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Article

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South African Journal of Business Management

Provided in Cooperation with:
University of Stellenbosch Business School (USB), Bellville, South Africa

Suggested Citation: Paulo, S. (1994) : Mutually exclusive capital projects: A critique of Fisherian analysis, South African Journal of Business Management, ISSN 2078-5976, African Online Scientific Information Systems (AOSIS), Cape Town, Vol. 25, Iss. 1, pp. 47-51, https://doi.org/10.4102/sajbm.v25i1.841

This Version is available at:
https://hdl.handle.net/10419/218117

Mutually exclusive capital projects: a critique of Fisherian analysis

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Received March 1993, accepted August 1993

In capital budgeting a Fisherian analysis is undertaken to resolve conflicts in rankings which arise when mutually exclusive projects have been evaluated according to the net present value and internal rate of return criteria. Within the literature, the projects which have been subjected to a Fisherian analysis, all have the same required rates of return because the required rate of return is held constant irrespective of the differences in the characteristics of the mutually exclusive projects. The conflict in rankings of mutually exclusive projects is typically ascribed to characteristics such as differences in initial outlay and project life span, disparities in the timing of cash flows, the reinvestment rate assumption, and the difficulties of multiple or no unique internal rate of return when the cash flows are non-conventional. Despite these differences among projects, the same required rate of return is used. The central question which is addressed in this article, is whether the same required rate of return can reasonably be used for the valuation of each of the mutually exclusive projects, as well as when a choice is made from among the mutually exclusive projects. In the discussion this 'conventional wisdom' of a constant required rate of return for both the valuations and the choice of an alternative is questioned, and it is suggested that one of the causes of a conflict in rankings may be the use of incorrectly specified required rates of return. Also presented in this article is a conceptual framework which enables a modified Fisherian analysis.

By investeringsbesluitneming word 'n Fisheriaanse ontleding toegepas om rangordeteenstrydighede op te los, wat ontstaan wanneer onderlinge eensydige projekte volgens die netto teenswoordige waarde en die interne opbrengskoersmetodes bereken word. Volgens die literatuur het projekte wat 'n Fisheriaanse ontleding ondergaan almal dieselfde vereiste opbrengkoers. Die teenstrydige rangordes word normaalweg toegeskryf aan verskillende eienskappe soos verskille in die grootte van die investering, die lewensduur van die projek, asook verskille in die tydsberekening van die kontantvloei, die herinvesteringskoers en die probleme wat ontstaan rondom onkonvensionele kontantvloei. Nieteenstaande hierdie verskille tussen die projekte, word dieselfde vereiste opbrengskoers gebruik om eerstens waardasies uit te voer, en tweedens om keuses te maak. Die kernvraag van hierdie artikel is of dieselfde vereiste opbrengskoers redelikerwyse gebruik kan word vir die waardasie van elk van die onderlinge eensydige projekte, asook wanneer 'n keuse tussen dié projekte gemaak word. Die bespreking wat ter tafel gelê is, bevraagteken hierdie 'konvensionele wysheid' van 'n konstante vereiste opbrengskoers vir beide die waardasie en die keuse van 'n alternatief, en suggereer dat een van die oorsake van strydende rangordes die gebruik van verkeerde vereiste opbrengskoerse is. Verder bied hierdie artikel 'n moontlike konseptuele raamwerk waarbinne 'n gewysigde Fisheriaanse ontleding uitgevoer kan word.

Introduction

Within the literature on capital budgeting, a Fisherian analysis is undertaken in order to resolve conflicts in rankings which arise when mutually exclusive projects have been evaluated according to the net present value (henceforth NPV) and internal rates of return (henceforth IRR) criteria. As will be shown in a brief literary review, without exception the projects which are subjected to a Fisherian analysis all have the same required rate of return (henceforth RRR). The conflict in rankings of mutually exclusive projects is typically ascribed to characteristics such as differences in initial outlay and project life span, disparities in the timing of cash flows, and the reinvestment rate assumption, as well as the difficulties of multiple or no unique IRRs when the cash flows are non-conventional.

The RRR is defined as the minimum rate of return necessary to maintain an investor's current wealth position intact. Accordingly, any factor which could jeopardize an investor's current wealth position should be taken into account in the RRR. The RRR comprises two major and distinct components, *firstly*, a risk free rate of return, and *secondly*, components which accommodate a wide diversity of risks such as business, financial, inflation, term structure, expectations, and tax risk. In other words, the second group of components are characterized by a variety of probabilities attaching to a variety of outcomes, whereas the first group is *not* described by means of a probability distribution function.

Since the risk free rate of return is common to all investors, the differences in the RRR must originate in the second group of components, the risk premia components. Extensive tests (Hendershoot & Van Horne, 1973: 301–314; Carghill & Meyer, 1974: 458–471) have revealed that risk free rates were relatively stable in the United States of America during the 1950s and 1960s; since the 1970s though, expected risk free rates have fluctuated (Fama, 1975: 269–282; Nelson & Schwart, 1977: 478–486; Hess & Bicksler, 1975: 341–360). The impact of these fluctuations has been relatively minor on the real risk free rate, but nominal risk free rates have fluctuated in keeping with anticipated inflation (Ben-Horim, 1987: 234; Clark *et al.*, 1984: 6). In other words, the risk free rate, which is a real rate of return, is subject to minimal variability.

When projects are being evaluated and compared (ranked), different characteristics and attributes, such as differences in initial outlay, project life, and the timing of cash flows, must surely be indicative of different risks. These differences in risks must surely have some impact on the RRR. Ibbotson and Sinquefield (Weston & Copeland, 1986: 139) found that the long run pre-tax rates of return, compounded annually, varied notably according to asset type. For example, over the period 1926 to 1981 the rate of return on common stocks was 9.1%, whereas stocks of smaller firms yielded 12.1%, long term corporate bonds yielded 3.6%, and short term U.S. treasury bills yielded 3.0%. These differences in returns reflected the differences in risk.

The central question which I seek to address in this article is whether the same RRR should be used for the valuation of each of the mutually exclusive capital projects, as well as when a choice is made from among the competing projects when a Fisherian analysis is used. As will be shown, literary evidence, the 'conventional wisdom', uses the same RRR for both the valuation of projects, and for the process of choice from among the competing projects when a Fisherian analysis is undertaken.

The purpose of this article is therefore to explore at the *conceptual level* the need to acknowledge that it is not entirely realistic to assume that mutually exclusive projects which have conflicting rankings should have the same RRR. Once required rates of return, which are correctly specified to impound the unique characteristics of mutually exclusive projects, are calculated, some projects which otherwise would have necessitated a Fisherian analysis may no longer display a conflict in rankings. Thus, one of the causes of a conflict in rankings may be an incorrectly specified RRR. If this is so, then Fisherian analysis could necessitate refinement.

This article commences by briefly reviewing the literature of conflicts in rankings, proceeds to a discussion of the conventionally accepted reasons for the existence of ranking conflicts, and stresses the need for a RRR appropriately calculated for each project. A framework for choosing among mutually exclusive capital projects is then presented, after which the implications of a misspecified RRR are briefly presented.

A brief literary review

Fisher's intersection (Clark, Hindelang & Pritchard, 1984: 65–68, 70, 74, 87–88), 'the rate of return over costs', also known as the critical reinvestment rate or incremental IRR, was first proposed as a concept for capital budgeting purposes by Fisher (1907: 150–156; 1930: 155–161, 168–174). The 'rate of return over costs' is an important switch-point when evaluating two or more mutually exclusive projects whose rankings in terms of the NPV and IRR criteria are in conflict. Consider for example two mutually exclusive projects, A and B, portrayed in Figure 1.

At required rates of return less than Fisher's intersection project A is preferred to project B because the NPV of A is greater than that of B. At Fisher's intersection the NPVs of A and B are equal so a matter of indifference prevails between these two projects. However, at required rates of return greater than Fisher's intersection, B is preferred to A.

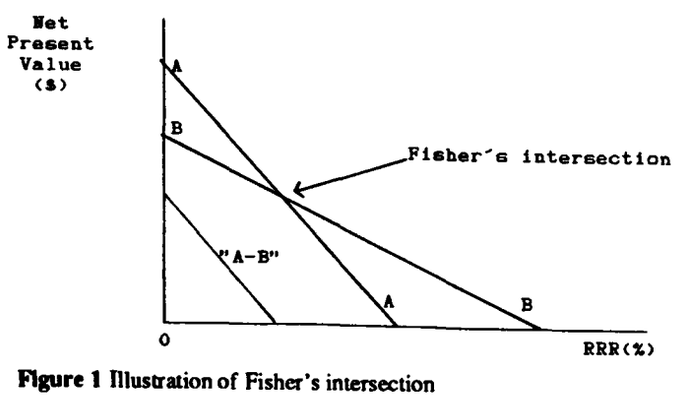

Figure 1 Illustration of Fisher's intersection

In order to resolve the question of which project to select, an incremental analysis is performed in terms of which a hypothetical project, 'A–B' is created by subtracting the net cash flow of B from A. The yield of this hypothetical project 'A–B' is 'the rate of return over costs' or increnental IRR. The decision rule which is applied for project selection under these circumstances necessitates that the incremental IRR exceed the RRR. If the incremental IRR does not exceed the RRR, 'A–B' as a hypothetical project is rejected, consequently A is rejected, and B is accepted as the superior investment alternative (Clark *et al.*, 65–68, 70, 74, 87–88; Herbst, 1982: 92–96).

The literature on this topic identifies a number of circumstances where conflicts in the rankings of mutually exclusive projects can arise. For example, where there are:

a. differences in the magnitude of initial investment;
b. disparities in the timing of cash flows;
c. differences in project lives;
d. the matter of the reinvestment rate (Clark *et al.*, 1984: 89; Herbst, 1982: 95; Kroncke, Nemmers, & Grunewald, 1978: 200–205; Levy & Sarnat, 1990: 64–66); and
e. computational difficulties which can arise with the IRR, such as multiple roots and no unique root (Levy & Sarnat, 1990: 81–85).

Under these circumstances the literature recommends a Fisherian analysis be undertaken to resolve the conflict in rankings. The reinvestment rate as well as situations where computational difficulties can arise with the IRR will not be considered in this article, however, the other circumstances ennunciated in the literature will be considered. It is beneficial though, when recalling the well documented drawbacks of the IRR criterion to bear in mind that the projects under consideration should be comparable, and further that sophistical illustrations, which can be a popular but unscientific way of making a case, serve little academic or operational purpose.

Differences in initial investment

According to the literature a conflict in project rankings when using the NPV and IRR criteria may arise as a result of differences in initial investment (Clark *et al.*, 1984: 69, 71–72, 87; Herbst, 1982: 82; Kroncke *et al.*, 1978: 206–208; Brigham & Gapenski: 1990, 275–276; Van Horne, 1980: 121; Levy & Sarnat, 1990: 55–56, 57–60). Upon closer consideration of the projects which have conflicting rankings and which are used to illustrate the application of a Fisherian analysis, it is apparent that the projects are discounted at the same RRR (Clark *et al.*, 1984: 69, 71–72, 87; Herbst, 1982: 82; Kroncke *et al.*, 1978: 206–208; Brigham & Gapenski, 1990: 275–276; Van Horne, 1980: 121; Levy & Sarnat, 1990: 55–56, 57–60), despite the fact that acknowledgement is given to the notable differences in initial investment. If size counts as a characteristic, differences in initial investment may be indicative of different types and levels of risk both with regards to the investment and its financing. These differences in risks do have an impact on the RRR of each project, consequently it is not correct to discount all the projects being considered at the same RRR. When required rates of return specific to each project are

calculated and used to establish NPV, some of the situations where ranking conflicts previously existed, could be eliminated.

If there is a notable difference in the magnitude of initial outlay, how legitimate is it to make a comparison among the 'unequals' and then exercise choices according to valuations based on one and the same RRR for all the alternatives being considered? Levy & Sarnat (1982: 57) present an example of mutually exclusive projects where the one project has an initial outlay of $1 000 and the other project has an initial outlay of $11 000. Can these two competing projects reasonably be valued and compared using the same RRR? The same questions can also be asked of the illustrative example of mutually exclusive projects used by Brigham & Gapenski (1990: 275) where the one project has an initial outlay of $1 000 000 and the competing project has an initial outlay of $5 000 000.

If, in these illustrative examples, the larger project was implemented and were to fail, would the implications for the firm be the same had the smaller project been implemented and also failed? Do these mutually exclusive projects have the same business, financial, and systematic risk? How would the financing of the larger project differ from the financing of the smaller project? As a result of differences in the magnitude in the initial investment and the consequent impact on risk and hence the RRR, it is unlikely that the same RRR, in the sense of both compositional structure and numerical value, can be used to value the larger as well as the smaller of the mutually exclusive projects. In the light of these considerations, there would seem to be merit in closely scrutinizing the compositional structure of the required rates of return of the competing projects.

Once the issues cited receive recognition, the validity of one and the same RRR for all mutually exclusive projects is questionable. This, in turn, reveals a fundamental flaw inherent in Fisherian analysis.

Disparities in timing of cash flows

Yet another reason proposed in the literature for a conflict in the rankings of mutually exclusive projects is that of disparities in the timing of cash flows (Clark *et al.*, 1984: 90; Kroncke *et al.*, 1978: 201; Brigham & Gapenski, 1990: 276–278: Van Horne, 1980: 119; Levy & Sarnat, 1990: 62–64). Disparities in the timing of cash flows of projects form part of time value. Differences in time value mean that there are differences in the type and magnitude of risks. Regardless of these differences in risks, which must mean that the projects under consideration do not all have the same RRR, in the literature such projects are discounted at the same RRR in order to establish NPV (Clark *et al.*, 1984: 90; Kroncke *et al.*, 1978: 201; Brigham & Gapenski, 1990: 276–278: Van Horne, 1980: 119; Levy & Sarnat, 1990: 62–64). Levy & Sarnat (1982: 61) illustrate with the following example,

	Cash flow		
	Initial outlay	Year 1	Year 2
Project A	–100	20	120.00
Project B	–100	100	31.25

In the above illustrative example, project A's cash flow in year two is six times its cash flow in year one, and project B's cash flow in year one is slightly more than three times its cash flow in year two. Not only do the two competing projects A and B have accelerating and decelerating cash flows respectively, a very important characteristic especially from a portfolio perspective, but the rates of change exhibit notable differences. If money has time value, then even if all the characteristics of A and B are the same excepting for the disparities in the timing and magnitude of the respective projects' cash flows, is it reasonable to discount these competing projects at the same RRR? If these projects were presented to a financial institution for funding, could funding reasonably be expected to occur at the same cost? Supposing year one were a boom year and year two a recession, would it be reasonable to use the same RRR for both projects A and B?

Brighams & Gapenski (1990: 178) illustrate the issue of disparities in the timing of cash flows with the following example.

	Cash flow		
	Initial outlay	Year 1	Year 2
Project L	–$1 000 000	$0	$4 046 000
Project s	–$1 000 000	$1 280 000	$0

Again, the questions raised with respect to the illustrative example of Levy & Sarnat (1982: 61) can be validly posed. In a nutshell, if R1.00 today is worth more than R1.00 in a year's time because of the time value of money, then as a result of disparities in the timing of cash flows, one and the same RRR should not be used to perform valuations because of the influence of differences in time value on project risk and hence project RRR.

Moreover, it is possible that the use of a correctly specified RRR, which accommodates the characteristics of each project being evaluated to establish NPV, may in certain circumstances eliminate situations which otherwise necessitated Fisherian analysis.

Differences in project lives

It has been asserted that differences in project lives can be the cause of conflicts in rankings (Clark *et al.*, 1984: 94; Herbst, 1982: 83–84; Levy & Sarnat, 1990: 66–68). Financial theory makes use of the term structure of interest rates (Mittra & Gassen, 1981: 204; Meiselman, 1962; Van Horne, 1978) to explain why rates of return differ for assets of different life durations. To a notable extent, the differences in rates of return for assets of different life durations can be described to the risks which attach *inter alia* to cyclical behaviour (Polakoff & Durkin, 1981: 519), expectations (Van Horne, 1965: 344–351), the coupon effect (Van Horne, 1978: 116; Tinic & West, 1979: 342), and the call option (Copeland & Weston, 1988: 232, 236). The difference in risk type and risk level for projects with different life spans means that the RRR for each of the projects under consideration must surely differ.

Brigham & Gapenski (1990: 319) use an illustrative example where the one project has a life twice as long as the competing alternative, yet the analysis is undertaken using the same RRR. When required rates of return, which are compositionally and numerically appropriate for each of the mutually exclusive projects being considered, are used to value these projects, it is within the bounds of reason that a conflict in rankings which occured as a result of using a misspecified RRR, will not arise.

A conceptual framework for choosing among mutually exclusive projects

In accordance with the arguments presented in the aforegoing sections, the mutually exclusive projects need to be evaluated in terms of the net present value and internal rates of return criteria, where the RRR is appropriate and specific to each of the projects being evaluated. If a conflict in rankings still exists, then a modified Fisherian analysis should be undertaken in terms of which ROROC (the rate of return over cost, the incremental yield) is evaluated in terms of the RRR of the project from whose cash flow the cash flow of the 'next in line' competing project has been subtracted. To illustrate, consider two mutually exclusive projects, A and B:

Project	CF_1	CF_2	CF_3...	CF_n	NPV	IRR	RRR
A	x	y	z	v	800	19%	15%
B	m	n	l	p	600	21%	18%

where:
CF = cash flow, and
B = 'next in line' project.

If the hypothetical project for analysis within a Fisherian framework is 'A–B', then the decision rules for a modified Fisherian analysis are:

If ROROC > RRR_A, then accept project A;
If ROROC < RRR_A, then reject project A.

On the otherhand, if the hypothetical project for analysis within a Fisherian framework is 'B–A', then the decision rules for a modified Fisherian analysis are:

If ROROC > RRR_B, then accept project A;
If ROROC < RRR_B, then reject project A.

Implications of using a misspecified RRR

The prime function of the RRR is to provide guidance in the acquisition and allocation of financial resources. The RRR is thus a yardstick in terms of which capital investments are evaluated. If this yardstick is misspecified, the result will be incorrect valuations and misallocations of financial resources because incorrect choices will be made. Where project characteristics are patently different, there must surely be implictions for project risk, in which event the RRR must reflect such risks. To discount mutually exclusive projects which display different characteristics at the same RRR is tantamount to a rejection of the definition of the RRR, and thereby to deprive financial managers of what is a pivotal concept in capital resource allocation. A misspecified RRR could give rise to a situation which would ostensibly seem to warrant further analysis, Fisherian analysis, which even when undertaken will still result in wrong choices being exercised.

Summary and conclusion

The purpose of this article was to explore at a conceptual level the need to acknowledge that it is not entirely realistic to assume that mutually exclusive projects which have conflicting rankings should have the same RRR. The risk adjusted discount rate approach explicitly accepts that as a result of different characteristics, which enable projects to be identified and grouped according to these characteristics, different RRR are applicable (Clark *et al.*, 1984: 181–182). To attempt to resolve the problem of differences in risk among mutually exclusive projects by means of certainty equivalent coefficients precludes any form of Fisherian analysis because it disenables the construction of net present value profiles (Paulo, 1993). Once required rates of return, which are correctly specified to impound the unique characteristics of mutually exclusive projects are calculated, some projects which otherwise would have necessitated a Fisherian analysis may no longer display a conflict in rankings. Thus, one of the causes of a conflict in rankings may be incorrectly specified required rates of return. It may even be possible to argue that in certain cases Fisherian analysis is *de facto* testimony to misspecified required rates of return.

With this article attention is drawn to the fact that misspecified required rates of return would seem to hallmark that part of the capital budgeting literature which deals with the conflicts in rankings of mutually exclusive projects, for how else can one and the same RRR, irrespective of the disparity of project attributes for all of the mutually exclusive projects being evaluated, be explained. To undertake an analysis holding the RRR constant cannot contribute to the resolution of the problems of valuation and choice.

The challenge, which this article poses to the 'conventional wisdom' of one and the same RRR for project evaluation and Fisherian analysis, is worthy of consideration.

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