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Centre Économie et Gestion

RELATIONSHIP BETWEEN INTERNAL RATES OF RETURN AND ACCOUNTING RATES OF RETURN

Denis Babusiaux - Sébastien Yafil

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ENSPM - Centre Économie et Gestion
228-232, avenue Napoléon Bonaparte, Boîte postale 311
92506 RUEIL-MALMAISON CEDEX.
télécopieur : 33 (1) 47 52 70 66 - téléphone : 33 (1) 47 52 64 25

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Saïd NACHET (*Editor*) tel. : **33 (1) 47 52 64 08**

Summary

The purpose of this paper is to provide a synthesis of the relationship between internal rates of return and accounting rates of return.

It restates and completes a number of classic results by providing demonstrations that are sometimes more general and often simpler than previous demonstrations. The example of a single project is briefly presented. Emphasis is placed on a firm in steady state growth and on the interpretation of accounting rates of return as internal rates of return that vary in time.

RELATIONSHIP BETWEEN INTERNAL RATES OF RETURN AND ACCOUNTING RATES OF RETURN

For the economist, accounting data are not generally considered to be relevant indicators when making investment decisions. Profitability computations are based on cash flow forecasts whereas the accountant thinks in terms of depreciation allowances and provisions which correspond neither to receipts nor to expenditure. For a company manager, the convergence between the economic approach and the accounting approach is a fundamental issue. This paper aims at reviewing the relationship between internal rates of return and accounting rates of return. The article by J.A. Kay (1976) on the subject is a reference. A number of his results have been used, but presented and demonstrated in a simpler and often more operational manner on a discrete time basis.

With regard to a firm in steady state growth, our starting point, apart from Kay's results, is the paper by J. Sigalla and Y. Poquet (1994). We will provide a simpler and more general demonstration of their formula and we will complete their approach by distinguishing between two possible definitions of the rate of return and between the rate of return in current money and constant money.

We will start by briefly expounding the relationship between the internal and accounting rates of return of a single investment project. We will then examine the case of a steady state firm, followed by that of a firm in steady state growth. Lastly, we will analyse the general case with reference to a sequence of annual internal rates of return.

In this paper the standpoint will be that of an overall return calculation. In other words, we will not consider the investment financing mix.

I - DEFINITIONS AND NOTATIONS

Whether a single project or the activities of a firm as a whole are being considered, the following notations will be used.

I_n : investment expenditure for the year n

R_n : gross operating surplus (operating profit - operating expenditure) net of tax for the year n

V_n : net accounting value at the end of the year n

F_n : cash flow for the year n, $F_n = R_n - I_n$

A_n : accounting depreciation for the year n

All these amounts are assumed to be in current money.

For an investment project, the internal rate of return (in current money) will be denoted r defined by the equation

$$\sum_{n=0}^{N} \frac{F_n}{(1+r)^n} = 0$$

The accounting rate of return is a ratio that is computed for each year of operation. There are several definitions of this rate. We will use that one which divides the net accounting profit by the net accounting value of fixed assets. There are two versions of this definition; the profit of a year may be divided by the net accounting value at the end of the year or at the beginning of the year.

The corresponding rates will be denoted ρ_n and τ_n

$$\rho_n = \frac{R_n - A_n}{V_{n-1}}$$

$$\tau_n = \frac{R_n - A_n}{V_n}$$

We will not consider the ratio of the net profit to the arithmetical average of the net accounting values at the start and end of a period.

Further, we do not propose to consider the accounting rate of return of an investment project defined as the ratio of annual average profit to the average value of immobilisations (or investment costs). The restrictions in using such a ratio as an investment choice criterion are common knowledge.

We will restrict ourselves to simplified definitions and formulae that do not involve provisions.

II - SINGLE INVESTMENT PROJECT

a) General formula

J.A. Kay (1976) and J. Barreau (1978) have proposed a general formula:

"The internal rate of return r is equal to the weighted arithmetical average of the accounting rates of return ρ_n (profit divided by its accounting value at the beginning of the year). The weighting coefficients are present values, calculated at the rate r, of the net accounting values." (J. Barreau, 1978)

An equivalent is to define the weighting coefficients as the present values of the net accounting values, discounted at a rate corresponding to an average of the accounting rates of return

b) Specific case

Let us consider a project whose investment costs are repaid in one year (year 0), and that generates a constant cash flow during N years.

If the accounting depreciation is straight line over N years, the accounting rate of return for a year *n* is

$$\rho_n = \frac{N}{N - n+1}\left[\frac{r}{1-\frac{1}{(1+r)^N}} - \frac{1}{N}\right]$$

(demonstration in appendix 1)

The amount between brackets is interpreted as the difference between two constant repayment annuities of \$ 1. The first is calculated at the rate *r*, and the second at a rate of zero.

III - STEADY STATE FIRM

Let us take a firm that annually invests a sum *I*, that annually shows a gross operating surplus *R* and whose net accounting value *V* is constant.

We will assume that inflation is negligible.

Let us here recall a classic property: the internal rate of return is equal to the accounting rate of return if we take the economic value of the firm as equal to its net accounting value.

Justification

The internal rate of return is computed as if the firm were purchased at a price equal to its accounting value *V*, then sold, still at a price equal to its accounting value *V* a number of years later. The annual cash flow is *R-I*..

The internal rate of return is $\frac{R-I}{V}$.

The net accounting profit is equal to the gross operating profit minus total depreciation. If we assume that the firm's stability is due to the renewal of machines by identical equipment with the same scheme of depreciation, and if we assume that in any given year the firm possesses equipment of all ages, the sum of the depreciation applied each year is equal to the annual investment I.

The accounting rate of return defined as the ratio of the net accounting profit to the average of immobilisations is therefore: $\frac{R-I}{V}$.

If the economic value of the firm is different from its accounting value, the ratio of the internal and accounting rates of return is equal to the ratio of the accounting and economic values.

IV - FIRM IN STEADY STATE GROWTH

Let us take a firm in steady state growth. More precisely, let us assume that its investments and its operating profit increase regularly at a rate g. If its accounting depreciation method is constant then its net accounting value also increases at a rate g.

a) Internal rate of return, economic value equal to the accounting value

As before, let us calculate the internal rate of return as if the firm were purchased at a value equal to the accounting value V_{N_1} at a year N_1 and sold at a year N_2 at a value $V_{N_2} = V_{N_1} (1+g)^{N_2 - N_1}$

The internal rate of return is known to be independent of the time during which the firm is held by the purchaser (cf. demonstration in appendix 2).

This rate can thus be calculated for a period of 1 year.

The cash flow of a year n, not involving purchase or sale is, as before, the difference between the operating profit R_n and investments I_n.

Hence the internal rate of return is

$$r = \frac{R_n - I_n}{V_{n-1}} + g$$

or

$$r = \frac{R_n}{V_{n-1}} + \frac{V_n - V_{n-1} - I_n}{V_{n-1}} \qquad (1)$$

b) Accounting rate of return computed in relation to the net value at the end of the year

If the firm is in steady state growth at the rate g, its net profit and its net accounting value increase at the same rate. The accounting rates of return ρ and τ are therefore constant.

Let A_n be the sum of depreciation recorded at the year n.

The accounting rate of return calculated in relation to the end of year value is written

$$\tau = \tau_n = \frac{R_n - A_n}{V_n}$$

Since $V_n = (1+g)V_{n-1}$

$$\tau = \frac{R_n - A_n}{(1+g)\ V_{n-1}}$$

$$\frac{R_n}{V_{n-1}} = (1+g)\ \tau + \frac{A_n}{V_{n-1}}$$

By substituting $\frac{R_n}{V_{n-1}}$ in (1)

$$r = (1+g)\ \tau + \frac{A_n - I_n + V_n - V_{n-1}}{V_{n-1}}$$

But by definition the accounting value

$$V_n = V_{n-1} + I_n - A_n$$

Hence $\boxed{r = (1+g)\ \tau}$

What we have here is a simpler proof of the formula developed by J. Sigalla and Y. Poquet (1994) in the specific case of straight line depreciation throughout the lifetime of plant and equipment. Note that our result is independent of the depreciation scheme.

c) Accounting rate of return calculated in relation to the net value at the end of the previous year

Let ρ be the accounting rate of return calculated in relation to the net value at the beginning of the year (equal to the value at the end of the previous year)

$$\rho = p_n = \frac{R_n - A_n}{V_{n-1}}$$

$$\frac{R_n}{V_{n-1}} = \rho + \frac{A_n}{V_{n-1}}$$

hence by substitution in (1) :

$$\boxed{r = \rho}$$

d) Internal rate of return in constant money

It is clear that all the previous calculations are valid in current money. If the rate of inflation is stable over the period considered and is equal to d, the relation between internal rate of return in current money r and its value in constant money $\bar{r}$ is

$$1+r = (1+\bar{r})(1+d)$$

$$\bar{r} \cong r - d$$

The value of the internal rate of return in constant money is thus

$$\bar{r} \cong (1+g)\,\tau - d$$

and more precisely $\bar{r} = \dfrac{(1+g)\,\tau - d}{1+d}$

or $\bar{r} \cong \rho - d$

and more precisely $\bar{r} = \dfrac{\rho - d}{1+d}$

Specific case: steady state in constant money

Let us take a firm in steady state growth whose value, investment and income are constant in constant money. In this particular case the rate of growth g is equal to the rate of inflation d.

Thus $\bar{r} \cong \tau - \dfrac{d}{1+d}$

$$\bar{r} \cong \frac{\rho - d}{1+d}$$

This leads to a <u>trivial but important remark</u>. **It is a well known fact that the accounting rate of return is a good approximation of the internal rate of return in the case of a firm in steady state growth, but it is important to note that it is an approximation of the value in current money of the internal rate of return and not its value in constant money.**

A demonstration with an explicit assumption concerning any depreciation scheme can be obtained from the authors.

e) Economic value differing from the accounting value

Let us now consider the case in which the economic value of the firm differs from its net accounting value. We will continue to assume that this value denoted W_n at the year n increases regularly at a rate g.

As before, the rate of return can be computed over a year.

$$(2) \qquad r = \frac{W_n - W_{n-1} + R_n - I_n}{W_{n-1}} = g + \frac{V_{n-1}}{W_{n-1}} \quad \frac{R_n - I_n}{V_{n-1}}$$

Furthermore, since the accounting rate of return calculated in relation to an accounting value at the beginning of the year is

$$\rho = \frac{R_n - A_n}{V_{n-1}} = \frac{R_n}{V_{n-1}} - \frac{A_n}{V_{n-1}}$$

by replacing $\frac{R_n}{V_{n-1}}$ by $\rho + \frac{A_n}{V_{n-1}}$ in (2)

$$r = g + \frac{V_{n-1}}{W_{n-1}} \left[\rho + \frac{A_n - I_n}{V_{n-1}}\right]$$

using the relation

$$V_n = V_{n-1} + I_n - A_n$$

yields

$$r - g = \frac{V_{n-1}}{W_{n-1}} (\rho - g)$$

In view of the steady growth assumption, the ratio $\frac{V_n}{W_n}$ remains constant in time. This ratio will be denoted β.

The relation is written

$$\boxed{r - g = \beta(\rho - g)}$$

This relation was demonstrated by J.A. Kay (using continuous compounding) in the case of a special definition of the economic value.

$$\boxed{r = \beta\rho + (1-\beta)\, g}$$

β is generally less than 1. The relation is thus interpreted as follows:

The internal rate of return is the weighted average of the accounting rate of return and the rate of growth of the firm. The weighting coefficients are the ratio β of the net accounting value of the firm to the economic value and the difference between β and 1.

V - General: ECONOMIC SIGNIFICATION OF THE ACCOUNTING RATE OF RETURN

a) Financing by loan and law of evolution of the capital to be repaid

Let us consider a loan for an amount B_0 (issued at a year 0), repaid by annuities X_n from year 1 to year N. Let i be the rate of interest and B_n the outstanding capital at the end of each year n after repayment of the annuity X_n. The evolution of the capital to be repaid B_n can be found by the formula

$$B_n = (1+i)\, B_{n-1} - X_n \qquad \forall n = 1, 2, ..., N$$

If the annuities do in fact repay the loan, the result should be $B_N = 0$, or, which amounts to the same

$$\sum_{n=1}^{N} \frac{X_n}{1+i} = B_0$$

Remark 1: the formula remains valid if we consider several loan issues, with a positive value of X_n corresponding to a repayment annuity and a negative value to a loan issue.

Remark 2: variable rate of interest

If the rate of interest of the year n is noted i_n, the formula is written

$$B_n = (1+i_n)\, B_{n-1} - X_n$$

b) Interpretation of an internal rate of return

Let us consider a simple investment project (one sign change in the cash flow schedule) with an associated schedule of cash flows denoted F_n at the year n, assuming here that F_0 is negative.

Let us assume $K_0 = - F_0$

The equation defining the internal rate of return is

$$- K_0 + \sum_{n=1}^{N} \frac{F_n}{(1+r)^n} = 0$$

It is the maximum rate at which the income from the project can provide a return on the initial amount of capital K_0 without involving a deficit.

At any given year n, only a fraction K_n of the capital has been repaid by the cash flows of previous years.

As in the previous paragraph, we have

$$K_n = (1+r)\ Kn\text{-}1 - F_n$$

$$K_N = 0$$

c) Variable internal rate of return

It is conventionally assumed that an internal rate of return sums up in a single value the return on the project. In other words, it is the maximum value r of the rate of interest that allows repayment of the initial amount of capital and is assumed to be constant in time. In fact it is possible to define an infinite sequence of rates $r_1, r_2, ..., r_n$ that satisfy the condition under which the net present value is zero

$$\sum_{n=1}^{N} \frac{F_n}{\prod_{p=1}^{n} (1+r_p)} = K_0 \qquad (3)$$

or that satisfy the following equations, which amounts to the same

$$\left.\begin{array}{ll} K_n = (1+r_n)\ K_{n-1} - F_n & \forall k=1, 2, ..., N \\ K_N = 0 & \end{array}\right\} (4)$$

The usual formula for the rate of return is found by adding to the equation (3) or to the system of equations (4) the constraints

$$r_1 = r_2 = ... = r_N$$

It is nevertheless possible to choose other options. In particular, an a priori determination of the law of evolution of the value K_n of the capital is possible.

Let us briefly review the principle references concerning possible depreciation laws.

d) Law of the economic depreciation of equipment

Based on the work of M. Boiteux, most economists are in agreement on defining the theoretical value or the economic value of a piece of equipment as the maximum price that a firm would be prepared to pay for identical equipment if its purchase proved necessary. In spite of this consensus there are several different ways of calculating the economic value and its variation in time (cf. D. Babusiaux 1990).

When a piece of equipment is replaced at the end of its lifetime by another similar piece of equipment providing the same service over a long period of time, the approach generally adopted is that of J. Desrousseaux (1966). It is based on the law of evolution of the equivalent cost which every year equals the sum of the operating costs of the year and an investment equivalent cost. The investment equivalent cost (sometimes called economic depreciation) represents the loss each year in the discounted economic value.

Directly or indirectly, the variation in the sales prices therefore determines the variation in economic value.

A second method consists in defining the value of a piece of equipment as the sum of the present values of the cash flows generated by its use. For a project with a positive net present value, the economic value at the date of purchase is therefore higher than the purchase price.

A third method, that of J.A. Kay (1976) and A. Thomas (1975), is to define the economic value as the sum of the present values of future profits from the project, discounted at a rate equal to the rate of return on the project.

In all three cases, there is a reference, implicitly or explicitly, to the market for goods and services generated by the equipment. It is this market that governs the law of economic depreciation.

There are nevertheless cases in which the analysis may be performed differently. Let us consider investment projects in a context in which there is a non-negligible risk of nationalisation. In the petroleum industry nationalisation entails compensation of the firm, and it is generally calculated with reference to the accounting value of the assets. In this case the main reference for determining the economic value of equipment may be the accounting value.

e) Variable internal rate of return, economic value equal to the accounting value

Let us return to the definition of a sequence of annual internal rates of return mentioned in the previous paragraph. If the economic value of the equipment is the accounting value, it is possible to identify for each year n the value K_n of the system of equations (4) with the net accounting value V_n.

The internal rate of return of a year n is then defined as

$$r_n = \frac{V_n - V_{n-1} + F_n}{V_{n-1}}$$

The method of reasoning is the same as in Section V but this time without the assumption concerning growth of the firm

$$\rho_n = \frac{R_n - A_n}{V_{n-1}}$$

$$\frac{R_n}{V_{n-1}} = \rho_n + \frac{A_n}{V_{n-1}} \qquad (5)$$

$$r_n = \frac{V_n - V_{n-1} + R_n - I_n}{V_{n-1}}$$

by replacing $\frac{R_n}{V_{n-1}}$ by $\rho + \frac{A_n}{V_{n-1}}$ in accordance with (5)

we find $r_n = \frac{V_n - V_{n-1} - I_n + A_n}{V_{n-1}} + \rho n$

$$\boxed{r_n = \rho_n}$$

The accounting rate of return determined with reference to the net accounting value at the beginning of the year has the properties of an internal rate of return (if the latter is determined as varying with time).

APPENDIX 1

Specific case: constant cash flow project over N years, straight line depreciation over N years.

Let t be the rate of corporation tax.

Let F be the cash flow before tax (gross operating surplus before tax), and $\widehat{F}$ the cash flow after tax.

$$\widehat{F} = (1-t)F + t\frac{I_0}{N} = (1-t)(F - \frac{I_0}{N}) + \frac{I_0}{N}$$

Let V_n be the accounting value for the year n, where $V_0 = I_0$

$$V_n = V_0 - n\frac{I_0}{N} = \frac{N-n}{N} I_0$$

The accounting rate of return for the year n is

$$\rho_n = \frac{(1-t)(F - \frac{I_0}{N})}{V_{n-1}} = \frac{(\widehat{F} - \frac{I_0}{N})}{V_{n-1}}$$

The internal rate of return (after tax) r is such that

$$I_0 = \widehat{F} \sum_1^N \frac{1}{(1+r)^n}$$

The accounting profit is written

$$\rho_n \; V_{n-1} = I_0 \left[\frac{r}{1 - \frac{1}{(1+r)^N}} - \frac{1}{N} \right]$$

It is interpreted as the difference between the constant annuity enabling repayment of I_0 at the rate r and the annuity at the rate 0 (accounting depreciation).

The accounting rate of return is then

$$\rho_n = \frac{N}{N - n + 1} \left[\frac{r}{1 - \frac{1}{(1+r)^N}} - \frac{1}{N} \right]$$

APPENDIX 2

Internal rate of return of a firm in steady state growth

Let V_n be the value of the firm for year N

F_n the cash flow for year N (income minus investments)

N the year that the firm is sold

Let us assume that the firm is bought in a year 0 and sold in a year N. The rate of return r is obtained by the relation

$$- V_0 + \sum_{n=1}^{N} \frac{F_n}{(1+r)^n} + \frac{V_N}{(1+r)^N} = 0$$

$$- V_0 + V_0 \left(\frac{1+g}{1+r}\right)^N + \frac{F_1}{1+r} \sum_{n=0}^{N-1} \left(\frac{1+g}{1+r}\right)^n = 0$$

$$V_0 \left[1 - \left(\frac{1+g}{1+r}\right)^N\right] = \frac{F_1}{1+r} \frac{1 - \left(\frac{1+g}{1+r}\right)^N}{1 - \frac{1+g}{1+r}}$$

$$r - g = \frac{F_1}{V_0}$$

$$\boxed{r = \frac{F_1}{V_0} + g}$$

This (classic) result is interpreted as in the Gordon model. The internal rate of return is the sum of a term characterising the return for year 1 and the rate of growth of the firm.

The internal rate of return is therefore independent of the date N of sale.

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