lnvestment Project Analysis and Financing Mix. A New Method in Sight ?

Denis Babusiaux, Jean Jaylet

Centre Économie et Gestion

Investment Project Analysis and Financing Mix. A New Method in Sight?

Denis BABUSIAUX (IFP)
Jean JAYLET (TOTAL)

June 1996

Cahiers du CEG - n° 24

ENSPM - Centre Économie et Gestion
232, avenue Napoléon Bonaparte
92852 RUEIL-MALMAISON CEDEX.
fax : 33 (1) 47 52 70 66 - tél. : 33 (1) 47 52 64 08

The "Cahiers du CEG" is a collection of articles written by the Center for Economics and Management of ENSPM, Institut Français du Pétrole. It is designed to promote an exchange of ideas on the topics covered.

The opinions expressed are the sole responsibility of the author(s) and do not necessarily reflect the views of ENSPM or IFP.

For any additional information, please contact :

Axel PIERRU *tel. :* **33 (1) 47 52 64 08**

INVESTMENT PROJECT ANALYSIS AND FINANCING MIX
A NEW METHOD IN SIGHT?

Denis BABUSIAUX, Jean JAYLET

SUMMARY

Profitability studies for investment projects may use different methods to account for the manner in which the project is financed. These methods include the After Tax Weighted Average Cost of Capital (ATWACC, overall return), the equity residual method, the ARDITTI method (Before Tax Weighted Average Cost of Capital) and the Adjusted Present Value method. The discount rates and determination of cash flow differ for each method. For example, the ATWACC calculations, which are the most commonly used, are based on operating cash flows that exclude debt cash flows. Return on equity calculations are based on equity cash flows that include cash flows associated with the external financing, whereas the ARDITTI method (shadow interest) involves tax credits related to the deductibility of interest payments without reporting the credits from loans nor the corresponding principal repayments.

The method described in this paper involves cash flows that, in addition to operating cash flows, include the cash flows related to the payment of interest on loans and their incidence on tax. However it does not take into consideration loan cash inflows nor loan capital repayments.

The purpose of this paper is to compare this method with previous ones in order to determine the conditions required for its validation. An attempt is made to identify the possible fields of application.

INTRODUCTION

We propose to study the profitability of an investment project with the associated cash flow schedule. The study will be limited to deterministic calculations (cash flows associated to a scenario of the evolution of the different project parameters or cash flows corresponding to expected values).

The projects considered will be those involving funding by means of loans.

First we will review the existing classic methods for profitability studies, then we will describe a new approach, compare it with the previous ones and try to identify possible fields of application.

I - CLASSIC METHODS

1) After Tax Weighted Average Cost of Capital (overall return)

In practice this is the method most commonly used and the only one used for small projects. It is based on the principle of separating corporate financial decisions, taken by the financial management, and investment decisions analysed by specialised departments such as the "project" department in Figure 1.

Figure 1 - SEPARATION OF INVESTMENT DECISIONS AND FINANCING DECISIONS

An overall return calculation represents the point of view of such a department. The cash flows considered are **operating cash flows** that include no cash flow related to the external financing of projects. The cost of capital is accounted for by the discount rate which is the internal transfer cost of capital between the financial division and the "project" departments. This discount rate is generally defined as the after-tax average cost of capital.

Note that the rate of return calculated in this approach is the overall rate of return, i.e. the maximum rate at which project revenues can repay the entire invested capital and pay interest on it.

The following notations will be used:

N last year of the period considered.

F_n Operating cash flow of the year n (operating income - operating expenditure - corresponding tax) ($n = 0, 1, 2, ..., N$). Tax is calculated on the basis of the operating income which does not include any financial cost.

a Cost of shareholders' equity (shareholders' discount rate)

b Interest rate of loans

t Corporate tax rate

α Debt ratio of the company: debt/ (debt + equity)

i Discount rate, after-tax average cost of capital. If all the above items are defined in current money:

$$i = \alpha(1-t)b + (1-\alpha)a \qquad (1)$$

NPV_g Net Present Value ("overall")

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

2) Equity Residual Method

We will assume that the financing program of the investment project to be studied is known, along with the characteristics of the loans involved, the interest rate and the repayment schedule.

The second approach takes the point of view of the shareholders who own the capital of the company.

The cash flows considered are equity cash flows and include all the payments received and made in connection with the loans. In particular, the initial investment that appears in the cash flow stream is not the entire amount of capital invested but the transfer of equity. The rate of return calculated characterises the maximum rate required for the income from the project to pay back the equity capital used for the project (hence the name of the method).

Supplementary notations:

jn Interest from loans of the year n.

pn Repayment of capital in the year n. A negative value for p_n corresponds to a loan issue

X_n Disbursements in the year n relative to the loan. For one year of repayment:

$$X_n = p_n + j_n$$

For a year in which a loan is issued X_n is negative. Generally speaking, X_n is the opposite of the debt cash flow.

E_n Equity cash flow in the year n.

$$E_n = F_n - X_n + tj_n$$
$$E_n = F_n - p_n - (1-t)j_n \qquad (2)$$

NPV_p Equity Net Present Value

$$NPV_e = \sum_{n=0}^{N} \frac{E_n}{(1+a)^n}$$

(The discount rate to use is naturally the cost of equity capital a.)

When studying an investment project with a debt ratio α' equal to that of the entire financing of the company α, this second approach leads to the same conclusions as an overall profitability calculation.

Note, in particular, that the rate of return on equity capital is the same as or higher than the discount rate a if, and only if, the overall rate of return is higher than the average cost of capital after tax i, at least when the debt ratio (in the sense defined by Linke and Kim, 1974) is steady throughout the life of the project (see § IV.3)

Similarly, the Net Present Value of equity capital is equal to the overall Net Present Value if the portion of the loan and the debt ratio of the project, that are assumed to be steady throughout the life of the project, are defined in relation to the theoretical value of the project [Chambers et al., 1979, Babusiaux, 1990]. We will return to this point in section V.

Lastly, note that the method is mainly used when the financing of a major project has little or no incidence on the debt ratio with which the other investments of the company have to comply.

3) The ARDITTI method, shadow interest method or Before Tax Weighted Average Cost of Capital

This third method takes the point of view of the funds suppliers as a whole. The cash flows considered [Arditti, 1973] are therefore the sum of cash flows received (or paid out) by the shareholders and lenders, expressed as follows with the previous notations:

$$S_n = E_n + X_n \qquad (3)$$

If we replace E_n in accordance with (2) :

$$S_n = F_n + tjn \qquad (4)$$

The cash flows S_n considered do not therefore include the sums received or disbursed in relation to the loans but simply the tax savings linked to the deductibility of interest (hence the name "shadow interest").

The discount rate used is the average cost of capital calculated before tax.

$$s = \alpha' b + (1-\alpha')a \qquad (5)$$

When considering a project with the same debt ratio as the financing of the company as a whole, this third approach leads to the same conclusions as the previous approaches. More precisely, in the case of a project with a debt ratio that is steady in the sense defined by Linke and Kim, the "shadow interest" rate of return is higher than the discount rate s, if, and only if, the overall rate of return is higher than the discount rate i. If the debt ratio (assumed to be steady) is defined in relation to the theoretical value of the project the Net Present Value is the same for the three methods [Bourdeaux, Long, 1979].

4) The Adjusted Present Value method (Myers method)

A current version of this method [Myers 1974, Brealey, Myers, 1981] consists in distinguishing between operating cash flows, discounted at a rate equal to the cost of capital for an unleveraged firm, and tax credits due to the deductibility of interest, discounted at the cost of debt.

Similarly to what was said before, and under certain assumptions, this fourth method leads to the same conclusions as the three previous ones.

II - A NEW METHOD - DESCRIPTION

1) "Z" cash flows

The cash flows (Z_n) that we are considering now are operating cash flows minus the interest payable on loans. When calculating tax, interest deductibility is taken into account.

With the previous notations:

$$Z_n = F_n - (1\text{-t})j_n$$

$$Z_n = E_n + p_n \qquad (6)$$

These cash flows do not take account of credits and expenditures related to loan cash inflows and loan capital repayments.

Note that during a year in which only the investment capital expenses are considered, the cash flow in question is the total sum of investments. This is a common characteristic with the classic overall (ATWACC) approach.

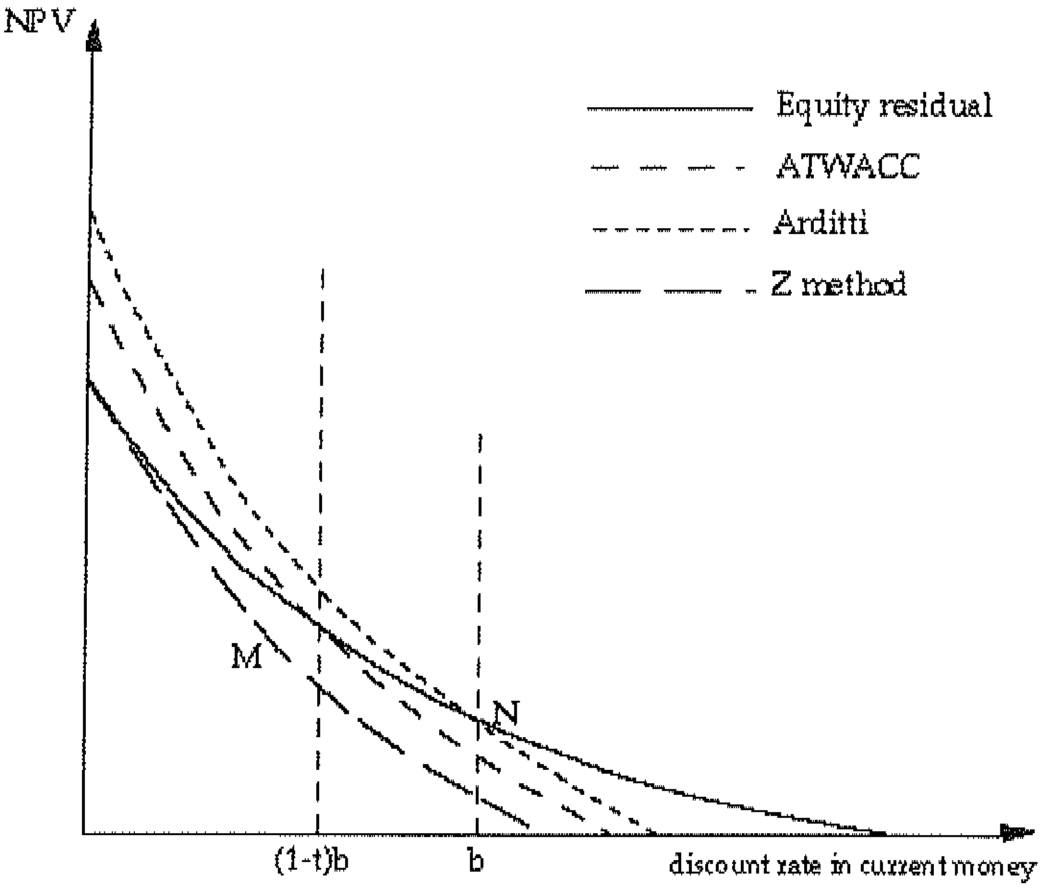
2) Discount rate

The cost of debt, which is taken into account in the definition of Z flows, is excluded from the calculation of the discount rate. We have therefore proposed a discount rate z which is the cost of equity capital multiplied by the proportion of equity capital used to finance the project.

$$z = (1 - \alpha')a \qquad (7)$$

III - COMPARISON OF PROFITABILITY PROFILES

Figure 2 illustrates the general shape of the profitability profiles of an investment project based on calculations by the ATWACC method, the equity residual method, the ARDITTI method and the Z method.



- figure 2 -
Profitability profiles

It may be observed that Net Present Value with the Z method, NPV_Z, is equal to the Net Present Value of equity capital, NPV_e, when the discount rate is zero since in this case the present value of loan capital repayments is equal to the present value of loan cash inflows.

Generally speaking, for a given value of the discount rate, NPV_Z is lower than NPV_e because the difference between Z_n and E_n is p_n, repayment minus loan cash inflow in the year n, and the discounted sum is in principle negative.

It may be noted that the rate of return r_z of a project is lower than its overall rate of return, which is lower than the shadow interest rate of return, which is in turn lower than the equity rate of return if the shadow interest rate of return is higher than the before-tax cost of debt. The first inequality is explained by the fact that the cash flow Z_n is always lower than the operating cash flow F_n.

IV - COMPARISON OF RATES OF RETURN

1) Relationship with the equity rate of return

Let us take an investment project with a debt ratio α' that is stable throughout the project life time in the sense of Linke and Kim. The rate of return r_Z by the Z method is then related to the equity rate of return r_e by the relation

$$r_Z = (1 - \alpha')r_e \qquad (8)$$

Demonstration:

The amount of loan not repaid (debt) at the year n is noted D_n. The evolution of D_n is defined by the equations

$$D_n = (1+b)D_{n-1} - X_n \qquad (n = 1, 2, ..., N) \qquad (9)$$
$$D_N = 0$$

Similarly, the evolution in equity capital A_n invested in the project can be defined by the equations

$$A_n = (1+r_e)A_{n-1} - E_n \qquad (n = 1, 2, ..., N) \qquad (10)$$
$$A_N = 0$$

where r_e is the project equity rate of return, and the system of equations (10) is equivalent to

$$A_n = \sum_{k=n+1}^{N} \frac{E_k}{\left(1+r_e\right)^{k-n}} \qquad (n = 0, 1, 2, ..., N-1)$$

in particular with the equation that defines the rate of return r_e

$$-A_0 + \sum_{n=1}^{N} \frac{E_n}{\left(1+r_e\right)^n} = 0$$

Let us take an investment project in which the share financed by loans is denoted α'. Repayment is such that the debt ratio (in the sense of Linke and Kim) is constant over the period considered and equal to α'. If the total capital at the year n is denoted K_n

$$D_n = \alpha' K_n = \alpha' (D_n + A_n)$$

It follows from (6) that $Z_n = E_n + p_n$

by replacing p_n by $D_{n-1} - E_n$ and E_n in accordance with (10)

$$Z_n = (1+r_e)A_{n-1} - A_n + D_{n-1} - D_n$$

$$Z_n = (1+r_e)(1-\alpha')K_{n-1} - (1-\alpha')K_n + \alpha'(K_{n-1} - K_n)$$

With

$$\left.\begin{aligned} Z_n &= \left[1+(1-\alpha')r_e\right]K_{n-1} - K_n \\ K_N &= A_N + D_N = 0 \end{aligned}\right\} \qquad (11)$$

The equations (11) imply that

$$K_o + \sum_{n=1}^{N} \frac{Z_n}{\left[1+(1-\alpha')r_e\right]^n} = 0$$

q.e.d.

Note that this demonstration does not take account of tax credits related to the deductibility of interest payments so equation (8) is valid whatever the tax system, particularly if the tax rate is not constant in time.

2) Relationship with the "shadow interest" rate of return

Assuming again that the project debt ratio (in the sense of Linke and Kim) is steady, we know that the equity rate of return r_e and the "shadow interest" rate of return r_s are linked by the relation

$$r_s = (1-\alpha')r_e + \alpha' b.$$

Hence

$$r_s = r_z + \alpha' b$$

3) Relationship with the overall rate of return

Let us return to the case in which the tax rate is steady over the period under consideration. In this case the overall rate of return r_g is linked to the equity rate of return r_e by the relation (all quantities are here defined in current money)

$$r_g = \alpha'(1-t)b + (1-\alpha')r_p$$

Hence

$$r_g = r_Z + \alpha' (1-t)b$$

4) Decision to accept or reject a project

Let us now consider a project partly financed by a loan. The loan share α' is equal to the overall debt ratio α of the company and the project debt ratio remains steady throughout its lifetime.

If we compare equation (8) $r_Z = (1-\alpha)\ r_e$ to equation (7) $z = (1-\alpha)a$, the rate of return r_Z is higher than the discount rate z if, and only if, the equity rate of return r_e is higher than the discount rate a.

On the basis of the assumptions considered, the Z method will lead to the same decisions to accept or reject a project as the other methods.

V - COMPARISON OF PRESENT VALUES

The above conclusion can be expressed in terms of present values: assuming a constant debt ratio equal to α, the Net Present Values calculated by different methods have the same sign. This information is not always sufficient and it is often advisable to know the value of the Discounted Cash Flow of a project. This is particularly true in the oil and gas industry where participations in a project are frequently exchanged by operators. The value of a participation is then of vital importance. This is in fact the sum of the present values of the cash flows that it generates. However, even assuming that the debt ratios are steady throughout the project lifetime, and if the share of the loan (in relation to the investment cost) is equivalent to the overall debt ratio of the company, the different methods examined here produce different - and sometimes very different - net present values for a project.

The formulae by which they are related are given in §V 4. If, on the other hand, the share of the loan for financing a project α' is calculated in relation to the theoretical value of the project and if the project debt ratio α' is steady and equal to α, the Net Present Value NPV_Z associated to the Z method will be shown to be equal to the present value found with the other methods.

We will first establish the assumption for the debt ratio used and then point out the relationships between the theoretical value of a project and the discounted cash flows used for each of the three classic methods.

This will be followed by a recurrence demonstration.

Lastly, we will describe the formula relating the present values of the different methods when the debt is defined in relation to the initial investment cost.

1) Debt ratio calculated in relation to the theoretical value of a project

Let us consider an investment project financed by a loan for which the data are as follows:

assumption a: the sum borrowed in the year 0 is

$$D_o = \alpha' (I_o + NPV)$$

where I_o represents the investment expenditure in the year 0. Note that this assumption can be justified by the fact that, when a project has a present value, its execution increases the (theoretical) value of the company and the increase is exactly equal to the Discounted Cash Flow. In theory, therefore, (in a certain future or on some assumptions of probabilisable future), if the company wishes to maintain a constant debt ratio α', it may borrow not only $\alpha' I_o$ but $\alpha'(I_o + NPV)$. If it borrows only $\alpha' I_o$ and if the market value of the shares increases due to the completion of the project under consideration, the debt ratio (calculated with reference to the market value) will fall below the value α'.

assumption b: the repayment method is such that the capital D_n remaining due in the year n is equal to a fraction α of the (theoretical) value of the project V_n.

The value of a project can be defined as the present value of future cash flows. If we take the standpoint of a project department, in other words the classic overall approach, the value of a project, once the investment has been made, is

$$V_o = \sum_{n=1}^{N} \frac{F_n}{(1+i)^n} = I_o + NPV_g$$

Similarly, the value of a project in a year n may be defined as the present value of cash flows after the year n

$$V_n = \sum_{k=n+1}^{N} \frac{F_k}{(1+i)^{(k-n)}}$$

The assumption b considered is an assumption of a debt ratio constant in time and equal to α'. The ratio is defined not in relation to the invested capital (accounting value I_o) but in relation to the theoretical (market) value of the project. It is equivalent to the assumption of the constant debt ratio in the sense of Linke and Kim which was used in the preceding paragraph, for marginal projects (with a rate of return equal to the discount rate).

2) Point of view of the three methods and value of a project

When making a **comparison with the ARDITTI shadow interest method**, note that the value of the project defined from the point of view of all the suppliers of funds is equal to the value V_n calculated from the classic point of view of a project department, i.e.

$$V_n = \sum_{k=n+1}^{N} \frac{F_k}{(1+i)^{k-n}} = \sum_{k=n+1}^{N} \frac{S_k}{(1+s)^{k-n}}$$

When making a **comparison with the return on equity calculations**, note again (cf. Babusiaux (1990)), that the value of a project in the year n is equal to the sum of the value of the equity capital and the value of the debt, i.e.

$$V_n = A_n + D_n \qquad (12)$$

with

$$A_n = \sum_{k=n+1}^{N} \frac{E_k}{(1+a)^{k-n}}$$

$$D_n = \sum_{k=n+1}^{N} \frac{X_k}{(1+b)^{k-n}}$$

or, in an equivalent manner

$$\left.\begin{array}{l} A_n = (1+a)A_{n-1} - E_n \\ A_N = 0 \end{array}\right\} \qquad (13)$$

$$\left.\begin{array}{l} D_n = (1+b)D_{n-1} - X_n \\ D_N = 0 \end{array}\right\}$$

Note: the definition of D_n, the value of the borrowed capital due in the year n, is equivalent to that used in the previous paragraph IV-I. For A_n,, the definition of the value of equity in the year n that is used here is different from that of §IV-1. The discounting is performed here on the basis of the discount rate a corresponding to the cost of equity whereas its was previously performed on the basis of the rate of return on equity r_e.

Note: Equation (12) is true whatever the definition of the project value V_n used (with the classic overall method or with the ARDITTI method).

3) Demonstration *

Let W_n be the sum of the values discounted at the rate z of the cash flows Z_k after the year n

$$W_n = \sum_{k=n+1}^{N} \frac{Z_k}{(1+z)^k}$$

or

$$W_n = (1+z)W_{n-1} - Z_n \qquad (14)$$
$$W_N = 0$$

We will demonstrate by recurrence that for any year n

$$W_n = V_n = A_n + D_n$$

In the year N-1

Equations (13) and (14) are written

$$E_N = (1+a)A_{N-1} \qquad (13')$$
$$Z_N = (1+z)W_{N-1} \qquad (14').$$

According to (6) and like $D_N = 0$

$$Z_N = E_N + p_N = E_N + D_{N-1} - D_N = E_N + D_{N-1}$$

By substituting Z_N and E_N according to (13') and (14'), we have

$$(1+z)W_{N-1} = (1+a)\,A_{N-1} + D_{N-1}$$

Using the constant debt ratio assumption

$$(1+z)W_{N-1} = (1+a)\,(1-\alpha)V_{N-1} + \alpha\, V_{N-1}$$

$$= [1+(1-\alpha)a]V_{N-1}$$

and by defining z (equation (7)):

$$W_{N-1} = V_{N-1}$$

* The authors would like to thank G. Guzman and S. Yafil [1992] who performed an initial demonstration during a project carrried out during their studies at ENSPM.

For a year n

Let us assume that the equation $W_n = V_n$

is satisfied for a year n.

In accordance with (14)

$$(1+z)W_{n-1} = W_n + Z_n = V_n + Z_n$$

In accordance with (6)

$$Z_n = E_n + D_{n-1} - D_n$$

By substituting E_n in accordance with (13)

$$(1+z)W_{n-1} = V_n + (1+a)A_{n-1} - A_n + D_{n-1} - D_n$$

Using the assumption of a debt ratio equal to α

$$(1+z))W_{n-1} = [1+(1-\alpha)a]V_{n-1}$$

$$W_{n-1} = V_{n-1}$$

The equation assumed to be true for a year n is satisfied at the year n_{-1}. Since we have checked that it was valid for the year N_{-1}, it is therefore valid for any year n.

The value of a project calculated with the Z method is equal to the value found using the ARDITTI method which is itself **equal to the sum of the value of the equity capital and the value of the debt**. If the classic overall method is usable, it is also equal to the value found by this method.

In particular, at the year O

$$W_O = A_O + D_O$$

Replacing W_O by $I_O + NPV_Z$
and A_O by $I_O - D_O + NPV_e$

confirms the equality of the net present values

$$\boxed{NPV_Z = NPV_e = NPV_s}$$

and if the overall method is used

$$\boxed{NPV_Z = NPV_g = NPV_e = NPV_s}$$

4) Loan defined with reference to the initial investment cost

In practice, the assumption of the debt ratio determined in relation to the theoretical value of the project may sometimes appear a little abstract and theoretical. The possible amounts to be borrowed are often determined in relation to the investment costs.

If the amount of the loan that can be associated with a major project was restricted to αI and not to $\alpha(I+NPV)$, then naturally it is the results of an equity method that would be pertinent.

On the other hand, the classic overall method implies the assumption of a debt ratio determined in relation to the theoretical value of the project.

When using a Z method, as for an ARDITTI method, it may be useful to measure the bias introduced by the assumption of a loan determined in relation to the (historical) cost of the investment, and then to compare the different methods in this last case.

Let us consider the following assumptions:

- the amount of the loan D_O at the year 0 is equal to αI_O.
- the loan repayment terms (and the terms of issue if the investment is spread over several years) are determined in such a way that the debt ratio of the project is constant in time. This ratio is calculated as the ratio of the amount of the loan still to be repaid to the present value of future operating cash flows (theoretical value of the project).

The relations between the present values of the first three methods [Babusiaux 1990] can be extended to the Z method and can be written

$$\frac{NPV_g}{\sum_{n=1}^{N} \frac{F_n}{(1+i)^n}} = \frac{NPV_e}{\sum_{n=1}^{N} \frac{F_n}{(1+a)^n}} = \frac{NPV_s}{\sum_{n=1}^{N} \frac{F_n}{(1+s)^n}} = \frac{NPV_z}{\sum_{n=1}^{N} \frac{F_n}{(1+z)^n}}$$

The principle of the demonstration (developed in [Guzmann and Yafil 1992]) is similar to that used for the first equations.

VI - POSSIBLE FIELDS OF APPLICATION

In order to try and determine the possible fields of application of this new method it should be compared principally to the shadow interest (ARDITTI) method because these two methods have a number of characteristics in common. The first property they share is a practical advantage, mainly when the classic overall method is difficult to use (complex tax systems).

1) Factors common to the Z flow method and the ARDITTI shadow interest method

Firstly, during the years when investments are made the Z flow method reports the entire amount of capital invested as cash flows. It is thus to a certain extent an overall return method. This type of approach is known to be generally favoured during the initial phases of project study and is (almost) always an important criterion.

The determination of the discount rate does not take into consideration the fiscal regulations concerning the accounting procedure for financial costs. This is an important factor in the oil and gas industry, particularly in the exploration for and production of oil and gas. Tax regimes are often complex and vary from one country to another, and often even from one permit to another. The tax rate may depend on the production rate of the field. Furthermore, the exploration subsidiaries of oil companies are not always in a positive situation, particularly at the start of activity in a new area. In this case the possible accounting losses which frequently occur during the first few years of exploration activity cannot be deducted from profit related to other activities and have to be carried forward. This factor tends to be encountered in countries which have set up a "tax barrier" between exploration permits.

For these reasons oil and gas taxation cannot be summed up by a tax rate and it is generally not possible to use a simple calculation method to determine the after-tax cost of debt. Classic overall rate of return calculations, which use an after-tax cost of capital as a discount rate, are therefore not suitable. Even if an after-tax average cost of capital was calculated, the company would have to determine as many discount rates (for a classic overall method) as it had petroleum tax systems to consider.

The ARDITTI method uses a before-tax cost of capital as a discount rate which is easier to determine and its value is independent of the tax regime. Similarly, the discount rate of the Z flow method, which only involves equity, is independent of taxation.

All the specific factors pertaining to the project, such as losses carried forward, tax deductibility of interest on loans, taxation of dividends, etc., are accounted for in the cash flow schedule.

All these factors, which explain the development of the ARDITTI method for studying major projects in the oil and gas exploration and production sectors, are equally favourable for the use of the Z flow method.

The restrictions and the care required in the use of these two methods are also similar. Naturally, the assumptions relative to the loan and necessary for the cash flow calculation must be consistent, at least approximately, with the assumptions used for determining the discount rate.

The discount rate should be calculated using the project debt ratio (and the cost of loans in the case of the ARDITTI method) unless using a shadow financing method based on a theoretical debt ratio. Note that the validation of these two methods is based, theoretically, on the assumption of a debt ratio assumed to be fixed and constant in time, Their field of application is therefore the same as that of equity rate of return calculations: projects with the same financing structure as the investments as a whole, or major projects whose financing can be considered as independent of the financing of other projects.

The danger, in practice, for either of the methods, is to use a discount rate and forget the assumptions that led to its determination, and to introduce different project financing assumptions.

2) The differences between the two methods

Sensitivity of the discount rate

In companies it is often possible to consider a small number of geographical areas within which the average before-tax cost of capital varies little. With the ARDITTI method the number of discount rates to be considered can thus be limited. It should be noted that although the project debt ratio α is required by both methods for calculating the discount rate, the rate

$$z = (1-\alpha)\, a$$

is more sensitive to a variation in α than the rate

$$s = (1-\alpha)\, a + \alpha b$$

The cost of equity a is often considered to be only a few percent points higher than the before-tax cost of loans b. This comment obviously points in favour of the ARDITTI method..

Sensitivity of loan rates

Let us consider a project and the associated sensitivity analysis relative to the cost of the loan. With the ARDITTI method the analysis cannot be performed without modifying both the cash flows (which include tax credits for interest) and the discount rate. It is clear, also with the ARDITTI method, that the rate of return and the discounted income calculated on the basis of an unchanged discount rate are higher when the interest rate on the loans is higher (since the cash flow S_n is equal to the operating cash flow F_n plus tax credits for financial costs $S_n = F_n + tj_n$).

Interpretation is therefore not an easy task. With the Z flow method the internal rate of return and the Discounted Cash Flow naturally decrease when the interest rate increases.

To put it crudely, when the interest rate varies, the ARDITTI method rate of return r_s varies in the wrong way and the rate of return r_z varies in the right way.

REFERENCES

[1] ARDITTI, F.D., The weighted average cost of capital; some question in its definition, interpretation and use, *Journal of Finance*, **28**, n° 4, September 1973.

[2] BABUSIAUX, D., *Décision d'investissement et calcul économique dans l'entreprise,* Technip-Economica, 1990,

[3] BOUDREAUX, K.J., LONG, H.W., The weighted average cost of capital as a cutoff rate : a further analysis, *Financial Management,* **8** n° 2, Summer 1979.

[4] BREADLEY, R.A., MYERS, S.C., *Principle of corporate finance.* MGraw Hill, New York, 1981.

[5] CHAMBERS, D.R., HARRIS, R.S., PRINGLE, J.J., Treatment of financing mix in analyzing investment opportunities, *Financial Management,* **8** n° 2, Summer 1979.

[6] GUZMAN, G., YAFIL, S., Étude d'une nouvelle méthode de calcul de rentabilité d'investissement, rapport interne IFP-ENSPM-CEG, septembre 1992.

[7] LEVY, H., SARNAT, M., *Portfolio and investments selection : Theory and practice*, Prentice Hall International, Englewood Cliffs, 1984.

[8] LINKE, C.M., KIM, M.K., More on the weighted average cost of capital : a comment and analysis, *Journal of Financial and Quantitative Analysis*, **9**, n° 4, December 1974.

[9] MYERS, S.C., Interactions of corporate financing and investment decisions. Implications for capital budgeting, *Journal of Finance*, **29**, n° 1, March 1974.

Déjà parus

CEG-1. D. PERRUCHET, J.-P. CUEILLE,
Compagnies pétrolières internationales : intégration verticale et niveau de risque.
Novembre 1990.

CEG-2. C. BARRET, P. CHOLLET,
Canadian gas exports: modeling a market in disequilibrium.
Juin 1990.

CEG-3. J.-P. FAVENNEC, V. PREVOT,
Raffinage et environnement.
Janvier 1991.

CEG-4. D. BABUSIAUX,
Note sur le choix des investissements en présence de rationnement du capital.
Janvier 1990.

CEG-5. J.-L. KARNIK,
Les résultats financiers des sociétés de raffinage distribution en France 1978-89.
Mars 1991.

CEG-6. I. CADORET, P. RENOU,
Élasticités et substitutions énergétiques : difficultés méthodologiques.
Avril 1991.

CEG-7. I. CADORET, J.-L. KARNIK,
Modélisation de la demande de gaz naturel dans le secteur domestique : France, Italie, Royaume-Uni 1978-1989.
Juillet 1991.

CEG-8. J.-M. BREUIL,
Émissions de SO2 dans l'industrie française : une approche technico-économique.
Septembre 1991.

CEG-9. A. FAUVEAU, P. CHOLLET, F. LANTZ,
Changements structurels dans un modèle économétrique de demande de carburant.
Octobre 1991.

CEG-10. P. RENOU,
Modélisation des substitutions énergétiques dans les pays de l'OCDE. Décembre 1991.

CEG-11. E. DELAFOSSE,
Marchés gaziers du Sud-Est asiatique : évolutions et enseignements.
Juin 1992.

CEG-12. F. LANTZ, C. IOANNIDIS,
Analysis of the French gasoline market since the deregulation of prices.
Juillet 1992.

CEG-13. K. FAID,
Analysis of the American oil futures market.
Décembre 1992.

CEG-14. S. NACHET,
La réglementation internationale pour la prévention et l'indemnisation des pollutions maritimes par les hydrocarbures.
Mars 1993.

CEG-15. J.-L. KARNIK, R. BAKER, D. PERRUCHET,
Les compagnies pétrolières : 1973-1993, vingt ans après.
Juillet 1993.

CEG-16. N. ALBA-SAUNAL,
Environnement et élasticités de substitution dans l'industrie ; méthodes et interrogations pour l'avenir.
Septembre 1993.

CEG-17. E. DELAFOSSE,
Pays en développement et enjeux gaziers : prendre en compte les contraintes d'accès aux ressources locales.
Octobre 1993.

CEG-18. J.P. FAVENNEC, D. BABUSIAUX,*
L'industrie du raffinage dans le Golfe arabe, en Asie et en Europe : comparaison et interdépendance.
Octobre 1993.

CEG-19. S. FURLAN,
L'apport de la théorie économique à la définition d'externalité.
Juin 1994.

CEG-20. M. CADREN,
Analyse économétrique de l'intégration européenne des produits pétroliers : le marché du diesel en Allemagne et en France.
Novembre 1994.

CEG-21. J.L. KARNIK, J. MASSERON,*
L'impact du progrès technique sur l'industrie du pétrole.
Janvier 1995.

CEG-22. J.P. FAVENNEC, D. BABUSIAUX,
L'avenir de l'industrie du raffinage
Janvier 1995.

CEG- 23. D. BABUSIAUX, S. YAFIL,*
Relations entre taux de rentabilité interne et taux de rendement comptable
Mai 1995

* this article is also available in English.