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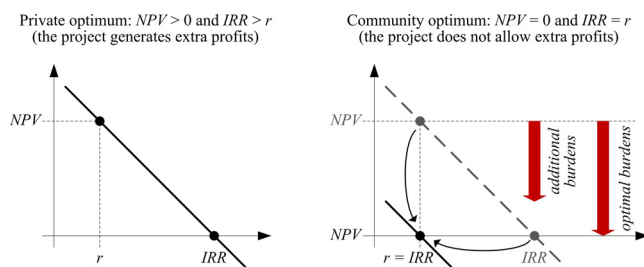
# A Discounted Cash Flow variant to detect the optimal amount of additional burdens in Public-Private Partnership transactions



Sergio Copiello\*

University IUAV of Venice, Department of Design and Planning, Venice, Italy.

## GRAPHICAL ABSTRACT



## ABSTRACT

The Discounted Cash Flow method is a long since well-known tool to assess the feasibility of investment projects, as the background which shapes a broad range of techniques, from the Cost-Benefit Analysis up to the Life-Cycle Cost Analysis. Its rationale lies in the comparison of deferred values, only once they have been discounted back to the present. The DCF variant proposed here fits into a specific application field. It is well-suited to the evaluations required in order to structure equitable transactions under the umbrella of Public-Private Partnership.

- The discount rate relies upon the concept of expected return on equity, instead than on those of weighted average cost of capital, although the latter is the most common reference within the scope of real estate investment valuation.
- Given a feasible project, whose Net Present Value is more than satisfactory, we aim to identify the amount of the additional burdens that could be charged to the project, under the condition of keeping the same economically viable.
- The DCF variant essentially deals with an optimization problem, which can be solved by means of simple one-shot equations, derived from financial mathematics, or through iterative calculations if additional constraints must be considered.

\* Corresponding author.

E-mail address: [copiello@iuav.it](mailto:copiello@iuav.it) (S. Copiello).

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## 1. Method details

### 1.1. Method description

During most of the last century, a variety of techniques and tools aimed at evaluating the feasibility of projects, from several perspectives, have been widely developed. It deserves mention, as the most notable example, the Cost-Benefit Analysis. The literature endorses that its origin lies somewhere back in time, between the second half of the nineteenth and the beginning of the twentieth-century [1], while its practice has widely spread after the Second World War. Furthermore, it has lent itself to be variously modulated, such as towards the cost-revenue analysis, rather than the cost-effectiveness investigation [2]. As another case in point, just bear in mind that the founding of the Life-Cycle Cost Analysis occurred during the mid-seventies. Originally applied within the scope of the US Department of Defense, it was meant to support the choices during the procurement process of weapons [3,4], especially jet fighters and aircraft carriers [5]. In the meanwhile, its purpose has evolved toward assessing the design, construction and operational features of a variety of goods and services, including manufacturing plants and factory buildings [6]. Moreover, it has been broadly used to compare alternatives with regard to the adoption of energy-efficient measures in the building sector [7,8].

The aforementioned techniques have a fundamental common characteristic. They adhere to the rationale of the financial mathematics, which consists in the need to discounting back to the present the values expected to occur in the future. Hence, all those analytical tools rely on the Discounted Cash Flow (DCF) method. According to Damodaran's definition [9], the DCF assumes that "the value of an asset is the present value of the expected cashflows on the asset, discounted back at a rate that reflects the riskiness of these cashflows". In his survey around valuation approaches [9], the same author identifies the origins of the method in a couple of studies dating back to the first three decades of the past century. The concept of present worth is noticed in Böhm-Bawerk [10] and Marshall [11], who indeed wrote the following sentence about a century ago: "... human nature is so constituted that in estimating the 'present value' of a future benefit most people generally make a second deduction from its future value, in the form of what we may call a 'discount', that increases with the period for which the benefit is deferred." Meanwhile, two fundamental studies by Fisher [12,13] laid the basis for the comparison rules, to which we resort in dealing with multiple alternatives to pick the best one. They are of various kinds but essentially linked to concepts such as those of the present worth and of the rate of return. Just a few years later, Boulding [14] deepened and fully developed the latter of the aforementioned concepts.

During the time span between the mid-sixties and the early seventies, the DCF approach has been progressively adopted in the theory and practice of the real estate appraisal. The literature agrees that several pioneering studies paved the way to the widespread of DCF-based estimates in the branch of property investment valuation. A significant set of these studies can be identified in those published by Downs [15], Dilmore [16] and Ratcliff [17], while a two-part article signed by Greaves [18], originating from his Ph.D. thesis, is widely recognized as the inspiration behind the adoption of DCF by the UK's appraisers. Just a few years later, the model developed by Marshall [19] marked a further advancement towards the common use of the DCF method in property investment valuations. Such a model exhibits two specific features: explicit projection of future cash flows the former; use of a risk-adjusted discount rate, which involves the concept of opportunity cost of capital, the latter. Due to

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