gold. But in order to increase exports a certain policy is necessary: the eventual markets of South African products are very distant and if the prices have to remain competitive the internal prices must be relatively low. Moreover, the successful development of export markets may require a greater liberalisation of commercial exchange and of exchange controls than either prospective importing countries may allow, or than South Africa may be willing to concede through reciprocal concessions. With the accession of the United Kingdom, which constitutes a preferential export market, to the European Economic Community, the barriers to enlarging the scale of South African manufacturing establishments through supplying exports markets may increase in the near future rather than diminish.

I have mentioned some economic features; if political features are also added the difficulties that the manufacturing sector can meet undoubtedly increase. However the development that it has shown during the last years cannot be denied, in the period 1962-69 the rate of accumulation was 27%, the rate of growth 8,7%; the productivity of capital about 30%, showing an increase, compared with the period 1956-62, of about 42%.

It is current opinion that (I use Kaldor's words)(42)

> "... fast rates of economic growth are associated with the fast rate of growth of the 'secondary' sector of the economy - mainly the manufacturing sector - and that this is an attribute of an

> "intermediate stage of economic development: it is the characteristic of the transition from 'immaturity' to 'maturity'". (43)

If this is so and if a high overall rate of economic growth is desired the secondary sector of the economy must develop to a greater extent than with the other ones.(44) A high correlation should exist between the overall rate of growth (the rate of G.D.P.) and the rate of growth of the secondary sector. Such a correlation has been found for South Africa, and the correlation coefficient has been found to be rather high and positive ( r = 0,8281).

Indeed it is not a random relationship; Kaldor has found a similar relationship for a sample of 12 countries, and has given, moreover, valid explanations of this in the work mentioned above. Therefore, on the basis of such a relationship, expressed by a regression equation, one can predict fairly accurately the rate of growth of an economy, if the rate of growth of the manufacturing sector is known. For South Africa, by using the data at my disposal for the period 1950-68, I found that the regression equation of the rate of growth of G.D.P. on growth of manufacturing output was:

$$y = 2,779 + 0,372x$$

where y is the growth rate of G.D.P. and x the growth rate of manufacturing output.

Coming back to Table 8, it is clear that the services sector has also shown an increasing productivity of capital over the period. This can be more satisfactorily demonstrated

by looking, by means of the usual interpolation, at the trend of the ICOR in the period under analysis. The interpolator used is the parabola $y = ax^2 + c$, since it is the function which shows the minimum square deviation compared with the other functions. Such a parabola, in this case, takes the following form

$$y = -0,0055\ (x - 1950)^2 + 5,8168$$

where y is the Incremental capital-output ratio and x = 1950, 1951 ... 1968. The negative coefficient of the parabola and the interpolated values (see Table 12) show the decreasing trend of ICOR and increasing trend of capital productivity.

Like the manufacturing sector, services also show a considerable increase in capital productivity during the period 1962-68 in comparison with the period 1956-62. In fact, in the former, the ICOR was 5,99 (and the productivity of capital about 16%), while in the latter the ICOR was 3,75 (and the productivity of capital about 26%), showing an increase of 60%. Nevertheless, the services sector is the sector which, together with the primary activity, shows the highest incremental capital-output ratio, in fact:

ICOR ($\triangle K/\triangle Y$) rates of growth ($\triangle Y/Y$) and rates of accumulation ($I/Y$) by sectors of economic activity. (Period 1950-68).

| | $\triangle K/\triangle Y$ | $\triangle Y/Y$ | $I/Y$ |
|---|---|---|---|
| AGRICULTURE | 4,53 | 4,39% | 17,33% |
| MINING | 3,38 | 6,01% | 20,91% |
| MANUFACTURING | 3,67 | 6,85% | 25,84% |
| SERVICES | 4,50 | 5,01% | 23,40% |
| TOTAL | 4,09 | 5,33% | 20,83% |

Table 12. Real and theoretical ICOR's in the Services sector

| Years | Real values | Theoretical values $y = a(x - 1950)^2 + c$ |
|---|---|---|
| 1950 | 5,23 | 5,816 |
| 1951 | 6,59 | 5,811 |
| 1952 | 4,28 | 5,794 |
| 1953 | 4,44 | 5,767 |
| 1954 | 5,45 | 5,728 |
| 1955 | 5,42 | 5,679 |
| 1956 | 4,75 | 5,619 |
| 1957 | 6,33 | 5,547 |
| 1958 | - | - |
| 1959 | 5,94 | 5,372 |
| 1960 | 4,83 | 5,267 |
| 1961 | 5,30 | 5,152 |
| 1962 | 2,74 | 5,026 |
| 1963 | 2,29 | 4,888 |
| 1964 | 3,66 | 4,740 |
| 1965 | 7,19 | 4,581 |
| 1966 | 4,72 | 4,411 |
| 1967 | 2,95 | 4,230 |
| 1968 | 4,87 | 4,038 |
| Period | | |
| 1950-68 | 4,50 | |

Unfortunately, it is impossible to analyse in a particular manner the services sector, since this sector includes, at least with the data at my disposal, branches of economic activity which have in common only the economic destination; that is, to be a service. Yet the economic significance of these services varies greatly and the amount of capital investment appropriate to a given output of services varies accordingly. The data at my disposal for this sector include those pertaining to transport and communications, to retail and wholesale trading, to financial services, to government functions, to services imputed to the ownership of dwelling-houses and other forms of fixed property. Data are not available to me through which the data may be disaggregated into each individual branch of economic activity covered by the broad heading. The significance of an ICOR calculated for such a conglomerate concept of services is therefore reduced. This does not mean that the ICOR calculated for such a sector may not be relied on; but only that it is composed of different components which may in fact possess widely different values or show different trends. The compilation of the national accounts simply prevents the separate calculation of the ICOR for branches of economic activity such as transport and communications, trade, financial services, etc. A statement that the ICOR in the services sector is high, is incomplete, since it tends, by nature of the case, to be high in the case of transportation, yet low in the case of trade, financial services (banking and insurance), or fixed property.

However, on account of the considerable importance which transport and communications and government take in this sector, it has been ascertained that such a sector, at a macro-economic level, shows the lowest productivity of capital, at least in those countries which are passing through a stage of rather rapid economic development, and where large expenditures take place on defence. Finally, it remains only to calculate the ICOR for the whole South African economy in the same period. Since all the economic sectors have shown a decreasing trend of ICOR (i.e. increasing trend of capital productivity), it seems that the economy as a whole will also show an increasing capital productivity during the same period. In fact, by using the usual interpolation of the annual ICOR, it is possible to see that the parabola $y = ax^2 + c$ (here also it is the best interpolator) takes the following form:

$$y = -0,0036\ (x - 1950)^2 + 5,027$$

where the negative slope merely shows the decreasing trend of the series. This can be seen more clearly from the values listed in Table 13.

What has been said about the increasing productivity of capital for the sectors already examined is also valid in this case; but a factor of general importance should be added to what has been already said. This will be done later in considering the factors which affect the incremental capital-output ratio.(45)

Table 13. Real and Theoretical ICOR's in the whole South African economy

| Years | Real values | Theoretical values $y = a(x - 1950)^2 + c$ |
|---|---|---|
| 1950 | 4,61 | 5,027 |
| 1951 | 6,36 | 5,023 |
| 1952 | 4,66 | 5,012 |
| 1953 | 4,85 | 4,994 |
| 1954 | 4,10 | 4,969 |
| 1955 | 4,27 | 4,937 |
| 1956 | 4,90 | 4,897 |
| 1957 | 8,39 | 4,850 |
| 1958 | 5,12 | 4,796 |
| 1959 | 5,15 | 4,735 |
| 1960 | 3,67 | 4,667 |
| 1961 | 3,77 | 4,591 |
| 1962 | 2,57 | 4,508 |
| 1963 | 2,18 | 4,419 |
| 1964 | 5,56 | 4,322 |
| 1965 | 5,12 | 4,217 |
| 1966 | 3,35 | 4,106 |
| 1967 | 4,88 | 3,987 |
| 1968 | 3,42 | 3,861 |
| Period | | |
| 1950-68 | 4,03 | |

2. The average capital-output ratio.

In calculating the average capital-output ratio(ACOR) the following economic aggregates have been used: capital stock and net product at constant 1958 prices.
The average capital-output ratio (ACOR) comes from the ratio:

$$\bar{k}_t = \frac{K_t}{Y_t}$$

where $\bar{k}_t$ is the ACOR, $K_t$ the stock of Capital in the period t, and $Y_t$ the net product in the same period. Such a coefficient is generally used to measure the capital intensity of production. The first method worked out by economic theory to measure the capital-intensity is the duration of the average period of production, a method supported by the writers of the early Austrian school. The basic concept of the Austrian theory is that, since every productive activity requires time, the longer the time employed the greater the product obtained, the longer the duration of production the more numerous the stages of production, and then the greater the quantity of productive instruments which can be created and utilised for the production of end-products together with the labour factor.

Consequently, the longer the period of production, the greater the quantity of capital utilised and, so, the higher the capital intensity of production. But this unit of measure cannot be applied to the economic structure as a whole. The productive structure does not consist of one process only, but of many parallel processes, each one having a different period of production; in order to measure in terms of time the whole amount of capital goods utilised, it would be necessary to make

a kind of sum or average of the different periods of production, which, for several reasons, is quite impossible.

On the other hand, even if it were possible, the measure obtained would not be of any significance; the period of production is concerned with the time spent in the past to produce a given capital good and is then therefore a kind of measure of the real cost of the capital equipment, but it tells us nothing about the capital itself when it is utilised. The theory of the period of production, as a measure of the quantity of capital, is a remnant of old theories of value which have been abandoned as instruments of theoretical analysis in the theory of value.

After all, time is also an economic good, and its value can vary from period to period.

Even if conditions of general equilibrium and, as a consequence, a very exact correspondence between the cost of production and the current value, are assumed, analysis of the period of production would only give a measure of the capital stock in existence; it would explain nothing about the productive structure, that is about the number of workers employed in relation to the total capital, and to the size of the flow of product which periodically comes from the capital stock. What is interesting is the quantity of capital per unit of product, not the absolute amount of capital. It is the relative values, that is, the capital-output ratios and the capital-labour ratios,

which characterise the productive structure, and on these the period of production cannot supply any information.

As has already been said, the ratio usually utilised as an index of the degree of capital intensity of the productive structure is the average capital-output ratio; the higher it is, the higher is the capital intensity of production. This ratio has often been considered an exclusive index, although sometimes the capital-labour ratio has been used in its place; often the two ratios have been confused. But it must not be left out of consideration that the two ratios are different and can eventually move in opposite directions. For a more complete analysis, both of them have been calculated. But while the Average capital-output ratio has been calculated for the same sectors as the marginal or incremental ratio, the capital labour ratio has been calculated, owing to the lack of data, only for the agricultural, mining and manufacturing sectors and for a shorter period. The results obtained are listed in Table 14 below.

As can be seen from Table 15, the two ratios in fact show just such a different tendency. Now, let us try to see why two such ratios can behave in a different way.

Table 14. The Average Capital Output Ratio by sectors of economic activity for South Africa.

| Years | Agriculture | Mining | Manufacturing | Services | Total |
|---|---|---|---|---|---|
| 1950 | 2,08 | 1,79 | 1,38 | 1,45 | 2,26 |
| 1951 | 2,03 | 1,91 | 1,40 | 2,79 | 2,27 |
| 1952 | 2,16 | 2,08 | 1,39 | 2,86 | 2,33 |
| 1953 | 2,07 | 2,31 | 1,46 | 2,88 | 2,37 |
| 1954 | 2,07 | 2,24 | 1,48 | 2,89 | 2,37 |
| 1955 | 2,11 | 2,11 | 1,47 | 2,92 | 2,36 |
| 1956 | 2,00 | 1,98 | 1,47 | 2,95 | 2,34 |
| 1957 | 2,13 | 1,83 | 1,44 | 2,89 | 2,35 |
| 1958 | 2,26 | 1,84 | 1,46 | 3,05 | 2,41 |
| 1959 | 2,11 | 1,68 | 1,48 | 3,14 | 2,41 |
| 1960 | 2,10 | 1,62 | 1,47 | 3,17 | 2,41 |
| 1961 | 1,94 | 1,59 | 1,44 | 3,15 | 2,36 |
| 1962 | 1,87 | 1,49 | 1,40 | 3,14 | 2,31 |
| 1963 | 1,94 | 1,43 | 1,33 | 3,06 | 2,25 |
| 1964 | 1,98 | 1,38 | 1,29 | 2,94 | 2,18 |
| 1965 | 2,00 | 1,37 | 1,36 | 2,97 | 2,21 |
| 1966 | 1,94 | 1,32 | 1,43 | 3,04 | 2,24 |
| 1967 | 1,58 | 1,36 | 1,49 | 3,05 | 2,22 |
| 1968 | 1,86 | 1,34 | 1,52 | 2,97 | 2,25 |
| 1969 | 1,71 | 1,37 | 1,44 | 3,01 | 2,22 |
| Mean | 1,99 | 1,70 | 1,43 | 2,92 | 2,30 |

Source: The data on capital stock and product have been provided by the South African Reserve Bank.

Table 15. The capital-labour ratio by sector of economic activity (constant Rand 1958)

| Years | Agriculture | Mining | Manufacturing |
|---|---|---|---|
| 1950 | 1,036 | 1,153 | 1,878 |
| 1951 | - | 1,256 | 1,888 |
| 1952 | 1,096 | 1,382 | 1,907 |
| 1953 | 1,121 | 1,570 | 2,042 |
| 1954 | 1,144 | 1,647 | 2,127 |
| 1955 | 1,146 | 1,716 | 2,141 |
| 1956 | 1,180 | 1,734 | 2,375 |
| 1957 | 1,248 | 1,751 | 2,385 |
| 1958 | 1,275 | 1,788 | 2,458 |
| 1959 | 1,235 | 1,685 | 2,591 |
| 1960 | 1,398 | 1,721 | 2,716 |
| 1961 | 1,282 | 1,749 | 2,710 |
| 1962 | 1,275 | 1,777 | 2,715 |
| 1963 | 1,454 | 1,838 | 2,667 |
| 1964 | 1,535 | 1,863 | 2,665 |
| 1965 | - | 1,892 | 2,728 |
| 1966 | - | 1,912 | - |
| 1967 | - | 2,027 | - |
| mean | 1,244 | 1,692 | 2,374 |

Source: The data on labour come from the "Statistical Yearbook" 1968, pp. 25, 33, 35.

In a productive system with two factors of production, we have:

$$Y = Y(L,K)$$

$$\Delta Y = \lambda \Delta L + \sigma \Delta K$$

where $\lambda$ and $\sigma$ are the marginal productivity of labour and capital respectively. If accumulation carries on while labour remains constant, $\Delta L$ will be equal to zero, and $\Delta K$ will take a positive value. The ratio K/L increases, but, it is not necessarily true that the ratio K/Y also increases. This ratio, after a single investment, is equal to:

$$\frac{K}{Y} = \frac{K}{Y} + \frac{\Delta K}{\Delta Y}$$

This ratio will be increasing, constant or decreasing according to:

$$\frac{\Delta K}{\Delta Y} \gtrless \frac{K}{Y}$$

that is

$$\frac{1}{\sigma} \gtrless \frac{K}{Y}$$

$\sigma$ is the marginal productivity of capital: if $\sigma$ is greater than the average ratio $\frac{Y}{K}$, we are in the zone of increasing returns and, so, every investment which increases the capital stock (i.e. net investment), increases the product more than proportionately, so that the coefficient K/Y decreases while the coefficient K/L increases. If, on the contrary, $\sigma$ is less than the average capital-output ratio K/Y, we are in the zone of decreasing returns and so the increase of output, due to the net investment, is less than proportional to the increase in the capital stock. In this case, the coefficient K/Y tends to rise and, then, moves in the same direction as K/L.

If, finally, the returns on investment are constant, the ratio K/Y remains constant, while the ratio K/L increases. It then appears that the ratios K/L and K/Y cannot be taken indifferently as a measure of capital intensity: they move in the same direction only if the accumulation of capital yields decreasing returns. But this does not seem to be the case. If we now give up the hypothesis of constant population, the possibilities that the ratios K/L and K/Y move in different directions are greater.

If capital and labour increase in a proportionally equal measure, i.e. $\frac{\Delta K}{K} = \frac{\Delta L}{L}$, the ratio K/L remains constant; but the ratio K/Y remains constant, increases or decreases according to the variation of capital productivity: here also the previous cases apply. If there are economies of scale, the capital coefficient will be decreasing because of the reduction in cost made possible by the greater size of the market and by the division and specialisation of labour. Analogously, in the case in which the proportional increase of capital is greater than the proportional increase in the working population, the capital labour ratio increases; but the capital output ratio could increase, decrease or remain constant according to what has been assumed about the marginal productivity of capital and labour during the accumulation process. If we look at Table 14, we can see that this is the case in the South African Republic during the period under consideration.

In fact both capital and labour increase, but in a different proportion, that is, capital has increased more than labour:

the increasing value of K/L, for the economic sectors where it has been possible to calculate it, shows this accurately - while the average ratio K/Y, for the same period and for the same sectors, has gradually decreased. This is due to the fact that in this period the capital was in a zone of increasing returns: in fact, as can be seen from the previous chapter, the marginal productivity of capital has been increasing over the whole period. In conclusion, the ratio K/Y and the ratio K/L can, and often do, behave in a different way, and sometimes can also contradict themselves with regard to the determination of the capital intensity of the economic sectors.

In fact, on the basis of K/L the sector which has come out with the highest capital intensity is the manufacturing sector; on the basis of K/Y however it is the agricultural sector.

However it is now acknowledged that in a country with a relatively strong economic growth agriculture should be the sector with the highest capital intensity; and if this has not been the case for the South African economy, several explanations are possible. For example, a possible "over-employment" in the agricultural sector and a possible "under-employment" in the manufacturing sector. In any case, the more suitable index for the measurement of capital intensity in a certain sector or in a certain process of production is the capital-labour ratio; in fact, the characteristics of a certain process of production are the factors employed, and therefore its structure will be better highlighted by the ratio between factors of production than by the ratio between one factor and the product of the combination of the factors themselves.

## Appendix

At this point I wish to dwell, from a theoretical point of view, upon the "increasing productivity of capital". At first sight, it would seem a paradox provided by some statistical data. It is known, in fact, that once a given quantity of a certain factor of production has been reached, equal increments of this factor yield gradually decreasing increments of total product. The productivity is therefore decreasing with the increase in the quantity of that factor; and beyond a certain limit, it tends to zero.

This is the famous law of decreasing marginal returns. If the capital stock is growing while the other factors remain available in a constant quantity, the hypothesis of the law of decreasing returns may be tested, and, as a consequence, such a law can be applied. But first it is necessary to see if this law can be applied to capital accumulation, and, so, if the case of accumulation is part of the hypothesis which is necessary for the validity of the law. It is easy to verify that the process of capital accumulation is beyond the hypothesis within which the law of decreasing returns is valid. This comes from the fact that, while the law of decreasing returns is a dynamic process, it is obtained by comparing the total product which comes from the combination of increasing quantities of a certain factor with constant quantities of other factors. The results of successive applications of a given factor are to be compared, while the other factors of the economic system, that is, the quantity of other factors applied, and the purchasing power of the market, remain, by assumption, constant. The mental experiment from which the law of decreasing returns emerges consists in comparing the effects of alternative applications of a given factor carried out in the same moment. It is then easy to see how the process of capital accumulation cannot be part of this scheme. Capital accumulation takes place during a succession of periods; in every period, as a consequence of the investments carried in previous periods(if they have been productive), the productive capacity of the system and thus the purchasing power of the market will be enlarged. The investment of a subsequent period is generally carried out at a higher level of income (the multiplier theory) and then those relationships between investment and product, which exist at a given level of income, very likely do not remain valid at the new higher level of income, reached by means of the investment itself. The accumulation of capital does not take place all at once; it is a gradual and slow process which takes place through a succession of periods. During this succession of periods the variables of the economic system continuously change.

Even if the fundamental variables (such as population, technical progress, availability of resources) remain constant, the level of income, as a consequence only of the investment, would change, and therefore in every period investment would

be carried out at a different level of income. Thus, the static hypothesis of constancy of all the variables of the system, on which the law of decreasing returns is based, fails. The very characteristic of the investment (if it is economically productive), which enlarges the productive capacity of the economic system, makes the hypothesis of the law of decreasing returns invalid. In conclusion, capital productivity in the period to be analysed can be decreasing, increasing or constant; and when it is decreasing, if it is decreasing, it does not mean at all that the law of decreasing returns can be applied to it.

# CHAPTER V

## Factors which may influence the ICOR

### 1. Rate of accumulation and rate of growth.

Since the capital-output ratio is a synthesis of economic magnitudes which can behave in different ways, it is interesting to compare the behaviour of some of them with that of the coefficient. At first sight we can say that there are some factors which directly affect the incremental capital-output ratio, and some which can indirectly affect it. The factors which directly affect such a coefficient are the rate of accumulation ( $i_a = \frac{\triangle K_t}{Y_t}$ ) and the rate of growth of product ($i_y = \frac{\triangle Y_t}{Y_t}$ ) It is sufficient, in fact, to divide the numerator and the denominator of the formula which defined the ICOR by the product Y, to obtain:

$$k_t = \frac{\triangle K_t}{\triangle Y_t} = \frac{\frac{\triangle K_t}{Y_t}}{\frac{\triangle Y_t}{Y_t}} = \frac{i_a}{i_y}$$

that is, the value of the incremental capital-output ratio can be considered a function of the rate of accumulation and the rate of growth; more precisely, $k_t$ is a direct function of $i_a$ and an inverse function of $i_y$ - In order to verify this, the annual rates of accumulation and annual rates of growth of product for the usual economic sectors and for the usual period, have been calculated - (see Tables 16 and 17),

Table 16. Rate of growth of product by sector of economic activity. (percentage values).

| Years | Agriculture | Mining | Manufacturing | Services | Total |
|---|---|---|---|---|---|
| 1950 | 8,50 | 2,87 | 6,69 | 3,89 | 5,09 |
| 1951 | -1,02 | 8,31 | 7,97 | 2,81 | 3,48 |
| 1952 | 9,09 | -0,49 | 5,70 | 5,18 | 5,26 |
| 1953 | 4,31 | 13,98 | 6,96 | 5,31 | 6,42 |
| 1954 | 1,51 | 12,13 | 6,57 | 4,21 | 5,25 |
| 1955 | 7,86 | 10,40 | 4,13 | 4,11 | 5,38 |
| 1956 | -4,05 | 10,80 | 5,56 | 4,78 | 4,40 |
| 1957 | -3,85 | 1,62 | 4,21 | 3,85 | 2,61 |
| 1958 | 8,89 | 12,00 | 3,55 | 2,33 | 4,63 |
| 1959 | 2,01 | 7,76 | 3,97 | 3,98 | 4,23 |
| 1960 | 9,98 | 6,03 | 5,25 | 4,78 | 5,74 |
| 1961 | 5,52 | 7,50 | 6,33 | 4,02 | 5,26 |
| 1962 | -1,87 | 5,08 | 12,79 | 7,19 | 7,03 |
| 1963 | 0,07 | 6,36 | 11,83 | 9,38 | 9,21 |
| 1964 | 1,16 | 3,52 | 7,44 | 6,30 | 4,01 |
| 1965 | 5,50 | 5,03 | 6,59 | 3,86 | 4,94 |
| 1966 | - | 6,40 | 6,84 | 5,61 | 5,42 |
| 1967 | -12,64 | 4,20 | 4,10 | 8,66 | 4,14 |
| 1968 | 10,60 | 1,55 | 10,75 | 5,11 | 6,80 |
| mean | 4,39 | 6,01 | 8,70 | 6,26 | 6,10 |

Table 17. Rate of accumulation by sector of economic activity (percentage values)

| Years | Agriculture | Mining | Manufacturing | Services | Total |
|---|---|---|---|---|---|
| 1950 | 24,08 | 29,56 | 27,51 | 20,36 | 23,50 |
| 1951 | 23,09 | 30,03 | 25,86 | 18,60 | 22,14 |
| 1952 | 23,08 | 38,30 | 24,47 | 22.18 | 24,57 |
| 1953 | 22,31 | 38,61 | 29,84 | 23,59 | 26,39 |
| 1954 | 22,22 | 35,64 | 28,16 | 22,99 | 25,47 |
| 1955 | 20,94 | 26,10 | 24,30 | 22,30 | 23,02 |
| 1956 | 17,71 | 20,65 | 22,04 | 22,74 | 21,58 |
| 1957 | 18,35 | 17,31 | 21,29 | 24,44 | 21,95 |
| 1958 | 18,97 | 17,25 | 23,51 | 26,75 | 23,77 |
| 1959 | 17,17 | 15,50 | 24,06 | 23,69 | 21,82 |
| 1960 | 16,38 | 18,34 | 21,12 | 23,16 | 21,12 |
| 1961 | 14,70 | 18,68 | 20,55 | 21,34 | 19,89 |
| 1962 | 13,85 | 13,11 | 20,23 | 19,74 | 18,12 |
| 1963 | 14,95 | 12,53 | 24,10 | 21,50 | 20,09 |
| 1964 | 15,83 | 14,44 | 27,63 | 23,14 | 22,33 |
| 1965 | 15,83 | 14,41 | 30,37 | 27,80 | 25,35 |
| 1966 | 14,94 | 13,14 | 31,74 | 26,50 | 24,90 |
| 1967 | 12,89 | 15,05 | 31,94 | 25,57 | 24,40 |
| 1968 | 14,84 | 14,70 | 27,55 | 24,93 | 23,29 |
| mean | 17,84 | 20,70 | 27,15 | 24,50 | 22,67 |

Even if in practice it is rather difficult, in analysing variations of the ICOR, to separate those which are the "effect" of the rate of accumulation from those which are the "effect" of the rate of growth, it remains of interest to attempt to establish which of these two factors can have the greater influence on the marginal coefficient of capital.

Let us begin with a short theoretical analysis. If we call $i_y$ and $i'_y$ two values of the rate of growth of the product, $i'_a$ and $i_a$ two values of the rate of accumulation, $\Delta i_y$ the difference $i'_y - i_y$ and $\Delta i_a$ the difference $i_a - i_a$, let us consider the elasticity E equal to:

$$E = \frac{\frac{\Delta i_a}{i_a}}{\frac{\Delta i_y}{i_y}} = \frac{\frac{\Delta i_a}{\Delta i_y}}{\frac{i_a}{i_y}} = \frac{\frac{i'_a - i_a}{i'_y - i_y}}{\frac{i_a}{i_y}}$$

where, remembering that $k = \frac{i_a}{i_y}$, we have

$$E = \frac{1}{k} \quad \frac{k'i'_y - Ki_y}{i'_y - i_y}$$

assume $b = \frac{i'_x}{i_y}$, then $i'_y = bi_x$, that is: $b-1 = \frac{i'_y}{i_y} - 1$

$$= \frac{i'_y - i_y}{i_y} = \frac{\Delta i_y}{i_y}, \text{ then}$$

$$E = \frac{1}{k} \quad \frac{k'bi_y - ki_y}{bi_y - i_y} = \frac{1}{k} \quad \frac{k'b - k}{b - 1} =$$

$$\frac{1}{k} \quad \frac{k'b - kb + kb - k}{b - 1} = \frac{b}{b - 1} \cdot \frac{k' - k}{k} + 1$$

since

$$b - 1 = \frac{i'_y}{i_y} - 1 = \frac{\Delta i_y}{i_y} ,$$

$$E = \frac{i'_y/i_y}{\Delta i_y/i_y} \cdot \frac{\Delta k}{k} + 1 = \frac{\frac{\Delta k}{k}}{\frac{\Delta i_y}{i'_y}} + 1,$$

that is

$$\frac{\Delta k}{k} = \left( \frac{\frac{\Delta i_a}{i_a}}{\frac{\Delta i_y}{i_y}} - 1 \right) \cdot \frac{\Delta i_y}{i'_y} = \left( \frac{1}{i'_y} \Delta i_a \frac{i_y}{i_a} - \Delta i_y \right)$$

and then

$$\frac{\Delta k}{k} = \frac{1}{i'_y} (\Delta i_a \cdot \frac{1}{k} - \Delta i_y)$$

From the last formula it appears that, if k is greater than 1, the variation in $i_y$ has more importance than the variation of $i_a$ for the variation in the incremental capital-output ratio; if, on the contrary, k is less than 1, the inverse occurs. Now, from a statistical point of view, that is applying certain statistical instruments to what has been obtained for the South African economy, it is possible to see how $i_a$ and $i_y$ behave compared with the ICOR; but the following

discussion is only valid in a certain situation defined as "normal". A phenomenon can be said to be in a situation of normality when nothing takes place to disturb its natural tendency. For example, the natural tendency of the rate of accumulation is to remain more or less constant over time; this, however, has not happened in the mining and agricultural sectors of the South African economy, where in fact it shows a marked tendency to decrease.

For this reason, the analysis which will follow, refers only to the manufacturing sector, to tertiary activities and to the economy as a whole. It has been said above that when $i_a$ is constant $k_i$ is inversely proportional to $i_y$, i.e. an increase of $i_y$ results in a decrease in k and vice versa.

Let us then see if this has happened during the period 1950-68 for the manufacturing sector, for tertiary activities and for the South African economy as a whole, where $i_a$ is approximately constant.

As Table 18 shows, the inverse relation between the ICOR and the growth rate of product is valid 48 times out of the 54 cases observed. Another statistical instrument which can be used to see how $i_a$ and $i_y$ behave compared with the ICOR, is a comparison of the relative variation coefficients and a calculation of the partial correlation coefficient.

Table 18. ICOR's and growth rates with their annual direction signs

| Years | Manufacturing | | | | Services | | | | Total | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | k | $i_y$% | direction of change | | k | $i_y$% | direction of change | | k | $i_y$% | direction of change | |
| 1950 | 4.10 | 6.69 | | | 5.23 | 3.89 | | | 4.61 | 5.09 | | |
| 1951 | 3.24 | 7.97 | - | + | 6.59 | 2.81 | +- | - | 6.36 | 3.48 | + | - |
| 1952 | 4.28 | 5.70 | - | - | 4.28 | 5.18 | - | + | 4.66 | 5.26 | - | + |
| 1953 | 4.28 | 6.96 | + | + | 4.44 | 5.31 | + | + | 4.10 | 6.42 | - | + |
| 1954 | 4.23 | 6.57 | - | - | 5.45 | 4.21 | + | + | 4.85 | 5.25 | + | - |
| 1955 | 5.88 | 4.13 | + | + | 5.42 | 4.11 | - | - | 4.27 | 5.38 | - | + |
| 1956 | 3.96 | 5.56 | - | + | 4.75 | 4.78 | - | + | 4.90 | 4.40 | + | - |
| 1957 | 5.05 | 4.21 | + | - | 6.33 | 3.85 | + | - | 8.39 | 2.61 | + | - |
| 1958 | 6.62 | 3.55 | + | - | 11.96 | 2.23 | + | - | 5.12 | 4.63 | - | + |
| 1959 | 6.06 | 3.97 | + | + | 5.94 | 3.98 | - | + | 5.15 | 4.23 | + | - |
| 1960 | 4.02 | 5.25 | - | + | 4.83 | 4.78 | - | + | 3.67 | 5.74 | - | + |
| 1961 | 3.24 | 6.33 | - | + | 5.30 | 4.02 | + | - | 3.77 | 5.26 | + | - |
| 1962 | 1.58 | 12,79 | - | + | 2.74 | 7.19 | - | + | 2.57 | 7.03 | - | + |
| 1963 | 1.62 | 14,83 | + | + | 2.29 | 9.38 | - | + | 2.18 | 9.21 | - | + |
| 1964 | 3.71 | 7.44 | + | - | 3.66 | 6.30 | + | - | 5.56 | 4.01 | + | - |
| 1965 | 4.60 | 6.59 | + | - | 7.19 | 3.86 | + | - | 5.12 | 4.94 | - | + |
| 1966 | 4.63 | 6.84 | + | + | 4.72 | 5.61 | - | + | 3.35 | 7.42 | - | + |
| 1967 | 5.77 | 4.10 | + | - | 2.95 | 8.66 | - | + | 4.88 | 4.14 | + | - |
| 1968 | 2.56 | 10.75 | - | + | 4.87 | 5.11 | + | - | 3.42 | 6.80 | - | + |

Let us begin with the variation coefficient. Such a coefficient is an index of relative variability given by the ratio between the root square deviation and the arithmetic mean. The highest value that it can take is equal to unity, the lowest to zero. The use of such an index for this purpose is explained on the basis of the following reasoning: considering that the ICOR varies over time, let us see which factor, $i_a$ or $i_y$, has the greater influence on these variations.

Variation coefficients

| Sectors | k | $i_y$ | $i_a$ |
|---|---|---|---|
| Manufacturing | 32,9% | 43,8% | 14,6% |
| Services | 39,8% | 36,2% | 10,3% |
| Total | 30,2% | 28,8% | 9,4% |

It appears that the variations in ICOR are due in a greater measure to the variations in the rate of growth. In order to see this it is sufficient to look at the values of the percentages obtained. The partial correlation coefficients also have shown that it is the rate of growth which has the greater weight in determining the ICOR; the ICOR and $i_y$ move in opposite directions, the ICOR and $i_a$ however move in the same direction.

Partial correlation coefficient

| Sectors | $r_{ki_y,i_a}$ | $r_{ki_a,i_y}$ |
|---|---|---|
| Manufacturing | - 0,9172 | 0,4023 |
| Services | - 0,8615 | 0,5812 |
| Total | - 0,9104 | 0,2747 |

To summarise, it can be said that the ICOR is a function of the rate of growth and of the rate of accumulation, if the rate of growth increases the ICOR decreases and vice versa, and if the rate of accumulation increases the ICOR should increase and vice versa. But since such a rate of accumulation is more or less constant over time, it is the rate of growth of output which determines the incremental capital-output ratio. On this basis it can be said that:

1. The incremental capital-output ratio seems to be a variable which is a function of economic growth rather than an explanatory variable of the same.
   A low level of k implies a fast economic growth, and vice versa in the case of high levels of k.
2. The results obtained would seem to undermine the acceleration principle as a model of analysis; it is known that at the basis of this principle is the constancy of ICOR; however, ICOR does not remain constant at all, but increases or decreases if the rate of growth of product (and so of income) decreases or increases.
3. Some heavy doubts could arise from the consideration of ICOR as an instrument of planning. It is the consequences of economic behaviour and, to a greater extent, the consequences of other features of planning policy which affect and, therefore, determine the level of the incremental capital-output ratio, rather than the reverse.
4. Finally, the ICOR is much higher in economic sectors or countries with low growth rates than in those with high growth rates. In fact, in the period 1962-69 the ICOR in the mining sector was 3,84 with a growth rate of 5,2%, in the manufacturing sector it was 3,24 with a growth rate of 8,7%, and in the services sector 3,75 with a growth rate of 6,3%.

2. Productive capacity.

Another factor which may affect the Incremental capital-output ratio is the different percentages of utilisation of productive capacity. In fact during periods of economic welfare entrepreneurs generally create productive capacity in anticipation of the market demand; analogously investments in "fixed social capital" are carried out.

All this automatically creates a certain amount of unused productive capacity which is used over time. Therefore, at the beginning of such a period the incremental capital-output ratio remains steady at a high level, during the subsequent period, however, since, among other things, so-called economies of scale become operative, it would decrease. In periods of economic welfare, when the entrepreneurs carry out large investment plans, surpluses of capital, which are not put to immediate use, can be created. The same situation occurs when, in the execution of development plans, infrastructural investments (i.e. in roads, railways, acqueducts, electrical power plants and transmission networks) are carried out: these investments, by their very nature, do not show immediate returns.

It seems that in such periods the capital productivity decreases or increases less quickly than usual. During the subsequent periods, when market demand expands, the flow of product can be partially obtained by the investments previously carried out and does not necessitate additional investment.

Thus, it seems that the return on investments grows suddenly and so does the productivity of capital. In such a case it may be that during buoyant periods, when total demand expands, not only are new additions to plant utilised, but also the old productive equipment is utilised much more intensively; on the other hand, during periods of stagnation, when total demand contracts, the utilisation of productive capacity is reduced.

Therefore, when the productive capacity utilised is relatively low, the incremental capital-output ratio should increase, and when it is relatively high, the capital-output ratio should decrease. In other words, these economic magnitudes (the incremental capital-output ratio and the productive capacity utilised) vary in opposite directions, and statistically speaking, we should have a negative correlation.

3. Employment.

Another factor which indirectly affects the determination of ICOR is the level of employment or rather its variation over time. It seems likely that such a factor plays a different part according to whether the supply of labour is plentiful or scarce. In fact, it has been established that in those countries where the supply of labour is not scarce, there is a tendency to organise a combination of factors with a lower capital intensity than is necessary in those countries where the supply of labour is limited. Therefore a close correlation should exist between the values of labour productivity (measured

by the output-labour ratio) and the incremental capital-output ratios; and furthermore labour productivity should increase as an effect of the substitution of capital for labour.

In fact, analytically speaking, if labour is replaced by capital, ceteris paribus, the numerator and therefore the value of the labour-output ratio decreases (the productivity increases) while the numerator and therefore the value of the incremental capital-output ratio increases.

Table 19 shows the values of the productivity of labour in the mining and manufacturing sectors in the period 1950-1967.

Table 19. Productivity of labour (Y/L)(constant Rand 1958)

| Years | Mining | Manufacturing |
|---|---|---|
| 1950 | 641 | 1 343 |
| 1951 | 657 | 1 357 |
| 1952 | 664 | 1 376 |
| 1953 | 677 | 1 396 |
| 1954 | 735 | 1 428 |
| 1955 | 810 | 1 450 |
| 1956 | 859 | 1 610 |
| 1957 | 879 | 1 646 |
| 1958 | 878 | 1 680 |
| 1959 | 959 | 1 740 |
| 1960 | 1 040 | 1 837 |
| 1961 | 1 132 | 1 872 |
| 1962 | 1 204 | 1 931 |
| 1963 | 1 278 | 1 992 |
| 1964 | 1 345 | 2 051 |
| 1965 | 1 380 | 2 104 |
| 1966 | 1 438 | 2 180 |
| 1967 | 1 486 | 2 240 |

Source: Statistical Yearbook, 1968, pp.25, 33, 35.

Let us see if such a theoretical relationship between Y/L and I/$\Delta$Y is valid for the mining and manufacturing sectors of the South African economy. The correlation coefficient between labour productivity and the incremental capital-output ratio has been equal to -0,1704 for the mining sector and equal to -0,3237 for the manufacturing sector. It was stated on page 102 that between Y/L and $\frac{\Delta K}{\Delta Y}$ a relatively high positive correlation could be expected to exist; this, however, has not been the case in South Africa. That is, the correlation has been low and furthermore negative. The reason for this low correlation can be found in considering the formulae which determine the productivity coefficient of labour and the ICOR. In other words, to obtain a higher correlation it would be necessary to free the product of the share pertaining to capital, in the calculation of the productive coefficient of labour, and the share pertaining to labour, in the calculation of ICOR.

It has also been said that the basic fact which would explain the positive correlation, at least from a theoretical point of view, between Y/L and $\Delta K/\Delta Y$, is the process of substitution of capital for labour. Now, on the basis of the results obtained, i.e. the negative correlation, it is possible to infer that this substitution has not taken place, at least not in the economic sectors considered. In other words, the incremental capital-output ratio has been decreasing during the period, while labour productivity has been increasing. This is a very important fact, and I believe that it has been one of the reasons for the remarkable South African economic development: that is, capital productivity and labour productivity increasing at the same time.

Let us now see if during the period 1950-67 in the manufacturing sector "the Verdoorn law" can be applied. According to this author the increment in productivity (labour productivity) is as great as the increment in production. We are not concerned with the positive correlation between these magnitudes. But what is important, according to Verdoorn, is first, the exact value of the elasticity E (the ratio between the growth of productivity and growth of production) and second, its constant value in different countries and periods. Verdoorn, in fact, formalises his own law in the following way: " ... the productivity as a rule has been increasing as the square root of the volume of output".(46) In other words the elasticity is equal to about 0,50, which means an increase in productivity of 5% per increase in output of 10%.

We wish to establish whether this has happened in the manufacturing sector during the period 1950-67. For this purpose the equation used has been of the following type:

$$p = x^{E} e^{kt}$$

where

p = productivity level

x = production level

the equation can be converted into:

$$\log p = E \log x + kt$$

and, differentiating, into

$$d \lg p = E \, d \lg x + K$$

which, for simplicity, has been written as:

$$P = k + EX$$

where

P = growth rate of productivity

X = growth rate of output.

The regression calculated on the basis of this latest equation, has given the following parameters:

$P = 0,615\ x - 0,126 \qquad R^2 = 0,8705$

In this case the elasticity is equal to 0,61 and thus is not very far from Verdoorn's elasticity (0,50). In addition, the high value of the determination coefficient ($R^2 = 0,8705$) also suggests the validity of this regression, and the positive correlation coefficient (equal to 0,933), the tied connection between the growth of productivity and output. Anyway, even if such a sector is on the limit of this law, it does not mean that the law can be ascribed absolute reliability. According to Verdoorn, the increase in production is a necessary and sufficient condition for the increase in productivity. In other words, the elasticity E entirely explains the increase in productivity, there is no growth of productivity which is independent of the increase of production. In terms of a regression line between the rates of growth of production (X) and productivity (P): $P = k + EX$, it is necessary that the constant k be equal to 0, in order that $E = P/X$.

Even if in the regression calculated above k is very low, this seems not to be the case.(47)

In short, even accepting these regressions as indicative means to work out a certain law which exists empirically it is necessary to consider that the increase in production only in part explains the increase in productivity. (It depends upon the value of k; Kaldor, for example, does not take into consideration the mutual importance of k and E in the English economy; from his regression the increase in production explains only 60% of the increase of productivity in the United Kingdom). If the elasticity E has not been found out by a regression line, but only by the ratio between the rate of growth of productivity and the rate of growth of production, in the case of a positive constant, it will turn out an approximate value.

Furthermore, if the value of the constant is relatively high, in order to know what determines the growth of productivity it is necessary to study the factors which may cause that value of k. According to some, one of these factors is investment. Verdoorn, however, is extremely explicit in denying that investment is one of the main factors which determine the value of k, he considers only increasing returns (economies of scale, learning curve)[48] which carry on with the expansion of production. Kaldor also says that increasing returns form the main explanation of Verdoorn's law.[49]

4. Technical progress.

Another factor, which indirectly affects the Incremental capital-output ratio is technical progress. If it is considered

as embodied progress it can have a positive or negative influence on the capital coefficient. When new plants are set up (from the point of view of capital productivity) we shall have a negative effect, in that the capital coefficient will tend to increase. But later, when economies of scale, shorter production periods, shortage of wastes are carried out, the factor technical progress will have a positive effect on the capital coefficient which will then have a tendency to decrease.

For the U.S.A. economy, R. Solow has found out that about 8% of the increase in production of about 65% which took place in the period 1909-49 in the States was due to the substitution of capital for labour, and the remaining 57% was due to technical progress, which made possible to obtain a higher production per unit of capital.

Looking at Table 20, we can see that where the incremental capital-output ratios are lowest, the importance of technical progress has been greatest.

Table 20. Growth rates in the period 1949-50

| Countries | $\frac{\Delta Y}{Y}$ | Contributions | | | ICOR |
|---|---|---|---|---|---|
| | | Labour | Capital | Technical progress | |
| W. Germany | 7,4 | 1,1 | 1,8 | 4,5 | 2,6 |
| Italy | 5,9 | 0,8 | 1,0 | 4,1 | 2,1 |
| Yugoslavia | 5,5 | 0,8 | 1,5 | 3,2 | 2,5 |
| Netherlands | 4,8 | 0,8 | 1,4 | 2,6 | 4,0 |
| France | 4,5 | 0,1 | 1,0 | 3,4 | 2,9 |
| Canada | 4,2 | 1,5 | 2,1 | 0,6 | 4,2 |
| Norway | 3,4 | 0,2 | 1,4 | 1,8 | 8,5 |
| Sweden | 3,4 | 0,3 | 0,6 | 2,5 | 4,1 |
| Belgium | 3,0 | 0,2 | 0,8 | 2,0 | 2,8 |
| U. Kingdom | 2,4 | 0,4 | 0,9 | 1,1 | 3,7 |

Source: United Nations: Some factors in economic growth during the 1950's, Geneva 1964, p.120.

5. Variations in the structure of new investments.

Finally, the capital coefficient can vary according to the destination of new investments.

It is known that some classes of industrial activity (such as chemicals, electricity, heavy industries) present a lower capital productivity than others (such as the manufacturing industries) and therefore the incremental capital-output ratio should be sensitive to changes in the structure of new investments, both for the whole economy and in particular for the industrial sector.

Unfortunately, the shortage of data on investments at a more disaggregated level has made calculation of the capital coefficient in the South African sectors and therefore the verification of such a statement difficult.

A few of the factors which can affect the Incremental capital-output ratio have been examined above, but the fact that there are other factors, such as psychological features, which can have more or less similar effects on the Incremental capital-output ratio and, generally, on economic magnitudes, must not be forgotten, even though these might not, generally be classified as economic factors.

# CHAPTER VI

## The possible Uses of ICOR

### 1. As an instrument in planning.

The ratio $\frac{\Delta K}{\Delta Y}$, supposing it to have been established, makes it possible to estimate the capital needs necessary to finance a certain increase in product. If k is equal to the ICOR, and $i_a$ to the rate of accumulation, we can write:

$$\frac{\Delta Y}{Y} = i_a \frac{1}{k}$$

In this equation, two magnitudes should be known. Since k is given, only a degree of freedom remains. If the growth rate is arbitrarily fixed, let us assume at about 5%, and the ratio k is equal to 3, the rate of accumulation necessary to finance this growth will be equal to 15%. In other words, knowledge of the incremental capital-output ratio certifies that, technical conditions given, to obtain an increase in product of about 5%, it is necessary to invest the 15% of the annual product.

The same formula which is used as an instrument of planning (i.e. applied to the future) can also be utilised with reference to the past, in order to ascertain whether the growth of the economic system has carried on within the limits of equilibrium. The condition of dynamic equilibrium can be expressed, according to the Swedish school, as a coincidence of planned and real

magnitudes; if this equality exists, the entrepreneurs notice that their expectations have not been false, and, as a consequence, they continue to act in the future as they did in the past. In such a case it is possible to speak about the equilibrium of the economic system. Each of the magnitudes shown in the formula can be accepted as a planned magnitude (i.e. the subject of decisions made by free enterprises of economic subjects) or as a real magnitude (i.e. actually obtained during a certain historical period). Now, if the equation is to represent conditions of equilibrium, some magnitudes must be accepted as planned and others as actual. Only in this case does the equation give the equality between ex-ante values and ex-post values and thus a correspondence between choices and realities which is the main feature of equilibrium.

Such a model can be used in several ways. The equation allows only a degree of freedom - two magnitudes have to be considered as given and in respect of these equilibrium exists by hypothesis. For the third magnitude the comparison between plans and reality must be established.

We can start from the propensity to save and from the planned capital-output ratio, solving the equation with respect to $\frac{\Delta Y}{Y}$ ; in such a way the rate of growth which can be obtained by investing voluntary saving and in accordance with the expected capital-output ratio, can be derived. By comparing this theoretical rate with the real one, it is possible to see whether or not the system is in equilibrium.

Similar results can be obtained by starting from the propensity to save and from the real growth, or from the capital-output ratio and the real growth rate. In the former case the equation will be solved with respect to k, in the latter case with respect to $i_a$.

2. As a measure of productive efficiency.

The incremental capital-output ratio is sometimes considered as an index of productive efficiency. For example, the incremental capital-output ratio equal to 3,5 obtained during the period 1962-68 in the South African economy, is a symptom of a remarkable productive efficiency.

However, three aspects which impose a certain caution in using this kind of measure must be pointed out. First of all, it is known that the incremental capital-output ratio is concerned with only one of the productive factors; a real measure of productive efficiency should be a measure of global prouctivity, that is, applied to all the economic factors of production.

In fact, a low capital-output ratio can be obtained by using a high quantity of other factors (for example labour): in this case, nothing can be said about the efficiency of the economic system. In other words, the productive technique (or input-mix) used exerts a great influence on the incremental capital-output ratio: a low capital coefficient may be an index

of primitive techniques rather than of high efficiency. Vice versa, a high incremental capital-output ratio may be an index of mechanised techniques and not of the low efficiency of the economic system.

Secondly, it is necessary to remember that the global incremental capital-output ratio is a weighted mean of the sectoral ones; an average where the weights are given by the importance of the relative products in the total income. As a result, the composition of total product (or output mix) exerts great influence on it. An increase in the incremental capital-output ratio can be due simply to the shifting of resources from certain sectors towards other sectors where the intensity of capital is much higher. In this sense, the incremental capital-output ratio is subjected to purely technical forces; a country can have a very high capital coefficient merely because there are some conditions which cause resources to be devoted to a certain type of production. Naturally, even if this does not provide a true reflection of the efficiency of the system, it has nevertheless an economic meaning: if $\triangle K/\triangle Y$ is relatively high, then people will have to carry out a greater effort of accumulation in order to yield a unit of product, and the real cost of production, in terms of consumption will be higher.

Finally, before making a judgement on the efficiency of the economic system, it is necessary that the capital-output ratio be not affected by typical phenomena of the short run, such as unused productive capacity.

3. As a criterion in making investment decisions.

According to this criterion, especially in underdeveloped countries, investment ought to be orientated towards those branches of production where the incremental capital-output ratio is low, and where, as a consequence, the capital productivity is high.(50)

Here also there are some objections to be made. The first one is connected with the interdependence between different sectors. If the sectoral ICORs are interdependent, they have no separate significance at all for the productivity of those investments in respect of the whole economic system.

Another objection, already mentioned, is connected with the fact that the ratio $\triangle K/\triangle Y$ gives the productivity of one factor only (capital). It can therefore be used as a criterion in making investment decisions only if the other factors are not scarce and then these latter need not be taken into consideration during single investment decisions.

# PART III

## A GENERAL FORECAST OF THE SOUTH AFRICAN ECONOMY IN 1975

# CHAPTER VII

## Description of the model utilised, and some considerations on it.

For this forecast my calculations will be based on some parameters (such as the incremental capital-output ratio, the percentage of depreciation, the elasticity) established for the last ten years (1960-69). 1969 will be taken as base year and the predictions will refer to 1975.

The model utilised is a linear model of 11 equations, which makes possible the calculation of the Gross Domestic Product (G.D.P.) at factor cost, gross fixed investments and the capital stock by sectors of economic activity, that is by agriculture, mining, manufacturing, services and the economy as a whole.

In such a model the mining and agricultural sectors are assumed to have little importance in the determination of the future growth rate of the South African economy, and therefore they will be considered as exogenous variables. By acting in such a way I believe to be following both the general principle which states that the manufacturing sector and, as a consequence, the services sector, is that which gives the greatest stimulus to the economic development of a certain country, and the results of the analysis carried on in the previous chapters; where the gradually decreasing importance of primary activities (agriculture and mining) in the South African economy, was pointed out.

The following equations have been used:

$$Y = Y_1 + Y_2 + Y_3 + Y_4 \qquad (1)$$

where Y is the G.D.P. at factor cost, 1, 2, 3 and 4 the agricultural, mining, manufacturing and services sectors respectively.

$$I = I_1 + I_2 + I_3 + I_4 \qquad (2)$$

where I is gross fixed investment.

$$D = D_1 + D_2 + D_3 + D_4 \qquad (3)$$

where D is the depreciation of capital stock.

$$K = K_1 + K_2 + K_3 + K_4 \qquad (4)$$

where K is the capital stock.

$$K_i^t = K_i^{t-1} + I_i^t - D_i^t \qquad (i = 1,2,3,4) \qquad (5)$$

$$D_i^t = \gamma_i^t \, K_i^t \qquad (6)$$

where $\gamma_i^t$ is the percentage of depreciation on capital stock.

$$K_i^t = \beta_i^t \, Y_i^t \qquad (7)$$

where $\beta_i^t$ is the incremental capital-output ratio.

$$Y_3 = f(Y) \; ; \quad Y_3 = dY^E \qquad (8)$$

$$Y_4 = f(Y_3) \; ; \quad Y_4 = c \, y_3^1 \qquad (9)$$

$$Y_1 = a + bt \qquad (10)$$

$$Y_2 = a' + b't \qquad (11)$$

Let us begin to calculate the gross domestic product at factor cost in 1975 on the basis of the equations 8, 9, 10 and 11, by considering as the basis year 1969; that is, let us solve the following system:

$$
\begin{aligned}
Y_1^{1975} &= a + bt \\
Y_2^{1975} &= a' + b't \\
Y_3^{1975} &= dY^E \qquad\qquad (I) \\
Y_4^{1975} &= c\ Y_3^l \\
Y &= Y_1 + Y_2 + Y_3 + Y_4
\end{aligned}
$$

As has been said, the agricultural and mining sectors are considered exogenous variables, and therefore the relative gross domestic product will be found by a simple extrapolation, while for the calculation of $Y_3$ and $Y_4$ the equations (8) and (9) must be transformed as follows:

$$\lg Y_3 = \log d + E \log Y \qquad (8')$$

$$\lg Y_4 = \log \quad + l \log Y_3 \qquad (9')$$

In other words, the elasticity E and the elasticity l must be calculated. For this purpose it is sufficient to calculate the regression between log $Y_3$ and log Y in the equation (8') and between log $Y_4$ and log $Y_3$ in the equation (9'). After the calculation of such a regression the system (I) takes the form:

$$
\begin{aligned}
Y_1 &= b + at \\
Y_2 &= b' + a't \\
Y_3 &= Y_3^o \left[ 1 + E \left( \frac{Y}{Y^o} - 1 \right) \right] \\
Y_4 &= Y_4^o \left[ 1 + l \left( \frac{Y_3}{Y_3^o} - 1 \right) \right] \qquad\qquad (II) \\
Y &= Y_1 + Y_2 + Y_3 + Y_4
\end{aligned}
$$

where the unknowns are $Y_1$, $Y_2$, $Y_3$ $Y_4$ and Y, while $Y_3^o$ and $Y_4^o$ are the gross domestic product of the base year, that is of 1969. The solution of such a system by the method of Cramer has given the following values for G.D.P. at factor cost and at 1958 constant prices.

| SECTORS | G.D.P. (R. Millions 1958) | GROWTH RATE |
|---|---|---|
| Agriculture | 1 061,1 | 3% |
| Mining | 1 169,2 | 3,2% |
| Industry | 3 630,5 | 7,8% |
| Services | 5 548,0 | 6,0% |
| Total | 11 408,9 | 6,0% |

Now, by applying the other equations of the model, the other economic aggregates forecast in the period 1970-1975 can be calculated:

Gross domestic product at factor cost
(R. Million 1958)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | growth rate |
|---|---|---|---|---|---|---|---|
| Agriculture | 915,4 | 942,9 | 971,2 | 1 000,0 | 1 030,0 | 1 061,1 | 3% |
| Mining | 990,0 | 1 031,1 | 1 063,9 | 1 097,0 | 1 132,1 | 1 169,2 | 3.2% |
| Industry | 2 493,8 | 2 688,3 | 2 898,0 | 3 124,0 | 3 367,7 | 3 630,3 | 7.8% |
| Services | 4 145,9 | 4 394,6 | 4 658,4 | 4 937,9 | 5 234,2 | 5 548,2 | 6% |
| Total | 8 545,1 | 9 056,9 | 9 591,5 | 10 158,9 | 10 764,0 | 11 408,9 | 6% |

Gross capital formation
(R. Million 1958)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 |
|---|---|---|---|---|---|---|
| Agriculture | 120,9 | 124,6 | 128,2 | 130,5 | 135,9 | 140,8 |
| Mining | 104,4 | 108,5 | 110,8 | 111,9 | 118,6 | 125,4 |
| Industry | 662,1 | 713,8 | 769,6 | 829,4 | 895,5 | 963,7 |
| Services | 1 056,2 | 1 119,2 | 1 187,1 | 1 257,8 | 1 333,4 | 1 413,0 |
| Total | 1 943,6 | 2 066,1 | 2 195,7 | 2 329,6 | 2 483,4 | 2 642,9 |

Capital Stock
(R. Million 1958)

| | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 | growth rate |
|---|---|---|---|---|---|---|---|
| Agriculture | 1 557,0 | 1 589,4 | 1 622,7 | 1 656,6 | 1 691,9 | 1 728,5 | 2% |
| Mining | 1 354,8 | 1 380,8 | 1 407,4 | 1 434,1 | 1 462,6 | 1 492,7 | 1,9% |
| Industry | 3 580,6 | 3 841,1 | 4 122,0 | 4 424,7 | 4 751,5 | 5 103,3 | 7,3% |
| Services | 12 465,5 | 13 193,0 | 13 964,7 | 14.782,3 | 15 649,0 | 16 567,5 | 5,8% |
| Total | 18 957,9 | 20 004,3 | 21 116,8 | 22 297,7 | 23 555,0 | 24 892,0 | 5,3% |

The model utilised, for its simplicity, can be considered as an extrapolation of what has been realised in the last ten years. In fact the parameters used in the model, that is the ICOR, the interdependence between sectors(measured by the relative elasticity), the percentage of depreciation, are those which existed in the period 1960-69. Therefore the results reached by these calculations will be significant and valid only if a certain validity is given to the past.

An interesting feature is the consideration of the manufacturing sector as the main important variable of the model; and therefore the South African economy in the next six years will be able to achieve, on the basis of the model adopted, an average growth rate of 6% only if the manufacturing sector is able to develop at the growth rate of 7.8%.

Moreover, in order to finance such a development the average propensity to save must be equal to 22%, that is, a little more than that achieved in the last ten years, which was about 20%.

The model also shows the different weight which the economic sectors considered (i.e. agriculture, mining, industry and services) will have in the composition of G.D.P. In fact agriculture's share will be about 10% (in the period 1960-69 it was 11,8%) that of mining about 11% (in the period 1960-69 it was 13,4%); the manufacturing sector will generate about 30% of the G.N.P. (in the period 1960-69 it was 26,4% ) and services about 49% (in the period 1960-69 it was 48,2%).

In other words, while the share of services will remain more or less the same percentage, the manufacturing sector will have a notable increase, to some extent as the shares of the agricultural and mining sectors decline.

## Conclusions

With this brief general forecast of the South African economy in 1975, I bring this study to a close.

In it I have attempted to give a theoretical explanation of the capital-output ratio; to distinguish between the different forms in which it may be calculated; to show the relations between these different calculations of ICOR and ACOR, and possible adjustment to overcome discrepancies due to the changing value of money. I have attempted to show their relations with other econometric magnitudes.

I have shown how only through a realistic study of the actual processes of economic development, dependent upon the calculation of capital-output ratios, may an answer be found to some of the conflicting theoretical speculations which exist in the literature, concerning the comparative productivity of capital investment in developed and less developed countries; in economies where labour is scarce and where it is plentiful. I have given statistics drawn from countries where these are available covering a period of considerable development of their economies, which may indicate the strong possibility that capital productivity, which can be most readily, if not entirely adequately measured through the capital-output ratios, varies in intensity during the different stages of the cycle of economic growth.

The capital-output ratios, which can only be studied historically, since they refer to real experience, which has already happened, have also a predictive value on account of that continuity which persists through changes in the economy, and hence possess a practical value in assisting national decision-making for the future.

Against this background I have set out capital-output ratios which I have calculated for South Africa for the period 1950-69 and manipulated them so as to obtain the maximum information from them. I have attempted, in the light of the figures which have emerged, on the one hand to explain these results, with the aid of information of another character concerning the changes in the South African economy during this period; and on the other hand to identify more clearly, out of these econometric calculations, some of the developments of the economy during this period which need to be explained.

From this study there has emerged the fact that the South African national accounts do not yet provide sufficient detail for a refined study of this important aspect of the economy. Not only could my study not have reached the stage of elaboration that has been achieved, but for the kind assistance of the South African Reserve Bank, which took the trouble to provide me with statistical information not available in published sources; but even so, severe limitations were placed upon the scope of my analysis by, for example, the lack of any detailed break-down of figures available for broad sectoral divisions of the economy,

which often - the case of the services sector is the most striking - contain some very disparate elements.

Within these limitations I have prepared a study which I hope will add to knowledge of the South African economy, and add to it in a way which may have some practical significance.

## Notes

1. J.M. Keynes, "The General Theory of Employment, Interest and Money"; Macmillan, London, 1936, p.136.

2. Colin Clark, "The Condition of Economic Progress", London, 1957, pp.565-615.
S. Kuznets, "Income and Wealth, Series II, The Income and Wealth of the United States", Cambridge, 1952.

3. A Graziani, "Teoria Economica",ESI, Napoli, 1957, pp.380-385.
S. Kuznets, Proportion of Capital Formation to National Product, American Economic Review, volume 42, May 1952.

4. P.N. Rosenstein-Rodan, Il fabbisogno di capitale nei paesi sottosviluppati, Comunita Internazionale, February 1965, p.97.
M.H. Khan, The Capital Coefficient in the Process of Economic Growth, Economia Internazionale, volume XVIII, February 1965, p.97.

5. S. Kuznets, Proportion of Capital Formation to National Product, American Economic Review, volume 42, May 1952, pp.507-526.

6. D. Creamer, Capital and Output Ratios in Manufacturing Industries, 1880-1948; N.B. of E.R., Occasional Papers, vol.41 1954.
I. Boneustein, Capital and Output Trends in Mining Industries, 1870-1948; N.B. of E.R., Occasional Papers n. 45, 1953.

7. W. Fellner, The Rate of Growth and the Capital Coefficient in Long-range Economic Projections; Studies in Income and Wealth, vol. 16, Princeton 1954, p.292.

8. A. Barrere, Le rapport du capital a la production; Revue d'economie politique, vol. XVII, 1955, pp.224-236.

9. A.D. Walters, Incremental Capital Output Ratios; Economic Journal, December 1966, vol. 76, pp.818. The formula which appears in Walter's article actually reads $\text{ICOR} = \frac{\text{Investment}}{X - W\Delta\frac{L}{L}} X$
For the sake of consistency, and in conformity with custom I have, however, throughout used Y as the symbol for output and have therefore substituted Y for Walter's notation of X.

10. J. Sandee, Possible Economic Growth in the Netherlands; Asefelt, Europe's Future in Figures, Geneva 1958, pp.230-35,

11. Alfred E. Ott, The Relation Between the Accelerator and the Capital-output Ratio; Review of Economic Studies, June 1948, vol. 25, pp.190-196.

12. As it is known, such a coefficient (r) shows the linear concordance between two series of data. It varies between - 1 and 1; when it assumes positive values it means that between the series under consideration there is concordance; in such a case the maximum value that it can have is equal to one, that is, one series varies in a certain direction and the other one in the same direction. For example, given the distribution x = 1, 2, 3, 4, 5 and the distribution y = 6, 7, 8, 9, 10, the correlation coefficient which comes out certainly is equal to 1. On the other hand, when such a coefficient assumes negative values it means that between the series under consideration there is an inverse relationship. That is, one series varies in a certain direction and the other in the opposite direction. The distribution x = 5, 6, 7, 8, 9, 10 and y = 20, 19, 18, 17, 16, 15, for example, gives a negative correlation coefficient. Finally, r is equal to 0 when between the series under consideration there is no concordance at all, that is, as is usually said, there is indifference.

13. Correlation between time-series is generally subject to criticisms, in that some factors (first of all the case and the time) are believed to be able to affect it greatly. Sometimes a high correlation between time-series was found, even if no logical connection existed between them: Yule called these types of correlations, correlations "without sense"; for this purpose statistical methodology teaches us that, when one wants to find the correlation between two time-series, it is necessary to use "free" values. To free such values from the interference of random factors, statistics suggest a few methods, in particular: the method of correlation between first or second differences or ratios. From such a method, in fact, the above correlation coefficients come out. Other methods are: the residual method and the method of partial correlation.

14. Such a distinction, for the Average Capital-output ratio, has not much importance, because the capital stock, for its very nature, at a certain moment of time, is estimated free of depreciation.

15. A. Graziani, Sviluppo economico e produttività del capitale, Tovene, Naples, 1957, p.123.

16. A.A. Walters, Incremental Capital-output ratios, Economic Journal, op.cit., pp.819-820.

17. M. di Palma, "Uno studio sul progetto inglese", Boringhieri, Rome, 1965, p.142.

18. M.H. Khan, The Capital Coefficient in the Process of Economic Growth; Economia Internazionale, February 1965, vol. XVIII, p. 95.

19. R. Goldsmith, The Growth and Reproducible Wealth of the U.S.A. from 1805-1950; Income and Wealth, Series II, New York 1952. pp. 297-300.
P.S. Anderson, The Apparerent Decline in Capital-output ratios; The Quarterly Journal of Economics, vol. LXXV, No. 4, November 1961, pp.615-34.

20. For a complete description of Van der Werde's thought, see: M. di Palma, il Rapporto capital-prodotto, Roma 1967, pp.10-15.

21. H. Leibenstein, Incremental Capital-output Ratios and Growth Rates in the Short Run; The Review of Economics and Statistics, February 1966, p.20.

22. C. Clark, "The Conditions of Economic Progress", 3td edition, London 1957, chapter XI, pp.565-615.
S. Kuznets, Quantitative Aspects of the Economic Growth of Nations; Economic Development and Cultural Change, vol.IX, N. 4, Part II, July 1961, pp.22-24.

23. R. Bicanic,"The Threshold of Economic Growth,"Kyklos, vol. XV, 1962, pp.7-28.

24. L.J. Zimmerman, The Distribution of World Income 1860-1960, Essays on Unbalanced Growth, E. Devries, The Hague, Mouton and Co., 1960, pp.52-54.

25. D.H. Houghton, "The South African Economy", Oxford University Press, 2nd edition, 1967, pp.6-18.

26. D. Tosti, Il rapporto capitale-prodotto nelle Ripartizioni italiane ed alcune considerazioni su di esso,Metron, International Journal of Statistics, December 1970, v. XXVIII.

27. W.A. Lewis, "The Theory of Economic Growth", George Allen and Unwin Ltd., London, 1955, chapter 4.

28. W.A. Lewis, op.cit. chapter 4.

29. H.W.Arndt, External Economies in Economic Growth, Economic Record, November 1955, vol. 31, pp.192-214.

30. R. Nurkse, "Problems of Capital Formation in Underdeveloped Countries", Blackwell, Oxford 1953, chapter I.

31. P.N. Rosenstein Rodanm Il fabbisogno di capitale nei paesi sottosviluppati, Comunita Internazionale, February 1965, p.130.

32. C.J. Du Pisanie, Die Bepaling en die Gebruik van Kapitaalopbrengsverhondings, Unpublished thesis, University of Pretoria, 1968, pp.40-45.

33. This trend was evidently interrupted in the 1960-63 period as far as the mining sector is concerned. For this there were probably special factors which related only to this particular period. There was considerable uncertainty within South Africa about industrial investment following the "incidents" at Sharpeville and Langa in the early part of 1960 which focussed attention on discontent among urban Africans. This, in particular, affected the flow of new foreign investment into South African industry. The period necessary for developing a mine is considerably greater than that necessary to bring industrial investments to fruition, and

it is impossible to discontinue sinking capital in a mining development already well under way, without losing all the capital already invested in it. Therefore the momentum created by existing commitments delays the response of mining investment to changes in "the climate of investment".

On the other hand, there were reasons why investment in mining during this period should have been less subject to pressures to contract, resulting from political uncertainties. The risks might to some extent have appeared offset by a more hopeful outlook upon the future profitability of gold-mining. This was sparked off by a sterling crisis which again focussed attention upon the fragility of a system of international payments so dependent upon a reserve currency, such as the pound sterling or the dollar, which was showing signs of weakness. This turned attention to the possibility of new international financial arrangements which would enhance the role of gold, and, by stimulating the monetary demand for gold, would result in a permanently higher gold price and a higher return to investment in gold mining.

When the prospect of an early development of this sort receded, it became evident again that the relatively greater attractiveness of investment in gold-mining was only of a temporary nature, and this, along with a resumption of confidence in the future of manufacturing industry, brought about a resumption (and indeed an enhancement) of the previous trend.

34. D.H. Houghton, op.cit., p.127.

35. It is to be noted that the ICOR in such sub-periods is not calculated as an average of all the annual ICOR's, but has been calculated on the basis of the following formula:

$$k_t = \frac{\sum_{t=1}^{7} It}{\sum_{t=1}^{7} \Delta Y_{t+1}} \qquad \text{(XVI)}$$

which is an average all the same. The result will differ a little from the real mean, but it is more reliable.

36. Such an index is calculated in the following manner:

$$\sqrt{\frac{\sum_{t=1}^{n} (y'_t - y_t)^2}{n}}$$

when $y'_t$ are the theoretical values and y the real values.

37. The gold mining industry has not until recently been able to pass on higher costs in the form of higher prices. This may well have proved to be a particular stimulus to improvements in productivity.

38. W.J. Busschau, Mining's Part in the Growth of Union, Mining Survey, March 1960, p.3.

39. D.H. Houghton, op.cit., p.108.

40. D.H. Houghton, op.cit., p.121.

41. D.H. Houghton, op.cit., pp.128-131.

42. N. Kaldor, "The Causes of Slow Rate of Economic Growth of U.K.", Cambridge University Press, 1966, p.3.

43. This term "is mainly intended to denote a state of affairs where real income per head has reached broadly the same level in the different sectors of the economy". N. Kaldor, op.cit., p.3.

44. In view of the undoubtedly extensive mineral deposits, still comparatively little exploited and in fact far from fully explored in South Africa, and also in view of the partial dependence of the current organisation of manufacturing industry in South Africa, upon the foreign exchange earnings of the gold-mining industry, this conclusion should be viewed with a certain amount of caution in the present state of the South African economy.

45. See the Appendix at the end of Chapter IV.

46. P.J. Verdoorn, On an Empirical law governing the productivity of labour, Econometrica, April 1951, p.210.

47. N. Kaldor, "Causes if tge slow rate of economic growth of U.K.", Cambridge University Press, Cambridge 1966, pp.36-38.

48. This phrase is intended to convey the idea that, as increasing technical knowledge is the product of experience, expansion of production in itself favours an increase in productivity due to improvements in skills.
Cf. K.J. Arrow, The Economic Implications of Learning and Doing, Review of Economic Studies, June 1968, pp.155-173.

49. N. Kaldor, op.cit., pp.8-10.

50. A.E. Kahn, Investment Criteria in Development Programs, Quarterly Journal of Economics, 1951, p.38.

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