On the use of multiple financial methods in the evaluation and selection of investment projects[*]

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Abstract

This paper addresses the analysis and evaluation of investment projects within a multicriteria framework. We mathematically define a multicriteria framework and we present a result that allows the identification of redundant methods. Then we try to define which financial methods can, and which ones cannot, be simultaneously used according to that framework. We also try to establish a set of guidelines to help decision makers choose the financial methods best suited to their particular situations.

Keywords: Project Evaluation, Project Analysis, Multicriteria Decision Aid

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1 Introduction

Analysis and evaluation of investment projects are fundamental activities in most businesses. In fact, their prosperity depends upon the correct allocation of the capital they raise - if many unprofitable investments are made, the survival of the companies may be in danger. Many methods for economic evaluation of investment projects, also known as financial methods, have been developed to help decision makers (DMs) assess whether or not an investment will be profitable, or compare the profitability of different investments. Although all these methods

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are, directly or indirectly, concerned with the profitability of the investments, they do not always yield the same results - in fact, different methods do sometimes yield contradictory results when evaluating or comparing the same investments. This fact raises some difficult questions to DMs in charge of investment selection, concerning:

- which method (or methods) should be used in a particular situation;
- whether one or more method(s) should be used in a particular situation;
- how should the results from different methods be aggregated.

To worsen matters, these methods cannot usually account for all the relevant information. One reason is that some strategic impacts of the investments are too complex to be properly quantified in the predicted earnings or cash flows. Another reason is that there are usually some issues, not related with the profitability of the investment, that DMs want to consider when they make an investment decision - these issues may refer to prestige, power or ethical concerns and are relevant to the DMs as individual human beings. This raises the question of knowing when and how these issues should be considered.

In this paper we will address the analysis and evaluation of investment projects within a multicriteria framework. This framework will provide a theoretical basis to the aggregation of the results yielded by different methods, and we believe it may also provide a basis for the aggregation of these with non-financial factors. It will also allow the use of decision theory methods in investment decisions and, hopefully, avoid some decision errors due to an incorrect aggregation of factors. The framework we use is based upon the work of Bana e Costa [3] and Roy [13]. In this framework, all the properties, or characteristics, of the investments are modelled as attributes, and the results yielded by financial methods will be called financial attributes. Among the attributes, the decision maker (DM) will build a set of criteria, taking into account his/her concerns, values and beliefs. Some of the criteria may result from the aggregation of several attributes.

First, we present the most widely used methods for project evaluation. Using a classification based upon [11,12], we divide the most important financial methods into five classes - equivalent worth, rate of return, ratio, payback and accounting.

In order to have a correct structure for the decision problem, we want the set of criteria to be a coherent family of criteria [3]. This means that we want the set of criteria to be exhaustive, cohese and non-redundant. Exhaustiveness means that all relevant criteria are included in the set of criteria. So, if any two alternatives are equal in all criteria they must be indifferent for the DM, or else we must conclude that there is at least one relevant issue that is not properly accounted for by the set of criteria. Cohesion means that if two alternatives, A and B, are equal in all criteria but one, and A is better than B according to that criterion, then A must be preferred to B. A set of criteria is non-redundant if the removal of any criterion causes that set to be no longer both exhaustive and cohese. In section 3, we mathematically define these conditions and present a result that can be applied to the identification of redundant criteria.

Then, we try to find out which financial attributes can, and which ones cannot, be used together as criteria, assuming that we want the set of criteria to be a coherent family of criteria and to be based on non-contradictory assumptions and concepts. We try to define whether or not financial attributes from the same class should be used together as criteria, and whether or not financial attributes from different classes should be used together as criteria, according to our framework. We argue that a DM will usually want to use at most one financial attribute from a single class. We also argue that a DM may use together attributes from different classes, but he/she will usually want to use at most one attribute from both the classes of ratio and rate of return methods. Afonso *et al.* [1] perform a similar analysis, using a slightly different classification of the financial methods.

In section 5 we try to establish a set of guidelines to help DMs choose the financial methods best suited to their specific situations. First, we characterise a set of decision situations, according to the degree of quantification, capital availability for the investments, degree of risk and uncertainty, interdependencies between investments and existence of previously undertaken investments. We try to find out which financial method(s) is (are) best suited for each situation, and how should each characteristic affect the investment selection process. Although this approach is similar to the approach of Fahrni and Spatig [5], there are some important differences between them. One important difference is that, while Fahrni and Spatig focus on R&D projects, we try to consider all kinds of projects. Possibly because of this, our characterisation of the decision situations is different from theirs. Also, while we aim to suggest one financial method for each situation, Fahrni and Spatig never suggest any particular financial method - they treat financial methods as a whole component that shall or shall not be used according to the situation.

Next, we try a different approach. We consider some classes of methods and we try to define in which situations should the methods belonging to those classes be used, without following any particular situation taxonomy.

We conclude that the net present value (NPV), or other method from the equivalent worth class, is usually the best choice. However, rate of return or ratio methods may be the best suited for some particular situations. We do not exclude that, in many situations, the DMs may want to consider other methods, along with the NPV (or the rate of return or ratio method), due to additional reasons.

2 Financial methods

A large number of financial methods is presented in financial textbooks and papers. In this section, we will describe some of the most important financial methods and, following [11,12], we will categorise them into five classes: equivalent worth, rate of return, ratio, payback and accounting.

Equivalent worth methods examine the project cash flows and, through discounting or compounding, resolve them to one equivalent cash flow or to an equivalent series of cash flows. The most important of these methods is the net present value (NPV). The NPV is the present monetary value of all the project cash flows (including investment and salvage value) discounted at the appropriate discount rate. The traditional definition of the NPV is:

$$NPV = \sum_{t=0}^{T} \frac{CF_t}{(1+r)^t} \tag{1}$$

where r is the discount rate, CF_t is the cash flow in period t and T is the horizon period (which is often the project lifetime). The NPV is nowadays considered by many authors to be, in most situations, the best economic profitability measure for investment projects (see, for example, [4]).

The future worth (FW), the annual worth (AW) and the capitalised worth (CW) are other equivalent worth methods. The FW is the monetary value of all the project cash flows in a future date, and it can be found through the compounding of the cash flows to that future date. The AW is the value of each of the cash flows of an equivalent project (having the same NPV) with a finite lifetime (usually identical to the lifetime of the original project or to the considered horizon period), whose cash flows are constant over its lifetime. The CW is equal to the AW except that it considers another equivalent project with an infinite lifetime. These methods can be defined in the following way:

$$FW = \sum_{t=0}^{T} CF_t \, (1+r)^{T_0 - t} = NPV \, (1+r)^{T_0} \tag{2}$$

$$AW = \frac{\sum_{t=0}^{T} \frac{CF_t}{(1+r)^t}}{\sum_{t=1}^{T} \frac{1}{(1+r)^t}} = \frac{\sum_{t=0}^{T} \frac{CF_t}{(1+r)^t}}{\frac{1}{r} - \frac{1}{r(1+r)^T}} = \frac{NPV}{\frac{1}{r} - \frac{1}{r(1+r)^T}} \tag{3}$$

$$CW = \frac{\sum_{t=0}^{T} \frac{CF_t}{(1+r)^t}}{\sum_{t=1}^{\infty} \frac{1}{(1+r)^t}} = \left(\sum_{t=0}^{T} \frac{CF_t}{(1+r)^t} \right) \cdot r = NPV \cdot r \tag{4}$$

In the definition of FW, T_0 is the future moment for which the FW is calculated. The remaining notation was previously defined.

The use of equivalent worth methods must include an adjustment for the risk of the project. This risk can be seen as the possible deviations from the expected project behaviour, and it can be divided into systematic and unsystematic risk. The unsystematic risk can be eliminated by holding a diversified portfolio of investments, and the systematic risk cannot be eliminated by diversification, and it is the only type of risk that should matter to investors with diversified portfolios. Also, financial theory prescribes that only the systematic risk shall be incorporated in the value of financial assets and projects. The measure used for this type of risk is the beta (β) coefficient, defined as the covariance of the asset (or project) returns with the market returns divided by the variance of the market returns. Using the project betas, it is possible to incorporate the systematic risk in the project NPV through the use of a risk-adjusted discount rate, calculated according to the Capital Asset Pricing Model (CAPM). According to the CAPM, if r_f is the risk-free discount rate, β is the project beta and $E(r_m)$ is the expected market return, then the correct risk-adjusted rate will be:

$$r = r_f + \beta \left[E(r_m) - r_f \right] \tag{5}$$

For more details on the calculation of project betas and risk-adjusted discount rates, see [4].

The adjustment of the discount rate works very well for the NPV, but not for the other equivalent worth methods. In fact, the use of such a risk-adjusted discount rate in the other equivalent worth methods will not correctly adjust for the project risk. To deal with this problem we suggest the adjustment of the cash flows, instead of the adjustment of the discount rate, by using certainty equivalents of the cash flows ([4], chapter 9). Specifically, r_f being the risk-free discount rate and r being the risk-adjusted discount rate, the period t cash flow is adjusted to its certainty equivalent,

$$CE = CF_t \cdot \left(\frac{1+r_f}{1+r}\right)^t \tag{6}$$

and then the risk-free discount rate is used. For the NPV, it is indifferent to adjust the discount rate or the cash flows. However, for the other methods, the adjustment of cash flows will allow the correct comparison of projects with different systematic risk.

Rate of return methods measure the rate at which the invested capital will grow if the project is pursued. The most widely used rate of return method is the internal rate of return (IRR). This rate can be defined as the discount rate for which the NPV equals zero, and corresponds to the yield-to-maturity on a bond. It can be calculated by solving the following equation:

$$\sum_{t=0}^{T} \frac{CF_t}{(1+IRR)^t} = 0 \tag{7}$$

Other methods from the rate of return class include the external rate of return (ERR) and the marginal return on invested capital (MRIC). Both these methods consider an explicit reinvestment rate. The ERR is the rate for which the future worth of the initial investment equals the future worth of the other cash flows compounded, at the reinvestment rate, to the end of the project. Using I_0 to represent the initial investment, we can define:

$$\frac{\sum\limits_{t=1}^{T} CF_t\,(1+r)^{T-t}}{(1+ERR)^T} = I_0 \tag{8}$$

The MRIC is defined in [9]. Two kinds of cash flows are considered - capital cash flows, used to finance the project, and operating cash flows, generated by the project. Capital cash flows are discounted, at the reinvestment rate, to the beginning of the project and operating cash flows are compounded, at the same reinvestment rate, to the end of the project. The MRIC is the rate at which the present value of the capital cash flows should be compounded so that it would equal the future value of the operating cash flows at the end of the project. So, the MRIC can be defined as:

$$\sum_{t=0}^{T} \frac{CCF_t}{(1+r)^t} = \frac{\sum\limits_{t=1}^{T} OCF_t\,(1+r)^{T-t}}{(1+MRIC)^T} \tag{9}$$

where CCF_t is the capital cash flow for period t and OCF_t is the operating cash flow for period t.

The most significant ratio methods can be defined as the quotient between the present value of the returns and the present value of the investment. The most widely used ratio method is the profitability index (PI), which is defined as the quotient between the present value of the future cash flows generated by the project and the initial investment:

$$PI = \frac{\sum\limits_{t=1}^{T} \frac{CF_t}{(1+r)^t}}{I_0} \tag{10}$$

Other ratio methods can be defined as the ratio between the present value of the returns and the present value of the investment. The benefit-cost ratio (B/C ratio), for instance, is the quotient between the present value of all cash flows, excluding the initial investment and the salvage value, and the difference between the initial investment and the present worth of the salvage value. If we use SV_T to represent the salvage value of the project, we can define:

$$B/C = \frac{\sum\limits_{t=1}^{T} \frac{CF_t}{(1+r)^t} - \frac{SV_T}{(1+r)^T}}{I_0 - \frac{SV_T}{(1+r)^T}} \tag{11}$$

Payback methods calculate how long it takes to recover the invested capital. These methods include the payback period and the discounted payback period. The payback period is the number of years required for the accumulated project cash flows to equal the initial investment. The discounted payback period is similar to the payback period, except that it considers the discounted cash flows instead of the raw cash flows. So, we can define:

$$\text{Payback} = \min\left\{k : \sum_{t=1}^{k} CF_t \geq I_0\right\} \tag{12}$$

$$\text{Discounted Payback} = \min\left\{k : \sum_{t=1}^{k} \frac{CF_t}{(1+r)^t} \geq I_0\right\} \tag{13}$$

Accounting methods consider profitability from an accounting perspective. This class includes the return on original investment (ROOI, a.k.a. original book method) and the return on average investment (ROAI, a.k.a. average book method), among others. The ROOI is the quotient between the average yearly accounting profit, which excludes depreciation, and the investment made in the project. The ROAI is the quotient between the average yearly accounting profit and the average book value (average value of the difference between investment and depreciation) during the project life. Using AP_t to represent accounting profit in period t and BV_t to represent book value in period t, we can define:

$$ROAI = \frac{\frac{\sum\limits_{t=1}^{T} AP_t}{T}}{\frac{\sum\limits_{t=0}^{T} BV_t}{T+1}} \tag{14}$$

$$ROOI = \frac{\frac{\sum\limits_{t=1}^{T} AP_t}{T}}{I_0} \tag{15}$$

A further description of most of these financial methods can be found in [11,12]. [4] and [10] also describe some of these methods, discussing its advantages and drawbacks and also discussing the calculation of the discount or compounding rate needed by some of them.

3 Mathematical definitions and results

This section provides some mathematical results used to find out which attributes can and which ones cannot be used together as criteria. We consider that, in order to have a correct structure for the decision problem, we want the set of criteria to be a coherent family of criteria [3]. As was said before, this means that the set of criteria must be exhaustive, cohese and non-redundant. Exhaustiveness means that all relevant criteria are included in the set of criteria. So, if any two alternatives are equal in all criteria they must be indifferent for the DM, or else we must conclude that there is at least one relevant issue that is not properly accounted for by the set of criteria. Cohesion means that if two alternatives, A and B, are equal in all criteria but one, and A is better than B according to that criterion, then A must be preferred to B. A set of criteria is non-redundant if the removal of any criterion causes that set to be no longer both exhaustive and cohese. We will now mathematically define these conditions and we will show that two attributes that rank projects identically will be redundant.

Assumptions

Let $A=\{a_1, a_2, \ldots, a_n\}$ be the set of projects and $F=\{g_1, g_2, \ldots, g_m\}$ the set of attributes used as criteria. $g_k(a_i)$ will be the performance of project a_i according to attribute g_k. Let us also assume, without loss of generality, that a larger value in a given attribute is always better than a smaller one.

Definitions The symbols P and I will be used as comparison operators: a_i P a_j means that a_i is considered to be preferred to a_j and a_i I a_j means that a_i and a_j are considered to be indifferent.

We will consider that, in order to be a coherent family of criteria, the set F must meet the following exhaustiveness, cohesion and non-redundancy conditions:

(Exhaustiveness)

$$\forall a_i,a_j \in A,\ (g_k(a_i)=g_k(a_j),\ \forall g_k \in F) \Rightarrow a_i \ \mathrm{I}\ a_j \tag{16}$$

(Cohesion)

$$\forall a_i,a_j \in A,\ \forall g_l \in F,\ (g_k(a_i)=g_k(a_j),\ \forall g_k \in F\setminus\{g_l\} \wedge g_l(a_i) > g_l(a_j)) \Rightarrow a_i \ \mathrm{P}\ a_j \tag{17}$$

(Non-redundancy)

$$\begin{aligned}&\forall g_p \in F,\ \exists a_i,a_j \in A\text{: } \{[(g_k(a_i)=g_k(a_j),\ \forall g_k \in F\setminus\{g_p\}) \wedge (a_i \ \mathrm{P}\ a_j \vee a_j \ \mathrm{P}\ a_i)] \vee \\ &[\exists g_l \in F\setminus\{g_p\}\text{:} g_k(a_i)=g_k(a_j),\ \forall g_k \in F\setminus\{g_p,g_l\} \wedge g_l(a_i) > g_l(a_j) \wedge (a_j \ \mathrm{P}\ a_i \vee a_i \ \mathrm{I}\ a_j)]\}\end{aligned} \tag{18}$$

The first part of expression (18) means that if any criterion g_p is removed then F will no longer meet the exhaustiveness condition; the second part of that expression means that if any criterion g_p is removed then F will no longer meet the cohesion condition.

Theorem (attribute redundancy):

Let us assume that, for two attributes g_r and g_s, we have:

$$\forall\ a_i,a_j \in A,\ g_r(a_i) > g_r(a_j) \Rightarrow g_s(a_i) > g_s(a_j) \tag{19}$$

If the criteria set F includes both g_r and g_s then F is not a coherent family of criteria because, if both the exhaustiveness and cohesion conditions are met, then the non-redundancy condition is not met. Specifically, g_r can be removed from F without the exhaustiveness and cohesion conditions ceasing to hold. We thus say that g_r is redundant.

Corollary: If two attributes rank the projects identically, then they will be redundant (only one of them should be used as criterion).

Theorem proof:

We will show that (a) if F meets the exhaustiveness condition, then $F\backslash\{g_r\}$ also meets the exhaustiveness condition and (b) if F meets the cohesion condition, then $F\backslash\{g_r\}$ also meets the cohesion condition. This will show that g_r can be removed from F without the exhaustiveness and cohesion conditions ceasing to hold, thus g_r is redundant.

Let us start by proving (a). (19) says that $g_r(a_i) > g_r(a_j) \Rightarrow g_s(a_i) > g_s(a_j)$, thus $g_r(a_j) > g_r(a_i) \Rightarrow g_s(a_j) > g_s(a_i)$. This means that we may only have $g_s(a_i)=g_s(a_j)$ when $g_r(a_i)=g_r(a_j)$. So:

$$\forall\ a_i,a_j \in A,\ g_s(a_i)=g_s(a_j) \Rightarrow g_r(a_i)=g_r(a_j) \tag{20}$$

Also:

$$\begin{aligned} g_k(a_i)=g_k(a_j),\ \forall g_k \in F\backslash\{g_r\} &\Rightarrow g_s(a_i)=g_s(a_j) \quad (\text{since } g_s \in F\backslash\{g_r\}) \\ &\Rightarrow g_r(a_i)=g_r(a_j) \quad (\text{using (20)}) \end{aligned} \tag{21}$$

And so:

$$\begin{aligned} g_k(a_i)=g_k(a_j),\ \forall g_k \in F\backslash\{g_r\} &\Rightarrow g_k(a_i)=g_k(a_j),\ \forall g_k \in F \quad (\text{using (21)}) \\ &\Rightarrow a_i\ I\ a_j \\ &\qquad (\text{because F meets the exhaustiveness condition}) \end{aligned} \tag{22}$$

(22) means that $F\backslash\{g_r\}$ meets the exhaustiveness condition, proving (a).

Let us now prove (b). We will prove that, if F meets the cohesion condition (if (17) holds) then $F\backslash\{g_r\}$ will also meet the cohesion condition, meaning that for any projects a_i and a_j:

$$\forall g_l \in F\backslash\{g_r\},\ (g_k(a_i)=g_k(a_j), \forall g_k \in F\backslash\{g_r,g_l\} \wedge g_l(a_i) > g_l(a_k)) \Rightarrow a_i\ P\ a_j \tag{23}$$

We will start by showing that (23) holds for all $g_l \in F\backslash\{g_s,g_r\}$. We will thus prove that, for $g_l \in F\backslash\{g_s,g_r\}$, if $g_k(a_i)=g_k(a_j), \forall g_k \in F\backslash\{g_r,g_l\} \wedge g_l(a_i) > g_l(a_k)$ then $a_i\ P\ a_j$.

Since $g_k(a_i)=g_k(a_j),\ \forall g_k \in F\backslash\{g_r,g_l\}$, and $g_l \in F\backslash\{g_s,g_r\}$, then we have $g_s(a_i)=g_s(a_j)$ and, by (20) we have $g_r(a_i)=g_r(a_j)$. So:

$$\begin{aligned} g_k(a_i)=g_k(a_j),\ \forall g_k \in F\backslash\{g_r,g_l\} \wedge g_l(a_i) > g_l(a_j) &\Rightarrow g_k(a_i)=g_k(a_j),\ \forall g_k \in F\backslash\{g_l\} \wedge g_l(a_i) > g_l(a_j) \\ &\Rightarrow a_i\ P\ a_j \\ &\qquad (\text{since the cohesion condition holds}) \end{aligned} \tag{24}$$

To complete the proof, we will show that (23) holds for g_l=g_s. From (19) we can say that $g_s(a_i) \leq g_s(a_j) \Rightarrow g_r(a_i) \leq g_r(a_j)$ and, consequently:

$$g_s(a_i) > g_s(a_j) \Rightarrow g_r(a_i) \geq g_r(a_j) \tag{25}$$

Using (25) we get, for g_l=g_s:

$$g_k(a_i)=g_k(a_j),\ \forall g_k \in F\backslash\{g_r,g_s\} \wedge\ g_s(a_i) > g_s(a_j) \Rightarrow g_r(a_i) \geq g_r(a_j) \tag{26}$$

Let us analyse the expression (26). It says that a_i and a_j are equal in all criteria except g_s and, possibly, g_r. Since F meets the cohesion condition, if $g_r(a_i)$=$g_r(a_j)$, then we have a_i P a_j (because $g_s(a_i) > g_s(a_j)$). If a_i is also better than a_j in g_r, then a_i is also considered to be preferred to a_j. So:

$$g_k(a_i)=g_k(a_j),\ \forall g_k \in F\backslash\{g_r,g_s\} \wedge\ g_s(a_i) > g_s(a_j) \quad \Rightarrow a_i \text{ P } a_j \tag{27}$$

We showed that (23) holds for all attributes $g_l \in F\backslash\{g_r\}$. So, if F meets the cohesion condition, $F\backslash\{g_r\}$ also meets the same condition. (22) shows that if F meets the exhaustiveness condition, then $F\backslash\{g_r\}$ also meets the same condition. This means that, when (19) holds, g_r will be redundant, so the theorem proof is complete.

The corollary of this theorem can now be used to find redundant attributes. Whenever two different attributes rank projects identically, they shall not be used together as criteria, since they will be redundant.

4 On the simultaneous use of different financial attributes

In this section we will try to find out which financial attributes can, and which ones cannot, be used together as criteria. For that purpose we will initially consider financial attributes from the same class, and then we will consider attributes from different classes. In this analysis we will assume that we want the set of criteria to be a coherent family of criteria, and also to be based on non-contradictory assumptions or concepts.

We will want the set of criteria to be not only a coherent family of criteria, but also to be based on non-contradictory assumptions or concepts. We acknowledge that, in the presence of risk, it may be worthwhile to consider the behaviour of the project under different scenarios (as will be discussed in section 5). However, the data and methods used in each scenario should not include contradictory assumptions or concepts, so that each scenario represents a consistent possibility of project behaviour.

In the following discussion, we will only consider the financial methods presented in section 2, which include the most common financial methods. We believe our conclusions are extensible to other methods, if these methods can be properly classified into one of the five classes we are considering. In the analysis of financial attribute redundancy, we will not discuss whether or not two attributes happen to rank the projects identically for a particular set of projects. We will only consider that two attributes are redundant if they always rank projects identically. This way, our results will be independent of any particular set of projects, and will still be valid when some projects are removed from or added to the initial set.

To start with, we will address the simultaneous use of different financial attributes from the equivalent worth class. Several constraints must be met by the methods from this class, so that they can be properly applied. One example: the projects being compared should have the same discount rate[1] [11]. It is easy to prove that, when properly applied, all equivalent worth methods rank projects identically. Let us consider the NPV and the CW. We will assume that the discount/reinvestment rate belongs to the interval]-1,+∞[, in which it has economic meaning, and that the projects being compared have the same discount rate, even if it is necessary to use certainty equivalent cash flows to achieve that. So, the CW will be equal to the NPV divided by the perpetuity factor, $\sum_{t=1}^{\infty} \frac{1}{(1+r)^t}$. Since, for $r \leq 0$, the perpetuity factor is $+\infty$, the CW is only defined for $r>0$, in which case the perpetuity factor equals $\frac{1}{r}$. So, we must assume $r>0$, in which case:

$$\begin{aligned} \mathrm{NPV}(\mathrm{a}_i) > \mathrm{NPV}(\mathrm{a}_j) \quad &\Leftrightarrow \quad \mathrm{NPV}(\mathrm{a}_i)\cdot\mathrm{r} > \mathrm{NPV}(\mathrm{a}_j)\cdot\mathrm{r} \\ &\Leftrightarrow \quad \mathrm{CW}(\mathrm{a}_i) > \mathrm{CW}(\mathrm{a}_j) \end{aligned} \tag{28}$$

So, the NPV and the CW rank projects identically. Park and Sharp-Bette [10], chapter 7, show that the NPV, the AW and the FW rank projects identically. Thus, according to the non-redundancy demand of a coherent family of criteria, at most one attribute from the equivalent worth class should be used as criterion. The interpretation of the NPV provides some advantages over the other equivalent worth attributes, so the NPV will usually be used. However, special circumstances may advise the use of a different attribute.

We will now consider the rate of return methods. It is well known that different rate of return methods may rank the same projects differently. That is because the results obtained depend on the reinvestment assumptions and on the implicit concepts of investment and return for each method. While the IRR assumes that the profits are reinvested at a rate equal to the IRR, the ERR and the MRIC consider an explicit reinvestment rate. The ERR differs from the MRIC on the concepts of investment and return. While the MRIC considers investment to be all the capital cash flows, the ERR considers investment to be only the initial investment. As different rate of return methods can yield contradictory results, we cannot say that rate of return attributes are redundant. However, in general only one should be used, chosen according to the DM's reinvestment assumptions and concepts of investment and return. If more than one rate of return attribute is used in the evaluation process, then contradictory assumptions or concepts will be simultaneously involved.

Like the rate of return methods, ratio methods may also rank the same projects differently. That is because they also assume different concepts of investment and return. While the PI assumes investment to be the initial investment and all the other cash flows to be return, the B/C ratio assumes investment to be the difference between the initial investment and its salvage value, and return to be all the other cash flows excluding the salvage value. Thus,

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[1] The adjustment of cash flows, suggested in section 2, allows us to use the same discount rate for all the projects, even when the project risk is different.

as different ratio methods may rank projects differently, we cannot say that their results are redundant. However, only one ratio attribute should be usually used, chosen according to the DM's concepts of investment and return.

Accounting methods differ in what they consider relevant about the investment. While the ROOI assumes that the whole value of the investment (the whole book value) matters, the ROAI assumes that it is the average book value, after the yearly depreciation, that matters. So, these methods can yield different results, according to the type of depreciation associated with each project, and thus they are not redundant. However, a DM will usually want to use at most one accounting attribute, according to what he/she thinks is more significant about the investment: the whole book value or the average book value. Moreover, because these methods do not take the time value of money into account, it is arguable that a DM will consider them relevant. Accounting attributes should only be used when accounting issues are considered important.

Payback methods may rank the same projects differently, and lead to different accept/reject decisions. That is because while the discounted payback period takes the time value of money into account, the payback period does not. This means they are not redundant, but usually at most one of them will be used, according to whether or not the time value of money is considered important. A DM will usually consider the time value of money relevant and will thus prefer the discounted payback period.

We will now consider the simultaneous use of attributes from different classes. To start with, we will try to figure out which perspective, or dimension, of the profitability does each class address. The equivalent worth class addresses the absolute value of the project, accounting methods address the accounting profitability and payback methods address the time it takes to recover the initial investment, or the liquidity recovery speed. As for the rate of return and ratio classes, we can see that for each ratio method we can find out or define a rate of return method that is equivalent in the sense that it ranks projects in the same way and always leads to the same accept/reject decisions. The opposite is also usually true[2]. As an example, we can see that the PI is equivalent to the ERR, thus they are redundant. For the MRIC, we can define an equivalent ratio method (let us call it Modified Profitability Index, MPI) as:

$$MPI = \frac{\sum\limits_{t=1}^{T} \frac{OCF_t}{(1+r)^t}}{\sum\limits_{t=0}^{T} \frac{CCF_t}{(1+r)^t}} \tag{29}$$

where OCF_t is the operating cash flow in period t, CCF_t is the capital cash flow in period t, r is the discount rate (equal to the MRIC reinvestment rate) and T is the horizon period. Once more, if we assume that the rate r belongs to the interval]-1,+∞[, in which it has economic meaning, and that this reinvestment rate is equal for both projects, we have:

$$\mathrm{MRIC}(\mathrm{a}_i) > \mathrm{MRIC}(\mathrm{a}_j) \quad \Leftrightarrow \quad 1 + \mathrm{MRIC}(\mathrm{a}_i) > 1 + \mathrm{MRIC}(\mathrm{a}_j)$$

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[2] For each rate of return method that uses an external rate to resolve all the cash flows into two cash flows, we can define a ratio method that is equivalent. This is the case of the ERR and the MRIC.

$$\begin{aligned}
&\Leftrightarrow \quad \sqrt[T]{\frac{\sum\limits_{t=1}^{T} OCF_t(\mathrm{a}_i)\cdot(1+r)^{T-t}}{\sum\limits_{t=0}^{T}\frac{CCF_t(\mathrm{a}_i)}{(1+r)^t}}} > \sqrt[T]{\frac{\sum\limits_{t=1}^{T} OCF_t(\mathrm{a}_j)\cdot(1+r)^{T-t}}{\sum\limits_{t=0}^{T}\frac{CCF_t(\mathrm{a}_j)}{(1+r)^t}}}\\
&\Leftrightarrow \quad (1+r)^T\,\frac{\sum\limits_{t=1}^{T}\frac{OCF_t(\mathrm{a}_i)}{(1+r)^t}}{\sum\limits_{t=0}^{T}\frac{CCF_t(\mathrm{a}_i)}{(1+r)^t}} > (1+r)^T\,\frac{\sum\limits_{t=1}^{T}\frac{OCF_t(\mathrm{a}_j)}{(1+r)^t}}{\sum\limits_{t=0}^{T}\frac{CCF_t(\mathrm{a}_j)}{(1+r)^t}}\\
&\Leftrightarrow \quad \frac{\sum\limits_{t=1}^{T}\frac{OCF_t(\mathrm{a}_i)}{(1+r)^t}}{\sum\limits_{t=0}^{T}\frac{CCF_t(\mathrm{a}_i)}{(1+r)^t}} > \frac{\sum\limits_{t=1}^{T}\frac{OCF_t(\mathrm{a}_j)}{(1+r)^t}}{\sum\limits_{t=0}^{T}\frac{CCF_t(\mathrm{a}_j)}{(1+r)^t}}\\
&\Leftrightarrow \quad \mathrm{MPI}(\mathrm{a}_i) > \mathrm{MPI}(\mathrm{a}_j) \qquad (30)
\end{aligned}$$

So, the MRIC and the MPI rank projects identically. Park and Sharp-Bette [10], chapter 7, show that some rate of return and ratio methods, including the ERR and the PI, rank projects identically. It would also be easy to define a rate of return method equivalent to the B/C ratio. This relation between rate of return and ratio methods led us to the conclusion that they would probably address the same profitability dimension. And, in fact, they both address the relation between the return and the investment. Thus, as both classes address the same dimension, we should usually use at most one attribute from both these two classes. As for the other classes, since they address different profitability dimensions, attributes from different classes can be simultaneously used as criteria, given that they are not based on contradictory assumptions or concepts. Table 1 summarises these results.

In this section we dealt with the simultaneous use of different financial attributes as criteria. We concluded that a DM will usually want to use at most one financial attribute from a single class, and that a DM may use together financial attributes from different classes, but he/she will usually want to use at most one attribute from both the ratio and rate of return classes.

5 On the selection of financial methods

In this section we will try to establish a set of guidelines to help DMs choose the financial methods best suited to their specific situations. First, we will consider that the different decision situations are defined according to five characteristics: degree of quantification, capital availability for the investments, degree of risk and uncertainty, interdependencies between investments and existence of previously undertaken investments. We will try to define how each of these characteristics shall be considered in the investment selection process. Next, we will consider different financial methods, and define in which situations shall each method be used.

The degree of quantification defines whether or not financial methods can be used to evaluate the investments. In fact, financial methods cannot be used unless quantitative data about the investment costs and returns are available. The specific needs depend on the chosen methods, and can vary from the project cash flows (required by the NPV and IRR, for instance) to more detailed accounting data (required by accounting methods). So, when quantitative

Table 1: Simultaneous use of different financial attributes, assuming that a coherent family of criteria is wanted.

Class	Attributes considered	Simultaneous use (same class)	Simultaneous use (different classes)
Equivalent Worth	NPV FW AW CW	Just one attribute.	Attributes from all the other classes can be simultaneously used.
Rate of Return	IRR ERR MRIC	Just one attribute, chosen according to the DM's reinvestment assumptions and concepts of investment and return.	Attributes from all the other classes except ratio can be simultaneously used.
Ratio	PI B/C Ratio	Just one attribute, chosen according to the DM's reinvestment assumptions and concepts of investment and return.	Attributes from all the other classes except rate of return can be simultaneously used.
Payback	Payback Discounted Payback	Just one attribute, chosen according to the DM's perceived importance of the time value of money.	Attributes from all the other classes can be simultaneously used.
Accounting	ROOI ROAI	Just one attribute, chosen according to the DM's concept of investment.	Attributes from all the other classes can be simultaneously used.

data are not available, different methods (other than financial) must be used to evaluate the investments. In this paper we will not address the evaluation of investment projects in the absence of quantitative information.

Capital availability for the investments is, perhaps, the most important characteristic to be accounted for when selecting the financial method(s) to be used (when quantitative data are available), so we will discuss it in some detail. We will start by making some considerations about management goals and NPV application. It is usually considered that the management goal should be the maximisation of the company value. The company value is maximised when all the investment projects with a positive NPV are undertaken, so many authors consider that the NPV should be the preferred method to evaluate investment projects (see, for instance, [4]). However, the use of NPV has some implicit assumptions - it assumes that markets are efficient and that the intermediate cash flows can be reinvested at the discount rate in investments with a similar systematic risk. About the first assumption, Brealey and Myers [4] say the NPV will only be weakened when the company owners cannot access an efficient capital market. About the second assumption, we think that, if the discount rate is properly calculated, it will usually be met. Even if one of these assumptions does not hold, it is not always certain the existence of a better method other than the NPV for the considered situation (although in some specific cases better methods can be found).

From what was said we can conclude that, when unlimited capital is available for the investments, the NPV should be the preferred method. Now, the following question can be made: will any other methods be appropriate for this situation? In the previous section it was said that all equivalent worth methods will yield equivalent results when properly applied, so any other equivalent worth method can be used instead of the NPV. Methods from other classes will not always lead to value maximisation, so they will not usually be as appropriate for this situation as equivalent worth methods. However, there may be circumstances that do not advise the use of the NPV nor the use of any other equivalent worth method. One of these circumstances, which was previously referred in this section, has to do with the unavailability of proper quantitative data and, when this happens, non-financial attributes should be used. Other circumstances have to do with the NPV assumptions (which are also implicit to the other equivalent worth methods). For example, if the reinvestment assumption does not hold, then maybe we can find a method from other class that conforms the reinvestment situation[3]. When it is considered that equivalent worth methods should not be used, rate of return and ratio methods should be preferred to payback and accounting methods, since the former do usually lead closer to value maximisation than the latter.

We will now suppose that the available capital for the investments is limited and known. In this situation, it is seldom possible to undertake all investment projects with a positive NPV, because the capital needed to finance all those investments may exceed the available capital. Thus, the management should usually aim to build a portfolio of projects with an aggregate NPV as high as possible. If all the available investment projects are known (which is what usually happens when companies are preparing their annual investment plan), NPV maximisation may be achieved by solving a mathematical programming problem. The variables of this problem will be the projects, their coefficients in the objective function will be the projects NPVs and the constraints will be the capital limitations for the considered periods[4].

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[3] Another possible solution to this problem may be the definition of a new equivalent worth method , based on an existing one (possibly the NPV), that will assume a different reinvestment situation.

[4] Such a problem can consider several periods, with capital limitations in each period.

See [10], chapter 8, for a survey of some mathematical programs for the optimal selection of a set of projects.

Notice that any other equivalent worth method could be used instead of the NPV to build this mathematical program. Also notice that, in some circumstances, the NPV assumptions may not be met and, thus, methods from the equivalent worth class will be rendered inappropriate. When equivalent worth methods cannot be applied, one may think the use of a mathematical program to maximise an aggregate rate of return or an aggregate ratio as the best approach. However, rate of return and ratio attributes are not additive, resulting probably in a complex non-linear mathematical programming problem. We think that a heuristic approach could consist in ordering the profitable projects according to an adequate rate of return or ratio attribute, and choosing the more profitable projects until no other profitable project can be chosen without going beyond the available amount of capital. Asquith and Bethel [2] argue that, if not all positive NPV projects are funded, then the use of such a heuristic may also be preferable to the use of a NPV-based rule when forecast biases are present in the cash flow estimates and information about these biases is costly to obtain.

Sometimes it is known that the available amount of capital is not unlimited, but the limit is not known. An ordering of the investment projects according to their profitability will be wanted in this situation, with non-profitable projects being commonly excluded from that ordering. Usually an ordering will be wanted such that, if projects are chosen accordingly, the aggregate NPV will be maximised. Notice that the NPV will not be a good ordering criterion. If we were to order projects according to the NPV, a project with a high NPV but needing a very large investment might be considered better than other projects with only slightly lower NPVs and much smaller investment required. As the available capital is limited, the latter projects should be preferred to the former, so the ordering obtained through the use of NPV would not lead to the maximisation of the aggregate NPV. In this situation, it would be better to order projects according to an attribute from either the rate of return class or the ratio class. Since methods from these classes evaluate the relation between the return and the investment, projects with a higher return for each unit of invested capital will be rated higher. Thus, value maximisation may be approximated if projects are ordered by using such an attribute.

When the available capital for investment projects is limited (known or unknown), it may happen that the available amount is to be used not only with the investment proposals currently known but also with possible investments to be proposed in a future period. As an example, consider a company that has just raised a reasonable amount of capital and knows it will be very difficult to raise more capital in the near future. Notice that the uncertainty about which investment projects will be proposed in the future can occur both when the amount of available capital is known and when it is not known. An NPV-based ordering and selection of investment projects will be inappropriate in this situation, and a better selection process may be achieved with a rate of return or ratio method. We think this process should consist in the determination of a hurdle rate (or hurdle ratio) and in the selection of all investment projects having higher rates than that hurdle rate on the financial attribute chosen to make the decision. Historical data about past investment proposals considered by the company should be used to determine the hurdle rate, when available. This hurdle rate should be periodically re-examined according to the investments that have been proposed since its last calculation.

The degree of risk and uncertainty is not usually relevant to the choice of the financial methods. However, it will be important to the selection process, both because it may determine whether or not risk analysis should be performed and because risk should be incorporated in the evaluation of the projects. If the situation faced by the DMs is close to certainty, risk can usually be neglected. On the other hand, when the situation is not close to certainty, risk analysis should be performed on the investment projects. The risk analysis tools should be chosen according to the available data. Monte Carlo simulation may give accurate information about the statistical distribution of the financial attributes, but it cannot be used unless there are available data about the probability distributions of the relevant variables and a detailed model of the investment projects is built accordingly [4]. Under some assumptions about the distribution and statistical independence of the relevant variables, the variance can be calculated for some financial attributes, and it can be used as a measure of the total project risk [8]. Sensitivity, scenarios and break-even analysis demand less data than Monte Carlo simulation and may provide useful information about the investments [4]. Scenario analysis may be particularly useful, since it allows the DM to assess how the project will behave under different circumstances. Each scenario will be defined by a set of assumptions, and will represent a consistent possibility of project behaviour. It is thus possible that different methods make sense in different scenarios of the same project, according to the assumptions of those scenarios.

There are also several methods to incorporate risk in project evaluation. Some of them, like the certainty equivalent method that was referred in section 2, are based on the adjustment of the cash flows. Others, like the use of the CAPM, are based on the incorporation of risk in the discount or compounding rates (when discounting or compounding based methods are being used), or in the hurdle rate (when rate of return methods are being used). When some sequential decisions must be made according to the outcomes of various events, decision trees may be used to represent and evaluate the project. Recently, Option Pricing Theory has gained a wide acceptance in the evaluation of investment projects. Option Pricing Theory provides another tool for the calculation of the project NPV when an active management of the project may influence its value, for example by reducing losses when the outcome is unfavourable or by increasing profits when the outcome is favourable. When options are involved, both the traditional discounted cash flow analysis (as performed by expression (1)) and the use of decision trees may fail to correctly incorporate risk in the value of the project [14] and option analysis may provide more accurate project values (see [4,14,15], for example, for more details). Although both option valuation and decision trees are primarily used for the calculation of the project NPV, other methods that can be based on the project value may also be adapted to these types of valuations.

When a multicriteria evaluation of investment projects is being performed, risk also can be incorporated through one or more attributes. Some financial attributes are sometimes used as risk proxies - in a NPV based evaluation, some rate of return or payback attributes can be used as risk proxies. For a complete description of some risk analysis and risk incorporation techniques, see [4,7,15]. For multicriteria models that incorporate risk, see [6] and the chapter 3 of [7].

Interdependencies are usually typified as synergies (positive or negative), mutual exclusion and technical dependence. We can say there are synergies between investments A and B when the financial attributes of A change depending on whether or not B is pursued. Investments A and B are mutually exclusive if the investments cannot be both pursued – that is, if one of them is pursued, the other cannot be. Finally, we say that A is technically dependent on B if A cannot be pursued unless B is pursued.

Interdependencies can be dealt with mathematical programming, in a similar way as the one referred when we considered that the available capital was limited and known. However, when we are dealing with non-additive financial attributes such a program is complex, and it may be difficult to solve. When this happens, it is often useful to change all interdependencies into mutual exclusion. When synergies exist between two investment projects, A and B, we can turn these two investment projects into three mutually exclusive projects: project A, project B and project AB, the latter of which consists in pursuing both projects A and B. Also, when A is technically dependent on B, we can consider two mutually exclusive projects: B and AB, the latter of which consists in pursuing both projects A and B. All interdependencies can be thus turned into mutual exclusion, usually easier to deal with. For example, if a selection process consists in ordering all projects according to an attribute, and then selecting projects according to that order, it is very easy, after each project is selected, to seek and exclude all the projects mutually exclusive with the selected project. Combinatorial analysis can also be a very effective tool to deal with interdependencies.

The selection process may be affected by the existence of a portfolio of previously undertaken investment projects. If such a portfolio does exist, it may or may not be possible to abandon the previously undertaken projects.

The existence of previously undertaken projects that can be abandoned may be dealt with by considering these projects at the same level of the newly proposed projects. When re-evaluating existing projects, care should be taken not to consider unrecoverable costs or past benefits, and to properly consider their present salvage values as opportunity costs (the costs of not selling the assets needed to continue the projects). These present salvage values correspond to the investment cost in new projects. After this, the process may proceed as if there were no previously undertaken projects.

If the previously undertaken projects cannot be abandoned, then it is not necessary to re-evaluate these projects. However, some care should be taken in the selection process, because it will still be necessary to consider the interdependencies between existing projects and new projects, as well as the capital requirements of existing projects. Interdependencies may eliminate some new projects (when there is mutual exclusion), or change the financial attributes of some of them (when there are synergies). When the available capital for the investments is limited, the capital requirements of existing projects must be subtracted from the available amount. After this, the selection process may proceed normally.

Thus far we have considered the decision situations defined by a set of five characteristics, and we have explained how should each of those characteristics affect the investment selection process. We argued that equivalent worth attributes should usually be used, and that rate of return and ratio attributes should be used in particular situations instead of equivalent worth attributes. Some questions may now be made, concerning whether or not accounting and payback methods should ever be used. We will now address this issue.

Firstly, we will consider accounting methods. Only by chance these methods will lead to aggregate NPV maximisation. This means that they should only be used when the DMs' goal is different from that. So, when will DMs use accounting methods ? The only answer we have to this question has to do with the way the company's results are made available to stakeholders, which is usually in the form of accounting statements. If accounting methods are used, it may be possible to present better accounting results and it is possible that stakeholders will be happier and, thus, it may be easier for the company to raise money and managers may get better rewards. However, there are two severe drawbacks to this strategy. The first is that it is a short term strategy - in the long term, accounting results will have a higher growth when decisions are made to maximise the company value than when accounting methods are the only criteria to select investments. The second is that intelligent and well informed stakeholders will look beyond accounting results to get a clearer picture of the company, and this picture will be more favourable if the management is aiming to maximise the company value than if it is aiming to maximise short term accounting results.

We will now turn to payback methods. Some reasons may be presented for the use of these methods. One of these reasons may be the existence of catastrophic or political risks that may cause the company to lose, at any moment, the assets on which it invested, and so the company may want to recover the invested capital as soon as possible. We do not think this is always valid, because these risks can be accounted for, either through a proper adjustment of the discount rate or through an adjustment of the predicted cash flows, when equivalent worth, rate of return and ratio methods are used.

Another reason has to do with the need of quickly obtaining liquidity, when it is difficult to raise capital either for new investment projects or for financial engagements of the company (the need to pay interests or principal in existing debts, for instance). Notice that such situations will be related to capital markets imperfections. We think that, in these situations, the use of mathematical programming to maximise the aggregate NPV according to some constraints that have to do with liquidity necessities will provide better results than the use of payback methods, if data are available. However, in these situations, we cannot find any reason to oppose the use of a payback attribute along with an equivalent worth attribute in a multicriteria evaluation.

We will present another reason that is also related with possible capital markets imperfections. When the owners of the company may need money at any time and cannot access an efficient capital market either to raise money for their needs or to sell their stakes in the company, they may want the company to have high liquidity as often as possible. It can be argued that, in this situation, payback methods will provide the best results to satisfy the company owners wishes. Nevertheless we think that the use of mathematical programming to maximise the aggregate NPV, according to a set of constraints that represent the possible needs of the company owners, may provide better results. Once again, in this situation we cannot find any reason to oppose the use of a payback attribute along with an equivalent worth attribute in a multicriteria evaluation.

In this section we have considered that the decision situations are defined by a set of characteristics, and we have explained how should each of those characteristics affect the investment selection process. We concluded that equivalent worth attributes should usually be used, and that rate of return and ratio attributes should be used in particular situations instead of equivalent worth attributes. Then, we tried to find some situations in which the use of accounting or payback methods might be appropriate. We concluded that accounting methods might be used to achieve good short-term accounting results, but not to maximise long-term accounting results. We considered the use of payback methods to account for the company's or its owners' liquidity needs (particularly when capital markets are imperfect) and also when the company faces political or catastrophic risks. We argued that equivalent worth methods (eventually within a mathematical programming problem) are best suited for those situations, but we could not find any reason to oppose the use of a payback attribute along with an equivalent worth attribute in a multicriteria evaluation, in those situations.

6 Conclusions

This paper addressed the analysis and evaluation of investment projects within a multicriteria framework. In this framework, all the properties, or characteristics, of the investments are modelled as attributes. The decision criteria are chosen from the attribute set. In order to have a correct structure for the decision problem, we defined that the set of criteria should be a coherent family of criteria, and should not include contradictory assumptions.

We started with a presentation of the most common methods for project evaluation. In this presentation, we classified the methods into five classes, following a similar classification from [11,12]. Then we mathematically defined the conditions that must be met by the set of criteria in order to be a coherent family of criteria, and presented a mathematical result that states that two criteria that order projects identically will be redundant.

The first problem we dealt with was to find out which financial attributes can, and which ones cannot, be used together as criteria. We concluded that attributes from the same class either rank projects identically or are based in contradictory assumptions, so a DM will usually use at most one attribute from a single class. Attributes form different classes address different perspectives, or dimensions, of the profitability, with the exception of the rate of return and ratio classes, which both address the relation between the return and the investment. We also stated that, for each ratio method, it is possible to define a rate of return method that ranks projects identically, and that the converse is also usually true. So, according to our framework, a DM may simultaneously use attributes from different classes, but he/she will usually want to use at most one attribute from both the classes of ratio and rate of return methods.

Then, we tried to establish a set of guidelines to help DMs choose the financial methods best suited to their specific situations. We considered a set of characteristics of the decision situation – degree of quantification, capital availability for the investments, degree of risk and uncertainty, interdependencies between investments and existence of previously undertaken investments - and analysed how these characteristics affect the investment selection process. The degree of quantification defines whether or not financial methods can be used. When unlimited capital is available, or when the available capital is limited and known, equivalent worth methods should usually be used. However, when the available capital is limited and the limit is unknown, or when the available capital must also be used in future projects not yet known, rate of return and ratio methods may be a better choice, even if the ultimate goal is the maximisation of aggregate NPV. In the presence of risk, it will be important to incorporate the risk in the project evaluation, and to perform risk analysis. We briefly referred some methodologies for risk analysis and for the incorporation of risk in project evaluation. We explained that interdependencies could be dealt with through the use of mathematical programming and combinatorial analysis. Finally we explained that, if a portfolio of previously undertaken projects exists, these projects should be re-evaluated, and their interdependencies with new projects and effect in the available capital (if the available capital is limited) must be considered in the evaluation process.

Since the analysis of the characteristics of the decision situation seemed to never recommend the use of accounting and payback methods, we also tried to define in which situations might these methods be used. We concluded that accounting methods might be used to achieve good short-term accounting results, but not to maximise long-term accounting results. We considered some situations in which the use of payback methods seemed appropriate. Analysing these situations, we always concluded that equivalent worth methods (eventually within a mathematical programming problem) might be best suited to those situations. However, we could not find any reason to oppose the use of a payback attribute along with an equivalent worth attribute in a multicriteria evaluation, in those situations.

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