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An Assessment of Discount Methods for Evaluating Efficiency of Investments in Education

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Abstract

As clearly stated by Pareto, no society can avoid the economic problem of "opposition between tastes and obstacles" that is, as in other categories of economic decisions, investments in education have to take into account their opportunity cost. This implies that when education policies need to be implemented, there is a previous need of comparing different actions and evaluating them to assess their attractiveness. In this comparison process, one of the technical difficulties which has to be solved is the choice of the correct mathematical aggregation rule (i.e. the commonly called investment evaluation criterion or discount method) to use. The internal rate of return *(IRR)* is widely used in educational policy and planning; the main justifications are three: 1) the choice of a discount rate may vary for different countries and at different times, while *IRR* is an "objective" measure, 2) *IRR* allows the comparison with investments in the private sector, and 3) *IRR* allows the comparison of investments in different educational fields, such as primary schooling and university (by simply considering the average rates of return in each field). However, the debate on the proper evaluation criterion to use, when a private investment decision has to be taken or a public project appraisal has to be carried out, is a traditional one in financial, public and production economics. Although the considerable amount of existing literature, the problem of the choice of the right investment evaluation criterion is still an open one. The majority of authors claim that net present value (*NPV*) is a superior criterion and thus it is the one to be always used. Other authors try to show that various investment evaluation criteria, under specific conditions, arrive at the same recommendation. This research aims at clarifying this controversial topic by focusing on some clear cut formal properties of the various investment evaluation criteria and by considering the empirical characteristics of the different fields of application. Clear guidelines for education investment evaluation will be drawn.

1. Introduction

There is no doubt that expenditures in education have to be considered as *social investments* in human capital presenting positive benefits for economic growth and societal well-being in general. However, as in other categories of economic decisions, investments in education have to take into account their opportunity cost and try to answer difficult questions such as: How much of the national budget has to be devoted to education? Have all forms of education be financed equally? Is it better to invest in pre-schooling or in universities? Private family investments have to deal with similar problems too, e.g. What topic to study? In which university?

Economists try to answer these questions by considering the costs and benefits linked to each option (see e.g. Cohn and Huches, 1994; Wolff *et al.,* 2014; Temple and Reynolds, 2007). In the case of private decisions, the literature, following the pioneering work of Mincer (1974), has focused on the earnings of a more educated person in comparison with less educated individuals. In the general cost-benefit framework, the costs are measured by the expenses to keep a student in school, plus his/her foregone earnings while studying. In the "Mincerian" method, one has to estimate wages by considering years of schooling and years of labor market experience as independent variables. However one has to note that even in individual decisions, non-pecuniary and social aspects are always present.

Kaldor, one of the father of cost-benefit analysis, himself recognized that "*individuals might, as a result of a certain political action, sustain losses of a non-pecuniary kind- e.g., if workers derive satisfaction from their particular kind of work, and are obliged to change their employment, something more than their previous level of money income will be necessary to secure their previous level of enjoyment; and the same applies in cases where individuals feel that the carrying out of the policy involves an interference with their individual freedom.*" (Kaldor, 1939, p. 551).

The full cost of one own education must include public subsidies (which often finance large part of the cost related with e.g. school infrastructures, teachers' salaries, etc.) rather than just the amount an individual pays for his or her education. From an economic policy point of view, education should be public subsidized because of the *positive externalities* in terms of human capital accumulation, it produces. In fact if externalities are considered, such as better wealth, less criminality, higher female participation rate to the labour market, better parenting style, etc., social benefits will be much higher than private benefits (Oreopoulos and Salvanes, 2011). Aggregate human-capital externalities can help in explaining cross-country differences in economic development, the lack of capital flows to poor countries, the effects of agglomeration on economic growth, and other macroeconomic phenomena (Ciccone and Peri, 2006). From a public policy point of view, to assess these externalities is a key and difficult problem. However even if externalities are monetized in a fully satisfactory way and thus all costs and benefits would be "commensurable", a technical difficulty has still to be solved, that is, which is the correct mathematical aggregation rule (i.e. the commonly called investment evaluation criterion or discount method) to use?

This research tries to clarify this controversial topic by focusing on some clear cut formal properties of the various investment evaluation criteria and by considering the empirical characteristics of the different fields of application, i.e. private, public, financial and non-financial (i.e. physical investment such as school infrastructures). Next Section describes the main investment evaluation criteria developed in the specialised literature and commonly used in practice. Section 3 contains a systematic comparison of these evaluation criteria by considering their formal properties and empirical consequences. Section 4 is specifically devoted to the most common used criterion in education policy and planning, i.e. the internal rate of return; finally some conclusions are derived.

2. Main Investment Evaluation Criteria

In this research, the "classical" investment evaluation criteria are taken into consideration, i.e. the net present value, the benefit cost ratio, the payback period and the internal rate of return. Let us assume that **x** is the investment cash flow, **x**= x_0, x_1, x_2, ..., x_N, N the time horizon, and i the discount rate to compute the present value of **x**. By defining r_t and c_t respectively the revenues and costs (including both capital costs (k) and running costs (e)) associated with cash flows x_t, their analytical formulations are the following:

- Net Present Value (NPV), sometime called also Discounted Cash Flow (DCF):

$$NPV = \sum_{t=0}^{N} \frac{x_t}{(1+i)^t}$$

The evaluation rule is: for project economic acceptability *NPV* must be positive; the higher the *NPV* the more desirable the investment.

- Benefit Cost Ratio (BCR):

$$BCR = \frac{\sum_{t=0}^{N} \frac{r_t}{(1+i)^t}}{\sum_{t=0}^{N} \frac{c_t}{(1+i)^t}}$$

The evaluation rule is: for project economic acceptability *BCR* must be higher than one; the higher the *BCR* the more desirable the investment.

- Profitability Index (PI):

$$PI = \frac{\sum_{t=0}^{N} \frac{r_t - c_t}{(1+i)^t}}{\sum_{t=0}^{N} \frac{k_t}{(1+i)^t}}$$

It is a different version of the benefit cost ratio, where *k* refers to capital costs only; in summary, the profitability index is the ratio between *NPV* and the summation of the discounted capital costs. By using *BCR* or *PI,* the acceptability condition of a project gives the same result, but the investment ranking may change. The evaluation rule is: for project economic acceptability *PI* must be higher than one; the higher the *PI* the more desirable the investment.

- Payback Period (PB):

"*The payback period of a project is found by counting the number of years it takes before the cumulative forecasted cash flow equals the initial investment*" (Brealey and Meyers, 2003, p. 94). In mathematical terms, by defining with *X(S),* $1 \leq S \leq N$, the cumulative function of cash flows, i.e. $X(S) = \sum_{t=0}^{S} x_t$, it is

$$PB = \min S : X(S) \geq 0$$

The evaluation rule is: the lower the *PB* the more desirable the investment. A drawback of this criterion is that the time value of money is not taken into account since no discount rate is used. This problem is eliminated by using the Discounted Payback Period (DPB):

$$DPB = \min S : \sum_{t=0}^{S} \frac{x_t}{(1+i)^t} \geq 0$$

- Internal Rate of Return (IRR):

From a mathematical point of view, the internal rate of return is defined as the discount rate *r* if it exists and is unique, that makes the *NPV* of all cash flows of an investment equal to zero (in summary *r* is the discount rate at which the *NPV* of positive cash flows is equal the *NPV* of negative cash flows).

$$IRR = r: NPV = \sum_{t=0}^{N} \frac{x_t}{(1+r)^t} = 0$$

The evaluation rule is: for project economic acceptability the higher the *IRR* the more desirable the investment. From an empirical point of view, the *IRR* can be considered as the growth rate of returns that an investment is estimated to produce, thus it is used with the meaning of an *interest rate* (although technically it is a discount rate). In real-world practice, *IRR* is also used as a proxy of the *opportunity cost* of the investment, i.e. if no physical investment is able to generate an *IRR* bigger than the one of financial investments, thus it is better to invest on the financial market. Finally *IRR* can also be used as a measure linked to the *cost of financial capital*; if one has to borrow money to invest, this makes sense only if the expected investment *IRR* is bigger than the financial cost of the money to be borrowed on the financial markets.

One should observe that neither the existence nor the uniqueness of *IRR* is always guaranteed. Levi (1964) and Norstrom (1972) indicate some sufficient conditions for existence, uniqueness and non-negativity of *IRR*. In the case of *IRR*, one should note that it loses its consistency, when more than one solution exists. This is clear if one looks at Figure 1.

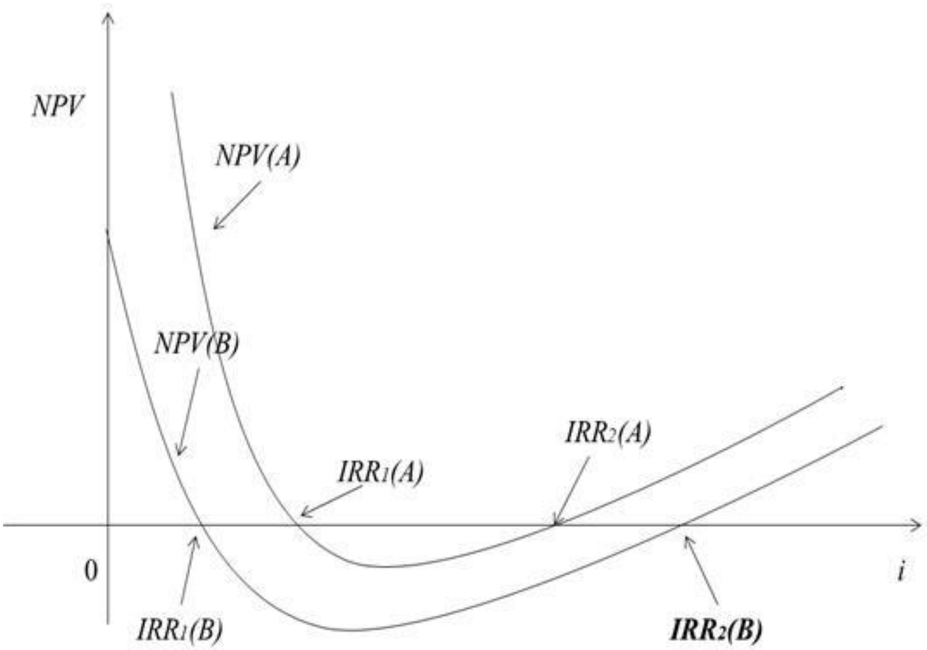

Figure 1. Consistency of *NPV* and *IRR*

In the case where *IRR* is not unique, it may happen that some solutions give the wrong advice. Although investment *A* is preferable to investment *B* clearly, *IRR2(B)* is bigger than *IRR2(A),* thus an inconsistency exists clearly.

The debate on the proper evaluation criterion to use, when a private capital investment decision has to be taken or a public project appraisal has to be carried out, is a traditional one in financial and public economics literature (see e.g. Alchian, 1955; Bouding, 1948; Dorfman, 1981; Fisher, 1930; Gordon, 1955; Hirshleifer, 1958; Lesourne, 1958; Lorie and Savage, 1955; Mishan, 1971; Osborne, 2010; Oehmke, 2000; Samuelson, 1936; Scitowski, 1951; Solomon, 1956; Teichroew *et al*., 1965). More recently, this debate has extended to production and engineering economics too (see e.g. Chiang *et al.,* 2010; Hartman and Schafrick, 2004; Hazen, 2003; Newnan *et al.,* 2011, Pasqual *et al*., 2013; Remer *et al.,* 1993; Zhang, 2005). However, although the considerable amount of existing literature, the problem of the choice of the right investment evaluation criterion is still an open one. Moreover, a conflict between scholars and financial practice seems to exist, in fact large corporations and banks currently seem to prefer the internal rate of return or payback criteria to *NPV* (Brounen *et al.,* 2004; Graham and Harvey, 2001; Kester *et al*., 1999; Liljeblom and Vaihekoski, 2004; Payne *et al*., 1999; Ryan and Ryan, 2002); on the contrary, *NPV* is the one supported by the majority of scholars (see e.g. Brealey and Meyers, 2003; Luemberger, 2012). Economics of education is the only relevant exception; in fact this is the only field where scholars too defend the use of *IRR* instead of *NPV* (e.g. Chetty *et al.,* 2011; Psacharopoulos and Patrinos, 2004; Woodhall, 2004).

3. Comparison of the Main Investment Evaluation Criteria

At this stage, one may ask two questions:

1) Is there any general rule which can *a priori*, indicate when results of the different investment evaluation criteria coincide?
2) When they provide different results, how can we choose the right investment evaluation criterion?

To answer these questions properly, it is useful to consider different decision frameworks. According to Roy (1996), a decision problem formulation can take one of the following forms:

(α) the aim is to identify one and only one final project (choice problem);

(β) the aim is the assignment of each project to an appropriate predefined category according to what one wants it to become afterwards (for instance, acceptance, rejection or delay for additional information) (sorting problem);

(γ) the aim is to rank all feasible projects according to a total or partial preorder (ranking problem).

The answer to the first question (i.e. to specify when results of the different investment evaluation criteria coincide) is easy: the answer given by *NPV*, *BCR* and *IRR* investment evaluation criteria always coincide if one has to evaluate the absolute acceptability of a single project, i.e. we are in an "accept-reject" decision framework (β decision problem formulation). The proof is straightforward; in fact if a project has a positive (negative) *NPV* at a given level i_0 of the discount rate, it necessarily has a *BCR* bigger (lower) than one, then both provide the same result. The same way of reasoning applies to the internal rate of return too.

What happens with the payback period? If *NPV* is positive and *BCR* bigger than one, it necessarily must exist a payback year, but the opposite does not hold too, since the *PB* criterion completely ignores the cash flow values (positive or negative, large or small) after that period. Therefore, this criterion can give no information at all about the problem at hand. Some authors claim that an investment project should be accepted if its *PB* is smaller than a specified cutoff period, interpreted as an efficiency threshold of the considered productive sector (for an overview of this topic see e.g. Dobbs, 1996).

The answer to the second question (i.e. how can we choose the right investment evaluation criterion?) is more complex. In economics and finance, a distinction is made between absolute and relative investment evaluation criteria, i.e. taking explicitly into account only the absolute value of the profit of a project, or its rate of profit, relative to a unit of invested financial capital. The net present value is an indicator of the financial attractiveness of an investment in absolute terms. It has been shown (Hirshleifer, 1958) that *NPV* represent the right evaluation criterion only if the projects considered are mutually exclusive (in the framework of α decision problem formulation) and a perfect capital market exists, i.e. no capital constraint has to be taken into consideration, of course this looks a quite optimistic assumption.

If one uses investment evaluation criteria such as the benefit cost ratio, the profitability index or the internal rate of return the financial attractiveness of a project is independent from the scale of such a project. In decision contexts where various projects have to be chosen but the budget available is limited, a very common real-world case indeed, a ranking is needed (γ decision problem formulation) and thus relative investment evaluation criteria such as the benefit cost ratio may look more appropriate than *NPV.*

First of all, let us make clear that when a project ranking is the final objective of an evaluation, given that the assumptions underlying each investment evaluation criterion are different, the results they generate are different too. In the case of *NPV* and *BCR*, this difference can be easily shown graphically (for more details see Matarazzo, 1981, pp. 191-205). If for simplicity, we assume cumulative discounted positive cash flows equal to $\bar{Y} = \sum_{t=0}^{N} \frac{r_t}{(1+i)^t}$ and cumulative discounted negative cash flows equal to $\bar{X} = \sum_{t=0}^{N} \frac{c_t}{(1+i)^t}$, it is $NPV = \bar{Y} - \bar{X}$ while benefit cost ratio is $\frac{\bar{Y}}{\bar{X}}$. In Figure 2, it is clear that given the project I, the benefit cost ratio is $\frac{\bar{Y}}{\bar{X}} = \tan \varphi$ while $NPV = \bar{Y} - \bar{X}$ is given by the straight-line AC. Let us now consider three projects I_1, I_2, I_3 and by using the same way of reasoning described for Figure 2, in Figure 3 one can see that according to the benefit cost ratio, since it is $\varphi_1 > \varphi_2 > \varphi_3$ the ranking of the three projects is $I_1 > I_2 > I_3$, while according to the net present value, it is $I_2 > I_1 > I_3$.

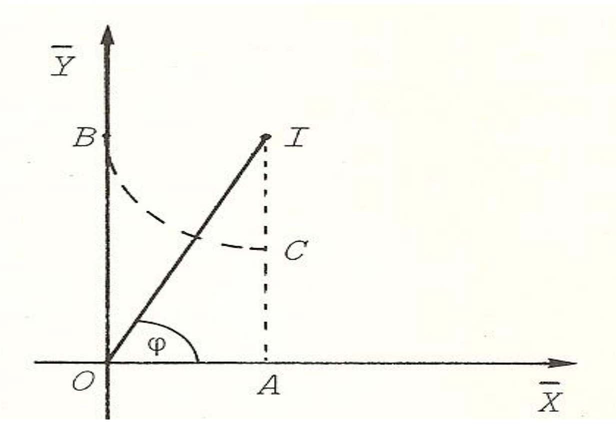

Figure 2. Graphical representation of *NPV* and *BCR*

(Source: Matarazzo, 1981, p. 193)

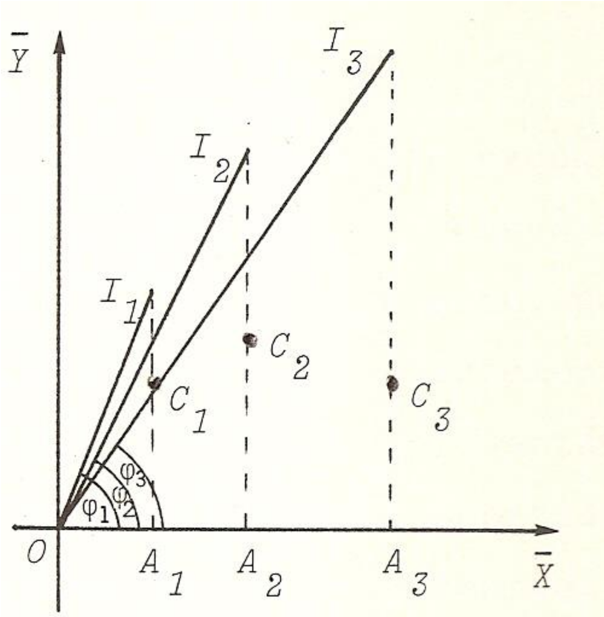

Figure 3. Graphical representation of project rankings according to *NPV* and *BCR*

(Source: Matarazzo, 1981, p. 195)

Let us now compare *NPV* and *IRR*. By looking at Figure 4, it is clear that according to *IRR,* investment G is preferred to investment H; but according to *NPV*, if the discount rate is lower than 15.6, H is definitely more attractive than G. One may easily understand that the only case where both *NPV* and *IRR* supply the same ranking is when all *NPV* graphics do not intersect one another and *IRR* exists and is unique. This is a very peculiar case, far from being common in the real-world experience (and almost impossible if the number of investments to compare is high).

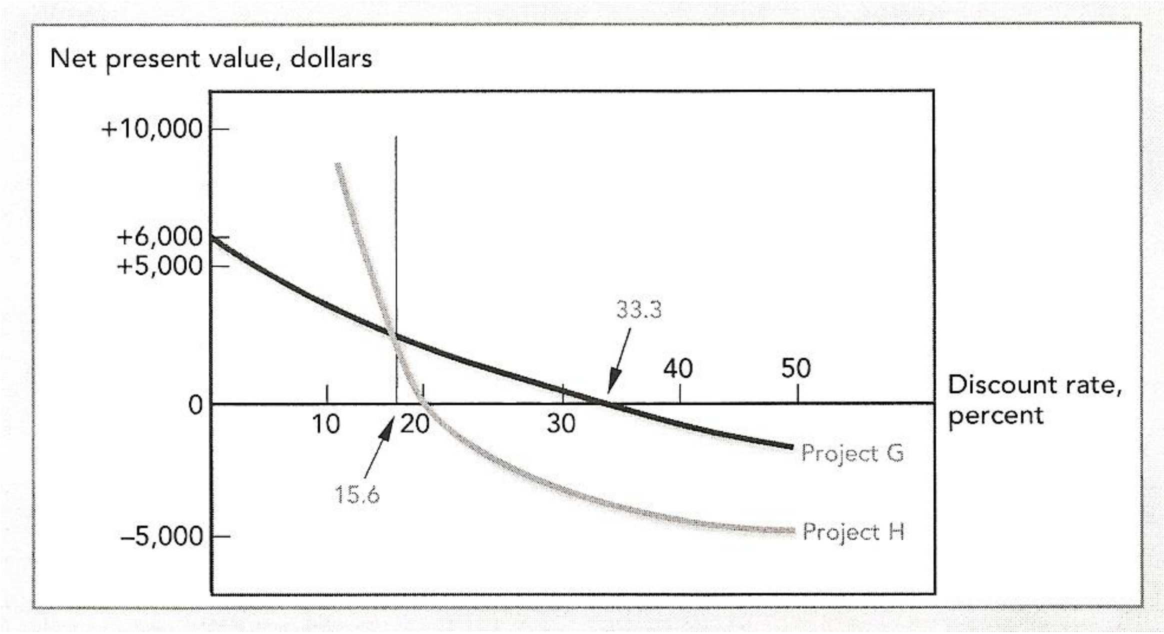

Figure 4. Graphical representation of project rankings according to *NPV* and *IRR* (Source: Brealey and Meyers, 2003, p. 103)

The payback criterion is not comparable with any of the other investment evaluation criteria. This because it does not take into consideration the cash-flows after the payback year and thus the time horizon is different. This evaluation criterion has been criticised heavily because it ignores all cash flows after the cut-off date. *"In order to use the payback rule, a firm has to decide on an appropriate cutoff date. If it uses the same cutoff regardless of project life, it will tend to accept many poor short-lived projects and reject many good long-lived ones."* (Brealey and Meyers, 2003, p. 95). This criticism is correct obviously, thus a legitimate question is: why so many real-world investments are evaluated by using *PB*? In my opinion, the main (and maybe unique) reason is that the concept of *PB* is very understandable, intuitive and simple, or better, from a scientific point of view, simplistic.

In the framework of the debate on the maximization assumption in microeconomics, Musgrave (1981) made a very useful classification of the assumptions made in economic theory. He makes a distinction between *negligibility assumptions, domain assumptions and heuristic assumptions.* The first type is required to simplify and focus on the essence of the phenomena studied. The second type of assumption is needed when applying a theory to specify the domain of applicability. The third type is needed either when a theory cannot be directly tested or when the essential assumptions give rise to such a complex model that successive approximation is required. An important negligibility/heuristic assumption underlying all the investment evaluation criteria considered here is that cash flows are under conditions of certainty. Knight (1921, p. 313) clearly stated: *"... We live in a world of contradiction and paradox, a fact of which perhaps the most fundamental illustration is this: that the existence of a problem of knowledge depends on the future being different from the past, while the possibility of the solution of the problem depends on the future being like the past*". In a heuristic framework, *PB* may be seen as a first approximation to real-world uncertainty, as information about the turnover speed. Agents know that to invest is always a risky activity and that reality is dynamic e.g. new investment opportunities with higher profits might appear, thus *PB* minimisation is a rationale objective for them. Given that indeed *NPV* or *BCR* measure the financial attractiveness of an investment and *PB* its connected uncertainty (at least as a proxy), there is the possibility to consider *PB* as complementary to *NPV* or *BCR*. One should note the importance of domain assumptions here. In fact, while to use *PB* in the private sector is understandable, at least from a psychological point of view, this is not in the case of public investments.

A proper evaluation of policy options needs to deal with a plurality of legitimate values and interests found in a society. From a societal point of view, financial optimization cannot be the only evaluation criterion. As already discussed, not all goods have a market price (*non-pecuniary benefits*), or this price is often too low (*market failures*). Distributional consequences (intra/inter-generational) must also be taken into account. If it is accepted that society as a whole has an indefinite lifespan (thus e.g. cultural heritage is a key intergenerational equity issue), a much longer time horizon than is normally used on the market is required; a contradiction then arises since the use of *PB* would be consistent with a very short time horizon only. From a descriptive point of view, probably this is correct, since often policy-makers consider four-five year time horizon, depending on the electoral system; this has the effect that long term societal goals are rarely among their priorities (thereby causing a *government failure*). However from a normative point of view, public authorities should be benevolent policy-makers[1]; for this reason, I think that evaluation of public projects should take into account the entire *"civil society"*, including ethical concerns about future generations, thus the use of *PB* is not advisable for public project evaluation.

At this stage, it is clear that the relevant research question is: shall we use *NPV, BCR* or *IRR*? Here, I will defend the following answer: when a ranking is needed and the capital

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[1] For an overview of different perspectives on the role of governments in the economic sphere see e.g. Buchanan and Musgrave, 1999.

is limited, the correct investment criterion to use depends on 1) the fact that the investment is financial (e.g. teachers' salaries, education vouchers, etc.) or physical (e.g. school buildings, computers and so on) and 2) on the private or public nature of it.

A) Financial investments. In this case, the correct ranking can be easily obtained by using *NPV* inside a linear programming (LP) model (One should note that Hirshleifer, 1958 already proposed this type of solution, although in a pure economic theoretical framework). In fact in the case of pure financial investments, these ones are generally fractional in nature, (LP may supply as a result to choose one unit of investment A, ¾ of investment B, ½ of C, etc.) thus *NPV* can be considered the objective function to be maximized by considering all the possible combinations of the feasible investments. This type of solution is clearly valid for both private and public financial investments.

B) Private physical investments. Physical investments in their great majority are not fractional; in this case, if one wishes to use a LP optimization model, there is a need to apply integer linear programming. One should note that no exact algorithm exists for the integer case of LP, in fact it is a so-called NP-hard problem[2]. Considering that in general the feasible options are limited in number and not repeatable (e.g. one cannot build two times the same school building in the same location), in this case to use *BCR* looks a rational option, since investment projects are ranked according to their relative financial performance per unit of capital invested. Even when the investment is repeatable (e.g. to buy computers, TV sets, etc.), *BCR* supplies a rational solution if used in a lexicographic framework; that is, once the option with the highest *BCR* has been completely exploited, if some capital is still available, the second position in the ranking is used and so on till the capital is used completely.

C) Public physical investments. Of course, all the arguments already considered for private physical investments apply to the public ones too. In addition to these arguments, we have to consider that in the case of public investments, social issues have also to be taken into consideration. Economic development implies the creation of new assets in terms of physical, human, social and cultural structures. Within a process of "creative destruction" traditional assets derived from a society's common heritage may disappear. The existence of a plurality of social actors, with interest in the policy being assessed, generates a conflictual situation. "*... Looking at a single individual, ... He is prevented from being better off than he is, not only because total production is*

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[2] The *complexity class* of *decision problems* that are intrinsically harder than those that can be solved by a *nondeterministic Turing machine* in *polynomial time*. When a decision version of a combinatorial *optimization problem* is proved to belong to the class of *NP-complete* problems, then the optimization version is NP-hard (definition given by the National Institute of Standards and Technology, http://www.nist.gov/dads/HTML/nphard.html).

limited, but also because so much of total production is at the disposal of persons other than himself. The same thing holds, of course, for any group or society of individuals, so long as that group is less than the totality of a closed community" (Hicks, 1939, p. 698-699). Welfare economics proposes the measurement of social costs and benefits made on the basis of the so called compensation principle (usually associated with the names of Kaldor (1939) and Hicks (1939)).

In empirical applications, the compensation principle is implemented by using social cost-benefit analysis, where costs and benefits are aggregated linearly in a net present value formula. The assumption underlying the *NPV* rule is that of an additive social welfare function, such as $SW = \sum_h U_h$ where the subscript *h* denotes the individual to whom the utility function applies. Under the assumption that the marginal utility of money income is *identical for all individuals,* the variation of this social welfare function indicating the social worth of a project is computed by using a *NPV* formula.

Nevertheless, the assumption of a constant marginal utility of income across individuals is a distributional question, and that assumption embodies particular social values[3]. Given that society is unlikely to be indifferent among various possible distributions of income, some ways of integrating the distributional aspects into the analysis have to be found. The most popular methodology is to introduce distributional weights explicitly, by using different weights for different social groups (Bojo *et al.,* 1990). However, it is not clear how to derive such weights, since they can be based on a variety of ethical, philosophical and methodological principles and who should attach them (economists, policy-makers, society, ...). On the other hand, it must be clear that failures to use any weighting system imply making the *implicit value judgments* either that the existing distribution of income is optimal and/or the change in income distribution is negligible. If, and only if, one is happy with such value judgments, it is reasonable to use un-weighted market valuations to measure costs and benefits. Therefore, there is no escape

[3] One should indeed note that Kaldor proposed the compensation principle exactly to avoid the principle one individual one vote, since equality was in his opinion a problem. "*Consider the Repeal of the Corn Laws. This tended to reduce the value of a specific factor of production-land. It can no doubt be shown that the gain to the community as a whole exceeded the loss to the landlords-but only if individuals are treated in some sense as equal. Otherwise how can the loss to some-and that there was a loss can hardly be denied-be compared with the general gain?"* (Kaldor, 1939, p. 549); and then he presented the solution to this "criticism": " *… It is only as a result of this consequential change in the distribution of income that there can be any loss of satisfactions to certain individuals, and hence any need to compare the gains of some with the losses of others. But it is always possible for the Government to ensure that the previous income-distribution should be maintained intact: by compensating the " landlords " for any loss of income and by providing the funds for such compensation by an extra tax on those whose incomes have been augmented. In this way, everybody is left as well off as before in his capacity as an income recipient; while everybody is better off than before in his capacity as a consumer. For there still remains the benefit of lower corn prices as a result of the repeal of the duty*" (Kaldor, 1939, p. 550).

from value judgments. It has to be noted that this conclusion contradicts the main argument which Hicks used as a defense of the compensation principle, since he was very attracted by its apparent objectivity. In fact Hick's was very worried by a positivist attack to normative economics, which he himself agreed with " *… Positive economics can be, and ought to be, the same for all men; one's welfare economics will inevitably be different according as one is a liberal or a socialist, a nationalist or an internationalist, a christian or a pagan*" (Hicks, 1939, p. 696). The compensation principle was a solution to this problem: *"By adopting the line of analysis set out in this paper, it is possible to put welfare economics on a secure basis, and to render it immune from positivist criticism".* (Hicks, 1939, p. 711) "*… I have accomplished my end if I have demonstrated the right of Welfare Economics - the "Utilitarian Calculus" of Edgeworth - to be considered as an integral part of economic theory, capable of the same logical precision and the same significant elaboration as its twin brother, Positive Economics, the "Economical Calculus" "* (Hicks, 1939, p. 712).

We should take for granted the existence of a multiplicity of legitimate values in society. Any social decision problem is characterised by conflicts between competing values and interests and different groups and communities that represent them (Munda, forthcoming). Any policy option always implies winners and losers, thus it is important to check if a policy option seems preferable just because some dimensions (e.g. the cultural one) or some social groups (e.g. the lower income groups) are not taken into account. From an operational point of view, it is then better *to have* a ranking of the different policy options rather than to select just one project; in fact, in this way social compromises may be easier. For example, the second or the third project in the ranking may minimize social opposition, while the top one could maximize it. In this way, policy-makers can balance efficiency and equity concerns in a more transparent way (Munda, 2009).

Moreover, one should remember that *NPV*, being an indicator of the attractiveness of an investment in absolute terms, always considers large scale projects as the most desirable ones. In this way, large public investments in infrastructures (e.g. a new university campus) will always be considered more desirable than smaller investments (e.g. ICT equipment, teachers' training, …). I think this is not desirable for at least a couple of reasons:

1) Large projects are necessarily localized in precise parts of a national territory, thus social conflicts and equity concerns are more probable to appear. However, one should note that this argument applies of course only for physical investments. Financial ones, such as the Erasmus + program (worth 14.7 billions Euro) is not localized in any specific European place.

2) Large infrastructural projects are usually the ones with the highest negative externalities from the social, cultural and environmental points of view. From a sustainability point of view, this is not often a desirable public policy.

As a conclusion we may state that in a social cost-benefit analysis to have a ranking of projects, by using the *BCR* investment evaluation criterion, i.e. the return, relative to a single unit of invested capital, is more desirable than to use a *NPV* formula.

4. Why to Use the Internal Rate of return?

What about *IRR*? Apart from its (apparent) attractive meaning due to its "objectivity" (no hypothesis is needed about the selection of the discount rate to compute present value), I think that the reasons for its popularity in the *private sector* are twofold. First in the same way of *PB,* it could be considered a measure of uncertainty; in fact, one should consider that it makes sense to use *IRR* when existence and uniqueness conditions apply. These conditions, which are sufficient but not necessary (Norstrom, 1972), imply that to have a unique *IRR,* it is sufficient that the average investment costs appear in a point of time before than the average revenues. This is the case for e.g. most of the investments in infrastructures, provided that the chosen time horizon is relatively short. In fact if at some point of time, large amounts of renovation costs appear, *IRR* uniqueness could disappear. Moreover, given that *IRR* is the same for all cash flows along the time horizon (while in the *NPV* and *BCR* calculations, a plurality of discount rates can be used along the time horizon), Norstrom's conditions cause that costs receive a bigger weight than revenues (since costs appear in average before revenues and thus their undervaluation due to the discount effect is lower) and as a consequence, long term investments are penalized. Thus an analogy with *PB* exists and the same line of criticism also applies here.

Second, as noted by Massé (1962) when a loan is needed for an investment (very common state of affairs in the real world), *IRR* is a measure of the maximum interest rate that an agent can pay for capital availability. No doubt, this information can be useful for e.g. a manager of a private university. However one should note that to use *IRR* for this purpose may imply the risk of losing uniqueness, since Bernhard (1962) and Teichroew *et al.*, (1965) showed that *"a project has to be a mixture of an investment and a loan in order not to have a unique internal rate of return"* (Norstrom, 1972, p. 1838). Therefore, an implicit assumption of *IRR* is that any financial complementary operation (e.g. a loan) should be possible at the same *IRR* of the project at hand. Obviously this assumption is not necessarily fulfilled in a real-world situation.

With reference to the *public sector,* the use of *IRR* may be justifiable on completely different grounds. In real-world public policy, a field where *IRR* is widely used is educational planning; the main justifications provided by scholars are three:

1) The choice of a discount rate may vary for different countries and at different times, while *IRR* is an "objective" measure. The costs of this apparent objectivity have been already extensively discussed in previous pages of this report.

2) *IRR* allows the comparison of investments in different educational fields, such as primary schooling and university (by simply considering the average rates of return in each field). This is not a particular strong argument, since the same comparison could be done by using the benefit cost ratio. *CBR* has the characteristic of being a relative measure of investment attractiveness, like *IRR,* but it has the advantages of a) avoiding all computational complexities of *IRR* and b) not having the short term bias linked to *IRR.*

3) *IRR* allows the comparison with investments in the private sector. This third argument is worthy to be explored more in depth.

As it is well known, in a perfectly competitive world provided that there are no distortions in capital markets and that all agents have perfect information, the suggestions of cost-benefit analysis imply a Pareto efficient resource allocation if the discount rate is set equal to the market interest rate. Since the real-world does not fulfills these ideal conditions, economists have proposed several theories for the choice of the social discount rate, but the choice of an appropriate social discount rate for public policy evaluation is still one of the most controversial topics in the economic literature (see e.g. Baumol, 1968; Dasgupta and Pearce, 1972; Eckstein 1961; Feldstein, 1964; Frederick *et al*., 2002; Loewenstein and Thaler, 1989; Marglin, 1963; Mishan, 1967; Prest and Turvey, 1965; Ramsey, 1928; Seagreves, 1970; Sen, 1961).

The most important theories are two: *social time preference rate* (STPR) and *social opportunity cost of capital* (SOC). STPR is composed by the societal time preferences, i.e. the rate at which a society is willing to postpone a unit of current consumption for obtaining more future consumption and the consumption growth rate (corrected by considering its decreasing marginal utility). STPR has been criticized mainly because:

a) Individuals have to deal with the risk of death and thus positive pure time preference (i.e. considering the future as less important than the present) is a rational behavior. However society as a whole is not a mortal body, thus valuing utility of future generations less than the present generation, is ethically unacceptable.

b) If STPR is calculated by considering the consumption growth rate only, the previous criticism does not apply anymore. The justification for discounting is simply that future generations will be richer. However, are we sure that future real GDP will be higher? Moreover, even if GDP growth rate is positive in real terms, are we sure that this effect will not be compensated by the population growth rate? It may happen that the per capita future GDP is even lower than the current one.

The proposal for using the social opportunity cost of capital is based on the empirical argument that resources in any economy are scarce; no society can avoid the economic problem of *"opposition between tastes and obstacles",* as Pareto made clear. This implies that the public and private sectors compete for the same funds. As a consequence, public investments should guarantee at least the same profitability as private investments; otherwise a Pareto improvement can be obtained by reallocating resources to the private sector. In this framework, *IRR* could be a useful public investment evaluation criterion, since a relationship with the market interest rate is created.

5. Conclusion

When education policies need to be implemented, there is a previous need of comparing different actions and evaluating them to assess their social attractiveness. Education investments can be evaluated according to different objectives; we may have simple "accept-reject" decisions, there could be a need of choosing only one project among a set of competitive alternatives or the construction of a complete ranking is needed. In the former case, when no comparison between different projects is required all evaluation investment criteria considered give the same results (with the exception of the *PB,* that cannot be compared with the other investment criteria since the time horizon is different). In the second case, if one and only one project has to be chosen, then the decision should be made on the grounds of the highest *NPV*. In the latter situation, the choice of the right evaluation criterion to use is more complex, since the various evaluation criteria provide different results to the ranking problem. In this decision environment, one has to consider three factors: 1) if the investment is private or public, 2) if the investment is financial or physical, 3) if the capital available is limited or not.

In the case of pure financial investments (both private and public), these ones are generally fractional in nature, thus *NPV* can be considered the objective function to be maximized inside a linear programming model, given a fixed amount of capital. This solution is also consistent with the marginalistic tradition. Another decision context arises when various physical projects have to be chosen and the budget available is limited; in this case a ranking is needed and benefit cost ratio may look more attractive than *NPV* both for private and social investments.

Both payback and internal rate of return can be considered just a first approximation for dealing with real-world uncertainty. Both criteria can be considered only as complementary in nature with *NPV* and *BCR*, when private investments have to be evaluated. In this context *PB* performs slightly better than *IRR,* since it is of a more general applicability and more intuitive meaning.

When a loan is needed for an investment, *IRR* is a threshold measuring the maximum interest rate that an agent can pay for capital availability; however one should note that existence and uniqueness conditions in this case do not necessary hold. *IRR* can also be interpreted as a proxy of the financial opportunity cost of a physical investment.

In the case of public investments, *PB* should never be used. *IRR* could have a role as an approximation of the social opportunity cost of capital, although one has to remember that its use implies an undervaluation of long term effects of the public investments considered.

References

Alchian A.A. (1955) – The rate of interest, Fisher's rate of return over cost, and Keynes' internal rate of return, *American Economic Review,* XLV, pp. 938-943.

Baumol W.J. (1968) - On the social rate of discount, *The American Economic Review*, Vol. 58, No. 4, Sep., pp. 788-802.

Bernhard, R. H. (1962) - "Discount Methods for Expenditure Evaluation - A Clarification of Their Assumptions.", *The Journal of Industrial Engineering,* Volume XII, No. 1, January-February.

Bojo J., Maler K.G. and Unemo L. (1990) – *Environment and development: an economic approach*, Kluwer, Dordrecht.

Boulding K.E. (1948) – *Economic Analysis,* Harper & Bros, New York.

Brealey, R. and Myers, S. (2003) - *Principles of Corporate Finance*, (7th ed.), McGraw-Hill, New York.

Brounen, D., De Jong, A. and Koedijk, K. (2004) - Corporate finance in Europe: Confronting theory with practice, *Financial Management,* 33(4), pp. 71-101.

Buchanan, J. M., Musgrave, R.A. - (1999) *Public finance and public choice.* The MIT Press, Cambridge.

Chetty, R., Friedman, J.N., Hilger, N., Saez , E., Schanzenbach, D.W., and Yagan D. (2011) - "How does your kindergarten classroom affect your earnings? Evidence from Project STAR". *Quarterly Journal of Economics*, 126 (4), pp. 1593-1660.

Chiang, Y.H., Cheng, E.W.L., Lam, P.T.I. (2010) - Employing the net present value-consistent IRR methods for PFI contracts. *Journal of Construction Engineering and Management*, 136(7), pp. 811–814.

Ciccone A. and Peri G. (2006) - Identifying Human-Capital Externalities: Theory with Applications, *Review of Economic Studies* 73, pp. 381–412.

Cohn E., Huches W.W. Jr (1994) - A benefit-cost analysis of investment in college education in the United States: 1969–1985, *Economics of Education Review*, Volume 13, Issue 2, Pages 109-123.

Dasgupta, A. and Pearce D. (1972) - *Cost–Benefit Analysis*. UK: Palgrave Macmillan.

Dobbs I.M. (1996) - On the use of payback thresholds in devolved Budgeting, *Project Appraisal,* Vol. 11, No. 1, pp. 51-59.

Dorfman, R. (1981) - The meaning of internal rates of return. *The Journal of Finance,*

36(5), pp. 1011-1021.

Eckstein, O. (1961) - A Survey of the Theory of Public Expenditure and Criteria, In Buchanan, J., (ed.), *Public Finance: Needs, Sources and Utilization*. Princeton, NJ: Princeton University Press.

Feldstein M.S. (1964) - The social time preference discount rate in cost benefit analysis, *The Economic Journal,* Vol. 74, No. 294, Jun., pp. 360-379.

Fisher, I. (1930) - *The Theory of Interest.* New York: Macmillan.

Frederick S., Loewenstein G., O'Donoghue T. (2002) - Time Discounting and Time Preference: A Critical Review, *Journal of Economic Literature*, Volume 40, Number 2, 1 June , pp. 351-401(51).

Graham, J., and Harvey, C. (2001) - The theory and practice of corporate finance: Evidence from the field. *Journal of Financial Economics,* 60, pp. 187-243.

Gordon M.J. (1955) – The payoff period and the rate of profit, *Journal of Business,* pp. 188-212.

Hartman, J., and Schafrick, I. (2004) - The relevant internal rate of return. *The Engineering Economist,* 49, pp. 139–158.

Hazen, G. (2003) - A new perspective on multiple internal rates of return. *The Engineering Economist*, Vol.48, pp. 31–51.

Hicks, J.R. (1939) The foundations of welfare economics. *Economic Journal,* vol. 49, No. 196, pp. 696–712.

Hirshleifer, J. (1958) - On the theory of optimal investment decision. *Journal of Political Economy*, 66, pp. 329-352.

Kaldor, N. (1939) - Welfare comparison of economics and interpersonal comparisons of utility. *Economic Journal,* vol. 49, No. 195, pp. 549–552.

Kaplan N. (1952) - Investment Alternatives in Soviet Economic Theory. *Journal of Political Economy,* Vol. 60, No. 2 pp. 133-144.

Kester, G., Chang, R., Echanis, E., Haikal, S., Isa, M., and Skully, M. (1999) – Capital budgeting practices in the Asia-Pacific region: Australia, Hong Kong, Indonesia, Malaysia, Philippines and Singapore. *Financial Practice and Education,* 9(1), pp. 25 - 33.

Knight F. (1921) - *Risk, Uncertainty and Profit*, Houghton Mifflin Company, Cambridge, UK.

Lesourne J. (1958) – *Technique économique et gestion industrielle*, Dunod, Paris.

Levi E. (1964) - *Corso di Matematica Finanziaria e Attuariale,* Giuffre, Milan.

Liljeblom, E., and Vaihekoski, M. (2004) - Investment evaluation methods and required rate of return in Finnish publicly listed companies. *Finnish Journal of Business Economics*, Vol. 53, No 1, pp. 9-24.

Loewenstein G., Thaler R.H. (1989) - Anomalies: intertemporal choice, *The Journal of Economic Perspectives,* Vol. 3, No. 4, Autumn, pp. 181-193.

Lorie, J., and Savage, L. (1955) - Three problems in capital rationing. *Journal of Business*, 28, pp. 228-239.

Luenberger D. G. (2012) – *Investment science,* Oxford University Press, Oxford

Marglin S.A. (1963) - The social rate of discount and the optimal rate of investment, *Quarterly Journal of Economics,* Volume 77, Issue 1, pp. 95-111.

Massé P. (1962) - *Optimal investment decisions; rules for action and criteria for choice,* Prentice-Hall, Incorporated, USA.

Matarazzo B. (1981) – *Sulla scelta degli investimenti privati,* Università degli Studi, Facoltà di Economia e Commercio, Istituto di Matematica, Catania.

Mincer, J. (1974) - *Schooling, experience and earnings.* National Bureau of Economic Research.

Mishan, E. (1967) - Criteria for Public Investment Some Simplifying Suggestions, *Journal of Political Economy*, 75, pp. 139–146.

Mishan E.J. (1971) – *Cost-benefit analysis,* Allen and Unwin, London.

Munda G. (2009) – A conflict analysis approach for illuminating sustainability distributional issues*, European Journal of Operational Research,* Volume: 194, Issue: 1**,** pp. 307-322**.**

Munda G. (forthcoming) - Beyond welfare economics: some methodological issues, *Journal of Economic Methodology.*

Musgrave, A. (1981) Unreal assumptions in economic theory: the F-twist untwisted. *Kyklos,* 34, pp. 377-387.

Newnan, D.G., Eschenbach, T.G., Lavelle, J.P. (2011) - *Engineering Economic Analysis*, 9th Ed., Oxford University Press, Oxford.

Norstrøm C.J. (1972) - A Sufficient Condition for a Unique Nonnegative Internal Rate of Return. *Journal of Financial and Quantitative Analysis,* 7, pp 1835-1839. doi:10.2307/2329806.

Oehmke, J.F. (2000) - Anomalies in net present value calculations, *Economics Letters,* 67, pp. 349–351.

Oreopoulos Ph. and Salvanes K. G. (2011) - Priceless: The Nonpecuniary Benefits of

Schooling, *Journal of Economic Perspectives—Volume 25, Number 1, Pages 159–184.*

Osborne, M.J. (2010) - A resolution to NPV-IRR debate? *The Quarterly Review of Economics and Finance*, 50, pp. 234–239.

Psacharopoulos, G. and A. Patrinos (2004) - Returns to investment in education: A further update, *Education Economics*. 12, no. 2, 2004, pp. 111-135.

Pasqual J., Padilla E. and Jadotte E. (2013) – Technical note: Equivalence of different profitability criteria with the net present value, *International Journal of Production Economics,* 142, pp. 205 -210.

Payne, J., Carrington Heath, W., and Gale, L. (1999) - Comparative financial practice in the US and Canada: Capital budgeting and risk assessment techniques. *Financial Practice and Education*, 9(1), pp. 16-24.

Prest A.R., Turvey R. (1965) - Cos-benefit analysis: a survey, *The Economic Journal,* Vol. 75, No. 300, December, pp. 683-735.

Remer, D.S., Stokdyk, S., Van Driel, M. (1993) - Survey of project evaluation techniques currently used in the industry. *International Journal of Production Economics*, 32, pp. 103–115.

Ramsey, F. (1928) - A Mathematical Theory of Saving, *Economic Journal* 38, pp. 543–59.

Roy B. (1996) - *Multicriteria methodology for decision analysis*, Kluwer, Dordrecht.

Ryan, P., and Ryan, G. (2002) - Capital budgeting practices of the Fortune 1000: How have things changed? *Journal of Business and Management*, 8(4), pp. 355-364.

Samuelson P.A. (1936) – Some aspects of the pure theory of capital, *Quarterly Journal of Economics*, 51, pp. 469-496.

Scitowski T. (1951) – *Welfare and Competition,* Richard D. Irwin Inc. Chicago.

Seagraves J.A. (1970) - More on the Social Rate of Discount, *Quarterly Journal of Economics* , Volume 84, Issue 3 , pp. 430-450.

Sen A. (1961) - On Optimizing the Rate of Saving , *Economic Journal* , 71, pp. 479–96.

Solomon E. (1956) – The arithmetic of capital-budgeting decisions, *Journal of Business,* XXIX, pp. 124-129.

Teichroew, D., Robichek, A., and Montalbano, M. (1965) - Mathematical analysis of rates of return under certainty. *Management Science*, Vo. 12, No. 3, pp. 393-403.

Temple J.A., Reynolds A.J. (2007) - Benefits and costs of investments in preschool education: Evidence from the Child–Parent Centers and related programs, *Economics of Education Review*, Volume 26, Issue 1, Pages 126-144.

Wolff E.N., Baumol W.J., Saini A.N. (2014) - A comparative analysis of education costs and outcomes: The United States vs. other OECD countries, *Economics of Education Review*, Volume 39, Pages 1-21.

Woodhall M. (2004) – *Cost-benefit analysis in educational planning,* UNESCO, International Institute for Educational Planning, Paris.

Zhang, D. (2005) - A different perspective on using multiple internal rates of return: The IRR parity technique. *The Engineering Economist,* 50, pp. 327–335.

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