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EVALUATING PUBLIC POLICIES

NORMATIVE MODELS BEYOND COST BENEFIT ANALYSIS

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Imagination is more important than knowledge. For knowledge is limited, whereas imagination embraces the entire world, stimulating progress, giving birth to evolution

A. Einstein

Abstract

The subject of the thesis: “Evaluating Public Policies - Normative Models Beyond Cost Benefit Analysis” arise from the interest in the public policies and their construction, and in particular from the problem of how to evaluate them.

The thesis, after a preliminary study of tools and mechanisms for European Public Policy founds distributions, has dealt with the Evidence-Based Policy-Making (EBPM). Thus, studying EBPM’s objectives and concepts, we studied the characteristics that make legitimate policies, but also those features that make public policies “unique” investment decisions, or better that make such decisions different from all other types of decisions. These feature were then analyzed and summarized in four points:

- medium or long-term time horizon;
- several different source of uncertainty related with the policy-maker;
- great importance of the economic aspect;
- great importance of the flexibility.

The study of these has pushed the research and our thesis towards the study of the tools and the mechanisms necessary for the public policies creation, management and monitoring. Therefore, from this broad framework the thesis is focused on the study of the normative tools currently available to the policy-maker, that are:

- Cost-Benefit Analysis (CBA);
- Decision Theory (DT);
- Real Options Theory (ROT).

In the first part of the thesis we presented these three tools in relation to public policies and policy-makers decision. From that it became clear the inadequacy of the existent tools in addressing the different aspects that characterize public policies. The CBA, despite being the tool in absolute more used and recognized as legitimate, fails to take account and manage one of the four fundamental policies features, namely the policy-maker flexibility to manage the policy in all its time horizon. On the other hand, the study of DT has highlighted the inadequacy of the decision tree analysis to consider and manage public policies in real time horizons. Finally, the ROT study has made clear that despite such tool represents an important evolution from the CBA, since it is closely related to finance, it fails to take into account the policy-makers subjectivity.

In the second part of the thesis, starting from the conclusions about the relevance of the use of CBA, DT and ROT in the field of public policies, we propose a "new instrument". Such tool could be considered an evolution of the decision tree, because although it is built

like a normal decision tree it take into account the time in practical terms: not only through a policy construction and decision-making over the time, but also through the inclusion of a subjective discount rate. The subjective discount rate, derived by the utility function of the policy-makers, is able to take account their personal time and uncertainty preferences. The thesis ends with a critical comparison between the new temporal decision tree proposed and the real options theory. The critical comparison show that the two tools are different in two main aspects:

1. The real options are based on the existence of an underlying asset, which allows many simplification. Assuming that the underlying asset perfectly replicate the investment and the investment decision, it is legitimate to use the risk-free discount rate and the risk neutral probabilities, then it is always on the existence of the underlying asset that it is based the probability conditioning.

2. Temporal decision trees on the contrary do not make any of these hypothesis. There is nothing that can replicate the investment, the decision and the policy-maker. The conditional probabilities depend only on the oracle choose, and all formal construction revolve around the subjectivity and preferences of policy-makers.

In conclusion we can say that, starting from the study of public policies and their characteristics, the assessment tools currently available to the policy-makers (CBA, DT, and ROT) are incomplete. In other words, they are not able to adequately considered and managed the four key characteristics. Overcoming this problem is essential to give at the policy-makers a comprehensive assess and decision aiding tool, thus we decide to build a decision tree ad hoc for the public policies. Such decision tree was constructed following the traditional model, but it is adding both the temporal dimension and the economic concept of costs and benefits. Moreover, we have also revised and integrated some ideas related to managerial flexibility arising from the ROT. In this way, the resulting “temporal decision tree” is able to consider and manage the specific needs of the public decision-making, remaining both in the normative rationality field through the economic evaluation concepts, and in the constructive rationality field, because the tool incorporates and revolves around the subjective preference of the policy-makers and those who legitimately represent.

Riassunto

Il soggetto della tesi "Evaluating Public Policies: Normative Models Beyond Cost Benefit Analysis" nasce dall'interesse verso le politiche pubbliche e la loro costruzione; e più precisamente dal problema di come valutare tali politiche pubbliche. La tesi, dopo un preliminare studio degli strumenti e dei meccanismi distributivi dei fondi relativi alle politiche pubbliche europee (App. A), si è avvicinata al tema dell'Evidence-Based Policy-Making (EBPM). Tale avvicinamento ha portato allo studio dei concetti e degli obiettivi dell'EBPM (Cap. 2) e pertanto alla ricerca delle caratteristiche che rendono una politica legittima, ma anche quelle caratteristiche che rendono una politica pubblica una decisione di investimento "unica", ovvero diversa rispetto a tutte le altre tipologie di decisione. Tali peculiarità sono state quindi analizzate e sintetizzate in 4 punti:

- orizzonti temporali medio-lunghi o molto lunghi;
- fonti di incertezza numerose e di diversa natura legate al decisore;
- grande importanza dell'aspetto economico;
- grande importanza della flessibilità.

Lo studio di queste caratteristiche ha spinto la tesi e la nostra ricerca verso lo studio degli strumenti e dei meccanismi necessari alla loro formazione, gestione e monitoraggio. Da questo ampio quadro di riferimento la tesi si è quindi focalizzata sullo studio degli strumenti normativi di valutazione e gestione a disposizione del legislatore, ovvero:

- l'Analisi Costi Benefici (CBA);
- la Teoria Decisionale e dell'Utilità attesa (DT);
- la Teoria delle Opzioni Reali. (ROT).

Nella prima parte della tesi abbiamo quindi presentato lo studio di questi tre strumenti in relazione alle politiche pubbliche e alle decisioni del legislatore. Da questo studio è emersa chiaramente l'inadeguatezza dei tre strumenti nel fronteggiare i vari aspetti caratterizzanti le politiche pubbliche. La CBA, nonostante sia lo strumento in assoluto più utilizzato e riconosciuto come legittimo, non riesce a tener conto e gestire uno dei quattro aspetti fondamentali, ovvero la flessibilità del legislatore nel gestire la politica in tutto il suo orizzonte temporale (Cap. 3). Dall'altro lato, lo studio della DT ha messo in evidenza l'inadeguatezza dello strumento principe di questo settore, ovvero gli alberi decisionali, di considerare e gestire le politiche pubbliche negli orizzonti temporali concreti (Cap. 4). Infine, lo studio della ROT ha esplicitato come nonostante lo strumento sia un'importante evoluzione della CBA, essendo fortemente legato alla finanza, non riesca a tener conto della soggettività del decisore (legislatore) (Cap. 5).

Nella seconda parte della tesi, partendo dalle conclusioni a cui siamo giunti in merito alla pertinenza dell'uso della CBA, DT e ROT nel campo delle politiche pubbliche, proponiamo e mostriamo un "nuovo strumento" (Cap. 6). Tale strumento può essere considerato un'evoluzione degli alberi decisionali, in quanto pur essendo costruito come un normale albero tiene conto del tempo in maniera concreta: non solamente attraverso una costruzione della politica e della decisione nel tempo, ma anche attraverso l'inserimento di un tasso di sconto soggettivo. Il tasso di sconto soggettivo ricavato mediante la funzione di utilità del decisore (legislatore) è in grado di tener conto delle sue personali preferenze sia sul tempo che sull'incertezza.

La tesi termina poi con un confronto critico tra il nuovo albero decisionale temporale proposto e la teoria delle opzioni reali. Tale confronto critico mostra che i due strumenti si differenziano sotto il profilo formale per vari aspetti:

1. Le opzioni reali si basano sull'esistenza di un asset sottostante, che permette una serie di semplificazioni. Partendo dall'ipotesi che l'asset sottostante replichi perfettamente l'investimento e la decisione d'investimento, si passa poi all'utilizzo del tasso di sconto risk free e quindi all'uso di probabilità neutrali al rischio, ed è sempre sull'esistenza dell'asset sottostante che si basa il condizionamento delle probabilità successive.

2. Gli alberi decisionali temporali al contrario non fanno nessuna di queste ipotesi. Non esiste nulla che possa replicare l'investimento, la decisione ed il decisore, le probabilità condizionate dipendono dall'oracolo e tutta la costruzione formale ruota attorno alla soggettività e alle preferenze del decisore.

Concludendo possiamo dire che, partendo dallo studio delle politiche pubbliche e delle loro caratteristiche intrinseche, gli strumenti di valutazione attualmente a disposizione del legislatore (CBA, DT, ROT) sono incompleti. Ovvero, non riescono a considerare e gestire adeguatamente e contemporaneamente le 4 caratteristiche fondamentali considerate. Superare questo problema è fondamentale per dotare il legislatore di uno strumento completo di valutazione e di aiuto alla decisione, pertanto abbiamo pensato di costruire un albero decisionale ad hoc per le politiche pubbliche. Tale albero decisionale è stato quindi costruito seguendo il modello del tradizionale, ma aggiungendo sia la dimensione temporale sia il concetto economico di costi e benefici. Inoltre, sono state anche rielaborate ed integrate alcune idee legate alla flessibilità manageriale provenienti dalla teoria delle opzioni reali. In questo modo, il risultante "albero decisionale temporale" è in grado di considerare e gestire le specifiche esigenze della decisione pubblica, rimanendo sia nell'ambito della razionalità normativa attraverso i concetti di valutazione economica, sia nell'ambito della razionalità costruttiva, poiché lo strumento ingloba e ruota attorno alle preferenze soggettive del decisore e di coloro che legittimamente rappresenta.

Résumé

Le sujet de la thèse “Evaluating Public Policies: Normative Models Beyond Cost Benefit Analysis” a été originé par l'intérêt vers les politiques publiques et leur construction; plus précisement par la question de l'évaluation de ces politiques publiques. La thèse, après avoir etudié les instruments et les mécanismes distributives de fonds liés aux politiques publiques européennes (Annexe A), a abouti le thème de l'Evidence-Based Policy-Making (EBPM). Ce rapprochement a porté a l'étude de concepts et objectifs de l'EBPM (Chapitre 2) et par conséquent à la recherche des caracteristiques qui rendent une politique légitime, mais aussi celles qui la rendent une décision d'investissement “unique”, c'est à dire différents par rapports à toutes les autres types de décision. Cettes particularités ont été analysées et synthétisées en 4 éléments:

- horizons temporels de moyenne-longue durée ou très longues;
- nombreuse sources d'incertitude de nature variable lié au décideur;
- grande importance de l'aspect économique;
- grande importance de la flexibilité.

L'étude de ces caracteristiques a poussé la thèse et notre recherche vers l'étude des instruments et mécanismes nécessaires à la formation, géstion, monitorage des politiques publiques. À partir de ce vaste cadre de réference la thèse s'est concentré sur l'étude des instruments normatifs à disposition du législateur pour l'évaluation et la gestion des politiques, c'est à dire:

- l'Analyse Coût Bénéfice (CBA);
- la Théorie Décisionelle et de l'Utilité Attendue (DT);
- la Théorie des Options Réelles (ROT).

Dans la prémière partie de la thèse donc nous avons présente l'étude de ces trois intruments par rapports aux politiques publiques et aux décisions du législateur. Cette étude a montré que les trois instruments sont inconvenables d'aborder les aspects caractérisant les politiques publiques. L'analyse CBA, bien que soit l'instrument le plus utilisé et reconnu comme légitime, n'abouti pas à considerer et gérer un de quatre aspects fondamentals, c'est à dire la flexibilité du législateur dans la géstion de la politique pendant tout son horizon temporel (Chapitre 3). D'autre part, l'étude de la DT a souligné l'inconvenabilité de l'instrument principal de ce secteur, c'est à dire les arbres de décision, de considerer et gérer le politiques publiques dans les horizons temporels concrets (Chapitre 4). Finalement, l'étude de la ROT a explicité comment cet instrument, malgré il soit un important évolution de la CBA, en étant fortement lié à la finance, ne réussi pas à considerer la subjectivité du décideur (législateur) (Chapitre 5).

Dans la deuxième partie de la thèse, en partant des conclusions auxquelles nous avons abouti par rapport à la convenabilité de l'utilisation de CBA, DT et ROT dans le cadre des politiques publiques, nous proposons un "nouveau instrument" (Chaapitre 6). Cet instrument peut etre consideré une évolution des arbres décisionnels vu qu'il tien compte du temps de manière concrète: pas seulement par une construction de la politique et de la décision dans le temps, mais aussi à travers l'insertion d'un taux de remise subjectif. Le taux de remise subjectif obtenu au moyen des fonctions d'utilité du décideur (législateur) est capable de considérer ses personnelles préférences soit sur le temps soit sur l'incertitude.

La thèse termine avec une comparaison critique entre le nouveau arbre décisionnel proposé et la théorie des options réelles. Cette comparison critique montre que le deux instruments sont différents du point de vue formel sous différents aspects:

1. Les options réelles sont basées sur l'existence d'un asset sous-jacent, qui permet de faire des simplifications. En partant de l'ipothèse que l'asset sous-jacent réplique parfaitement l'investissement et la décision d'investissement, on passe dépuis à l'utilisation du taux de remise risk free et donc à l'utilisation de probabilités neutre au risque, et le conditionnement des probabilités successives est toujour basées sur l'existence de l'asset sous-jacent.

2. Les arbres décisionnels temporels au contraire ne font pas ces ipothèses. Rien peut éxpliquer l'investissement, la décision et le décideur; les probabilités conditionnés dépendent de l'oracle et toute la construction formale tourne autour de la subjectivité et des préferences du décideur.

En concludant on peut dire que, à partir de l'étude de politiques publiques et de leur caractéristiques intrinsèques, les instruments d'évaluation à disposition du législateur (CBA, DT, ROT) sont incomplèts. C'est à dire qu'ils ne considèrent ni gèrent de manière appropriée et au meme temps les 4 caractéristiques fondamentales considérés. Surmonter ce problème est cruciale à fin que le législateur aie un instrument complèt d'évaluation et d'aide à la décision, pourtant nous avons pensé de construir un arbre décisionnel ad hoc pour les politiques publiques. Cet arbre décisionnel à été construit donc en suivant le modèle du traditionnel, mais on ajouté soit la dimension temporel soit le concept économique de coûts et bénefices. En plus, on a re-élaboré et integré des idées liées à la flexibilité manageriale provenant de la théorie des options réelles. De cette façon, le résultant "arbre décisionnel temporel" est en mésure de considérer et gérer les exigences spécifiques de la décision publique, en restant soit dans le milieu de la rationalité normative à travers les concepts d'évaluation économique, soit dans le milieu de la rationalité constructive, du moment qu'il inglobe et il tour autour de préferences subjectives du décideur et des ceux qu'il représente légitimement.

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CHAPTER 1

Introduction

1.1 Introduction

> *"It is change, continuing change, inevitable change, that is the dominant factor in society today. No sensible decision can be made any longer without taking into account not only the world as it is, but the world as it will be."*
>
> (Isac Asimov, 1920-1992)

Decision-making is the most common activity of our life. However, in an increasingly complex world, as that in which we live, it is not an easy task. We make several decisions every day, but such do not all have the same importance. Deciding to buy a new pair of shoes is quite different from deciding to build a new highway. The second decision is probably more complicated than the first is because it will have a greater impact and the decision will not affect only ourselves. In such more complicated situations we look for insight, we ask for suggestions and plus we value the pros and the cons. In practice, we need *evidence* to support risky decisions in order to claim that that decision is the best possible under certain circumstance. Evidence is information (we will discuss in a more systematic and detailed way this concept in chapter 2), but information that comes from a purposeful and systematic research [69]. Combining such information with experience, judgement and expertise we try to reduce errors, and improve the decision-making process.

This is especially true when the decisions' consequences have a wide social and economic impact. Very often such decisions are taken by governments or other administrative bodies. In such cases we refer to these situation as "Public Policies"(PP). Public policies involve more subjects, more decision-making levels, multiple fields and also multiple goals. In a public framework we have more problems and constraints than in a private. For such, public policies are considered very important. In fact, over the past 70 years PP became a specific field of study: "the public policy analysis".

Within the last decades more emphasis has been put on the need for an evidence-based policy (EBP). EBP is based on the *modernist* faith in progress informed by reason (rational analysis). Although the rationalist assumptions of Evidence-Based Policy Making (EBPM) have been challenged from a constructivist and a post-modernist perspective, it is argued that the attempt to ground policy making in reliable knowledge of *"what works and why"* retains its relevance and importance [241, 178]. Transparency of decision-making is imperative in the field of PP. Placing more emphasis on developing a sound evidence base for policy through long term impact evaluations of actions and programmes becomes central. It is argued from a realist position that such evaluation should be theory-based and focused on explaining and understanding how policy investments achieve their effects. Consequently talking about PP implies talking about its persuasive appeal.

Thus:

→ How to build public policies?

→ What kind of decision support?

→ What kind of model?

In this thesis we will try to answer such questions.

1.2 Why this research?

If made a decision is so complex, *"How we can help the policy maker to make decisions?"*
This is the question from which our research was started. This question lies at the heart of the current debate on Evidence-Based Policy Making (EBPM) that came out in the early 1990s, and has gained political currency since 1997 under the Blair administrations. From that moment many governments, in the last fifteen years, have focused their attention on the process, the mechanism and the tools used to decide which actions are better in order to build a policy that will be able to achieve their goals. Under this new trend, when concerns are on policies and therefore on expenditures effectiveness and efficiency, accountability becomes crucial. Thus, the growing demand of accountability had led to a steady increase in the use of analytic and often quantitative techniques in order to assist in resource allocation and aim in the policy-making process.

The European Union (EU)(see App.1) like any other governing body has been involved in this trend. Studying how the EU builds its policies and manages its founds we have learnt that there are no specific process or tools to assess quantitatively and also qualitatively the policies before they are implemented, neither at the top or at the bottom level. In the EU the only evaluation tool approved and formally applied just in particular cases is the Cost-Benefit Analysis (CBA). Indeed, in many sectors, although, the CBA limitations are recognized, it is considered the best way to evaluate such kind of investment [34]. However, we have a different point of view. We do not believe that this tool is the most appropriate. CBA, despite the undoubted merits and despite being a step forward compared to the sole discretion of the directors, does not allow the development of a coherent decision-making process. Process that becomes crucial in situations dominated by risk and uncertainty, and where the data and information are constantly evolving. Moreover, we believe that such situation introduces a *perverse* mechanism according to which there are no alternatives to choose from, distorting in this way the entire decision-making process.

The Evidence-Based Policy Making, accountability and decision aiding tools are composed of techniques based on a kind of "analytic rationality", thus on assumptions that are

the core of our research, and that are the basics of our research contribution. In fact, we believe that in public context and in public policies there is a need for a rational process, and a tool in order to support it. It is within this framework that our research will fit, it will suggest a "new" process tool that combine the different features proper of public policy environment. A process that will help policy makers at various levels, but focusing mainly on the alternatives construction and evaluation.

In literature it is possible to find theories and tools that have studied and analyzed these issues, but not all together and especially not in a public context, within its specific characteristics. The most relevant theories for us are the following:

→ *Cost-Benefit Analysis(CBA)*
that we want to use as a benchmark for our analysis, and also the starting point in order to introduce the normative rationality (like the economic) and normative tools.

→ *Decision Theory (DT)*
that we want to use as general decision framework that we consider in order to give form and shape to the most constructive and process aspect of our hypothesis. Moreover, in this context we propose to use the Decision Tree Analysis (DTA) and the Bayesian probability.

→ *The Real Option Theory (ROT)*
that we want to use in order to overcome the CBA, although without a complete change of the theoretical and normative assumption. In this way, we can incorporate the managerial flexibility, while being supported by a clear economic instrument.

Before concluding this chapter, in the following we want to present briefly what the *rational decision-making* means for us. Then, we will show the four possible rationality approach: "Normative", "Descriptive", "Prescriptive" and "Constructive", whit their assumptions in order to explaining why, in this environment, we prefer the normative and constructive.

1.3 Rational Decision Aiding Approaches

Define *rationality* with its multiple perspectives is not trivial. In fact, the concept of rationality, that we intuitively look for, that we use every day in common speech it is rather elusive, and its meaning is rarely questioned. In philosophy, the rationality is defined as the exercise of reason [110], and talking about *analytic rationality* means using reason in a scientific way (scientific method). For such reason we claim that the rationality is strictly related with consistency and logic. Watson and Buede [302] said that, if I assert that A implies B, and also that B implies C, then I presumably assert that A implies C. It is irrational to do otherwise or better it is inconsistent.

Said that, what is the *rational decision-making*? Usually, we believe that the decision-making is good if it is rationally done, because in face of complexity, uncertainty, conflicting objectives, and multiple decision-makers, this is the only way in order to consider all this kind of problems. The intuitive approach is to define a good decision as a rational one, but defining the rationality as we have done, it means making every decision using a rational approach.

In decision theory and decision aiding literatures ([20, 37, 94, 144, 237, 238, 73]) we may find reference to four types of rational approaches: "Normative", "Descriptive", "Prescriptive" and "Constructive". Each of these approaches is consistent and logical but they are built on different assumption. In order to describe such approaches we quote the definitions given by Dias and Tsoukiàs in their paper [73]:

- **Normative Approaches**
  "Normative approaches derive rationality models from norms established a priori. Such norms are postulated as necessary for rational behavior. Deviations from these norms reflect mistakes or shortcomings of the decision-maker who should be aided in learning to decide in a rational way. These models are intended to be universal, in that they should apply to all decision-makers who want to behave rationally. As an analogy, we may consider ethical norms, laws and religious norms. For more details the reader can see the following classics: [90, 91, 299, 170, 231, 244, 301]".

- **Descriptive Approaches**
  "Descriptive approaches derive rationality models from observing how decision-makers make decisions. In particular, these approaches may link the way decisions are made with the quality of the outcomes. Such models are general, in that they should apply to a wide range of decision-makers facing similar decision problems. As an analogy, we may consider scientists trying to derive laws from observed phenomena. For more details the reader can see: [6, 132, 139, 140, 192, 193, 229, 275, 292, 293, 300]".

- **Prescriptive Approaches**
  "Prescriptive approaches discover rationality models for a given decision-maker from his/her answers to preference-related questions. Modelling consists in discovering the model of the person being aided to decide, i.e. unveiling his/her system of values. Therefore, the models do not intend to be general, but only to be suitable for the contingent decision-maker in a particular context. Indeed the decision-maker can be in difficulty trying to reply to the analyst's questions and/or unable to provide a complete description of the problem situation and his/her values. Nevertheless, a prescriptive approach aims to be able to provide an answer fitting at the best the decision.maker's information here and now. As an analogy, we may consider a physician

asking questions to a patient, in order to discover his illness and prescribe a treatment. For more details the reader can see: [21, 142, 161, 294, 296, 298, 304]".

- **Constructive Approaches**
  "Constructive approaches build rationality models for a given decision-maker from his/her answers to preference-related questions. However, the "discussion" between the decision-maker and the analyst is not "neutral" in such an approach. Actually such a discussion is part of the decision aiding process since it constructs the representation of the decision-maker's problem and anticipates, to some extent, its solution. If, while talking on what to do tonight, we ask the question "where to go this night?" we implicitly do not consider all options implying staying at home. If we ask "who to meet?" we implicitly do not consider all options involving staying alone. Structuring and formulating a problem becomes as important as trying to "solve" it in such an approach. Recent real world applications (see for instance [15, 217, 270]) do emphasize the importance of supporting the whole decision aiding process and not just the construction of the evaluation model. Modelling under this approach consists in constructing a model for the person being aided to decide, suitable for that contingent decision-maker and his/her particular context. As an analogy, we may consider a designer or an engineer tentatively developing a new car. For details the reader might see: [51, 98, 109, 158, 159, 160, 236, 237, 245, 303]".

1.3.1 Differences

As Bouyssou et Al. [38] and Dias and Tsoukiàs [73] said we may divide these approaches in two groups. On the one hand normative and descriptive approaches use general models of rationality, established independently from the subject and the decision process. On the other hand, prescriptive and constructive approaches derive a model for the rationality of the contingent subject. Between normative and descriptive models the difference is mainly due to the process of obtaining the model. Normative models are based on economic considerations, while descriptive models are based on empirical observation. In the first case we focus on how decision-makers ought to decide, while in the second case we focus on how decision-makers actually make decisions. Then, the difference between prescriptive and constructive models is mainly due to how the model is obtained. In prescriptive models analyst believe that in the decision-maker a system of values exist before that the decision aiding process starts, while in the constructive models the analyst do not assume that preferences pre-exist, but let the decision-maker construct his/her system of values as the model is being constructed, because one construct is linked from the other. Indeed, the final model has to be validated through a consensus between the decision-maker and the analyst.

Despite such difference, usually in practice, an analyst use more than one approach, and not as in a manual theory. As said Dias and Tsoukiàs [73]:

> *"Normative approaches might be used with weaker versions of their axiomatics or adopting a more qualitative version (see for instance [78, 77]) knowing that this is empirically grounded. At the same time one adopting a prescriptive or a constructive approach might decide to introduce and fix a dimension of rationality in order to ease the dialogue with the DM and "force him/her" to accept a certain point of view (see for instance [142]). Such interactions between the approaches can be better understood when decision support tools come into practice (see also [21])."*

1.4 Research goal

This research arises from the need to support a public decision, and give to decision-makers a tool able to "design", "evaluate" and "implement" public policies. In fact, public decisions are so complex that just considering all these three dimensions together it is possible to achieve concrete results. However, since public policies are a particular field of studies with specific characteristics as:

- medium/long-term time horizons;
- many sources of uncertainty;
- importance of the economic aspect;
- high degree of flexibility;

and goals as:

- the increase in social welfare (which includes: health, safety, environment, economy, work, etc.);
- political stability;
- international relation;
- chance of being re-elected;

traditional decision aiding tools are inadequate and insufficient. We believe necessary a specific tool able to consider all that. Moreover, for public decision-makers will be useful to have a decision aiding tool able to identify and incorporate changes that have occurred in politics in recent years; from the introduction of a paradigm of Community programming, to the introduction and evolution of the concept of evidence-based policy-making (EBPM).

In fact, these changes require that public decisions are supported by legitimate "evidence", or to be more precise that public decisions are recognized as valid by the community in which they are. In this sense we talk about Habermas' communicative rationality [110], where the legitimacy is build through the agreement of everybody, one things is recognized as legitim because the community as whole has decide that.

In the light of that, our research want fit itself within the EBPM context, and thus its primary goal is to suggest a process-tool able to construct *"normative and constructive legitimation"*. With this term we want to indicate the possibility of having a decision-making process-tool, that builds itself on the assumptions of two approaches: normative and constructive. The tool that we suggest joint these two approaches combining a decision tree (tool typically used with a constructive rationality) with some principles and ideas originating in cost-benefit analysis and real options theory (economic tools based on a normative rationality). In this way we will have a tool whose characteristics are selected specifically to aid the public policy-maker, in a context where economic aspects are very important, as the managerial flexibility, or the ability to consider new information, constraints and changes, but where the decisions must be and must remain a political matter.

1.5 Plan and Overview of the research

Our research started studying the European Union programmes (Appendix A), then we focused on its decision system and on its evaluation tools. At the same time we studied the new European trends on policy construction and policy evaluation, focusing on evidence-based policy-making (chapter 2). Understood its principles and characteristics we decided to study the evaluation tool most used both in general and political context, namely the cost-benefit analysis (chapter 3). Studying this tool we have been able to understand its strengths and weaknesses, therefore we looked for other tools able to overcame such weakness in the light of public policies characteristics and goals. The tools that better seemed fit in our needs were: the decision theory and the real options theory. Analyzing the decision theory (chapter 4) and the real options theory (chapter 5) we understood that in public policies we must work with both e with neither. In other words, we understood that we must take something from both and "build" a new tool using such things together, in a rational perspective both normative and constructive. Finally, we theoretically built a "new tool" with all these characteristics (chapter 6), showing its capability and its differences from the existing tools.

Chapter 2: Public Policies and Evidence-Based Policy-Making
The aim of this chapter is to give an overview of concepts and notions of public policies and evidence-based policy-making. We introduce some public policies definitions, highlighting its most important characteristics and its goals. We analyze the concepts and the hypothesis

of evidence-based policy-making showing because this is very important in building and assessing public policies. Concluding, we discuss about its importance in this thesis and in which way its has influenced the research development.

Chapter 3: Cost-Benefit Analysis (CBA)
The aim of this chapter is to explain because the cost-benefit analysis has become so known and important in public assessment. What are the characteristics that make the CBA the most used and credited tool, and because such are important in our research. We start from its definition and history, then its principles and assumptions. Moreover we show some different approaches, and models. Finally, we discuss the limitations and criticisms moved against the cost-benefit analysis.

Chapter 4: Decision Theory (DT)
The aim of this chapter is to give an introduction to the Decision Theory (DT) by presenting some important notions and definitions. The first part is dedicated to a model of the "Decision Aiding Process", where we show the interactions between a decision-maker and an analyst. The second part deals with some basic elements of decision theory such as: problem statement, alternatives and criteria. Moreover, we present the "Value-Focused Thinking" by Keeney in relation to the importance of having a good and complete set of alternatives. In a third part we talk about decision tree analysis, subjective probability and information value. Finally, we discuss about some limits and problems of the decision theory.

Chapter 5: Real Options Theory (ROT)
The aim of this chapter is to give an explanation about what the real options theory is, which are its basic ideas and especially what makes the real options so interesting. We do that introducing the principles of real options theory, and presenting important definitions and notions. The first part is devoted to the description of the "theory", while the second part deals with the options evaluation models, such as: Black-Merton-Scholes equation, and binomial or trinomial lattice. Finally, in the last part we discuss about some limits, critiques and our interest about real options.

Chapter 6: Decision Theory and Real Options Theory in Literature The aim of this chapter is to show at the reader how CBA, DT and ROT have been seen and studied together during the last twenty years. We present the literature about these tree tools, showing the authors and their thought on the similarities, differences, and possible joint applications between them. In order to do that straightforward we present authors and theories divided by belonging fields. Whit this chapter we try to write at the same time a kind of conclusion for the first part of the thesis, and a natural introduction at the second, where we will present

our proposal. Namely, we will explain our thought and our ideas on the combined use of DT and RO.

Chapter 7: Decision Theory and Real Options Theory The aim of this chapter is to present our research idea, and so our model. We start showing the literature where decision theory and real options theory have already been studied together. Then, we will present and explain our idea and our model, where a decision tree will be developed using some ROT elements. In this way we will show how our idea, which, although not entirely new, introduces some important characteristics at the decision aiding tool. In order to do that we present two example the first with perfect information, and the second without it, and so introducing the use of conditional probabilities. Finally, we conclude by explaining the differences between our model and those already existing.

CHAPTER 2

Public Policies and Evidence-Based Policy-Making

2.1 Introduction

As anticipated this is an introductory chapter, it is important in order to understand the starting point of our reflections, but also our aims and motivations. In this chapter we will present public policies, public decisions and many other topics related to them, as the evidence-based policy-making. Moreover, in order to be as comprehensive as possible we will briefly discuss many decision-making and behavioral theories but not only. Therefore, we suggest to read this chapter firstly as in itself and secondly as placed into a wider context, namely in this thesis.

Policy is all around us, and directly or indirectly, it influences many aspects of our life. Beginning with an intuitive approach we can define policies as shapeless objects, modelled by politics, where a set of interrelated actions aims to achieve a set of multiple and interrelated goals in a period of time. Making decision is always complex, but in a public context it is possibly more complicated. Actually, in public policy context the "decision process" or "policy cycle" [163] (we will use them without distinction) has a very specific nature that sets it apart from every other decision process. First, because this policy cycle consists in a set of decision processes linked by main goals, resources, areas of interest or involved stakeholders. Second, in a public context, considering laws, rights and the governance principle it is difficult to identify the person or persons who will have the power to decide, so who is the policy-maker or policy-makers. Third, usually many issues are ill defined, goals are not clear, the stakeholder are many and difficult to detect. Forth, actions and policies are interrelated, and so their consequences. Consequences belonging to the same policy cycle, but also seemingly very distant and disconnected. Fifth, the factor time must be introduced. Public policies to be effective and to solve problems in a comprehensive and organic manner need a strategic and long-term approach, but this long-term is in contrast with the short term of legislation. In such the risks and uncertainties are high and difficult to manage [295].

In the last years the context became more complex: in fact, participation and "bottom up" actions become frequent and often due. Citizens, thus, becoming an active part in policies, they do not wait that some obscure decisions fall top down, but they want to know and to be informed on the government decisions and actions. They claim to receive explanations before accepting decisions, they are not subjects but active parts of democracy and, in this sense, accountability becomes crucial. That's why policy-making now more than ever should be accountable and "evidence-based" rather than based on unsupported opinions difficult to refute. Hence, the transparent relation between decision makers and stakeholders becomes fundamental in order to conquer and preserve consensus. Thus, policies became instrument "to exercise power and to shape the world" [102].

In 1997 the concept of Evidence-Based Policy-Making (EBPM) has been introduced, in modern form, by the Blair government [28]. EBPM is an acronym considered to be self-explanatory, but is it?. The idea of creating policies on the basis of available knowledge and research on the specific topic is not new and is generally acceptable. However, we need to deepen the concept and its peculiarity in order to understand better what it means exactly. First of all, what is evidence? According with the Oxford English Dictionary, evidence means "available body of facts or information indicating whether a belief or proposition is true or valid". This definition it is enough clear and univocal? And what does it mean this highlight given to evidence? It is sure that evidence counted also before as a variable to decide. In which sense now its contribution is different?

EBPM has been defined as the method or the approach that "helps people make well informed decisions about policies, programmes and projects by putting the best available evidence from research at the heart of policy development and implementation" [68]. It is important to point out that the scope of EBPM is to help and "inform the policy process, rather than aiming directly affect the eventual goals of the policy" [274]. In other terms we can say that EBPM is nothing more from "the integration of experience, judgement and expertise with the best available external evidence from systematic research" [69]. That said, it is considered evidence all data from past experiences, all information and good practices from literature review. This is certainly important and necessary, but is it also sufficient to make a good policy? For us, the central role is played by the policy decision process and not by the decision (policy) itself. Thus, in order to support such complex decision process we think more useful having something that consider the policy cycle as a whole, able to support the accountability requirement.

Davies [68, 69] and Gray [106] claim that the introduction of such a way of thinking produces a shift away from *opinion-based* decision making towards *evidence-based* decision making. In this new context the decisions are based on the opinions and judgements of experts. This shift is not easy because on one hand it needs to change established habits and more generally a whole way of understanding the politics, and on the other hand there are some constraints. One of this constraints it is the time factor, which becomes crucial in order to get sound policies, based on evidence, rather than on other factors. When policy makers are aware of a problem to solve, they're requested to act rapidly and then their actions are usually opinion-based and not scientifically or rationally founded. Policies are often based on the need to face as soon as possible the problem, but sound evidence needs a fitting time to be built; only then, policymakers can build rational and evidence-based policies.

Moreover, in this distinction between *opinion-based* and *evidence-based* decision making EBPM is viewed as an a-political, neutral and objective method to decide, but this statement is controversial. In fact, we know that data could be manipulated, the interpretations are subjective and that good practice are strictly linked with its specific framework, and

intuitively concepts, values, preferences and at least decisions should remain a political fact.

2.2 Public Policy

Speaking about public policies , it is important to understand that the concept of public policies should be enough wide and abstract in order to adapt itself to various applications and contests. For such reasons, over the past 50 years many definitions have been coined to define them. Such definitions have different meanings because the authors bring into focus different aspects as process, subjects, objects and decision levels [81, 136, 79, 9, 119, 151]. Starting from the above definitions, we can identify six main characteristics of PP:

- relations between multiple subjects,
- different institutional levels
- duration over time
- use of public resources
- decision/no-decision
- consequences

These features do not have always the same relevance: in different contexts these characteristics assume different undertones and worth in order to highlight and specify the alternative foundational concepts, relevant for each specific aim.

In our specific contest we want to underline that every public policy is a process that implies a set of decisions in a public context; thus, it is a public decision process. This process is developed over a period of time and involves different decisional levels, each one of them interacts with the others with respect to a set of determined rules. The process and the related interactions are developed in order to solve a problem having characteristic of public issue, or rather a problem in which resources and rationality are public. The concept of "public issue" is not always clear: the issue that the policy will face is a sign which conveys meaning. Giving the name to a public policy is the action of defining a signifier and it implies the legitimation of the signified. Thus, every subject affected by the policy-makers, experts and citizens, stakeholders make-up his own meaning of the policy, legitimated by its name and definition. In this context, a public decision is a public choice and it implies an allocation of public resources. Even no-action in a determined field is considered a policy because it implies the public choice of maintaining the same resource-allocation than before. Speaking about public resources, governments/public subjects have

to make understandable how and why they use public resources in order to solve problems. The public decision process is requested to be accountable to the public in contrast with the complexity of the entire process. Thus, we need an operational definition able to summarise the characteristics introduced:

"We consider a public policy as a portfolio of actions aiming at achieving a number of objectives settled by the public decision maker, considered as an organisation".

In the concept of public policy as defined above we want to highlight that policy has a meaning for the stakeholders affected by the policy itself and for the citizens in general. In fact, it not only pursues quantifiable objectives, but it generates a legitimation space, thus producing inclusion and/or exclusion.

2.3 Public Deliberation, Legitimation and Accountability

The main feature which helps to distinguish a public decision process from other decision processes is *"public deliberation"*: the outcome of the decision is a public issue, a public authority must communicate it, the public must know. The publication of an official document which defines and explains the policy is the act that produces the wanted and unwanted outcomes and reactions to the decision. The intermediate and the final act explain the motivations and the causes of that policy. Public deliberation is also expected to increase accountability of the public decision process and of the public authority itself and, to some extend, their legitimation to the general public or stake-holders.

Linked to deliberation, we find two concepts, recently used in the field of public policies: "Legitimation" and "Accountability". Legitimation and accountability are integral parts of the relations established between stakeholders. Moreover legitimation and accountability are fundamental in the creation, evolution and maintenance of a conceptual social space (to know more about this space, also called "action arena" or "interaction space" see: [211, 210]), where stakeholders interact creating relation, goods, service, but above all develop and define their rationality [108].

Speaking about *legitimation* we refer to authorisation and consensus. The need for legitimisation born from the relative dimension of power, that make it frail in terms of collective acknowledgement. In fact, political power doesn't get identification and legitimation from a transcendent order; thus, the recognition of its value and so the collective acknowledgement becomes an immanent issue, which has been faced and solved in the framework of public policies and within their criteria. On the one hand the legitimacy of the public action and its decisions, comes from the law, which gives to the elected the power to decide with authority and to manage public resources. On the other hand, legitimation (this concept is considered orthogonal to legitimacy, but not exclusive) is given by consen-

sus on the rationality of action and on the decision process itself. Thus, what is important and legitimising is rationality.

Which kind of rationality could be legitimising in the field of public policies? The concept of rationality is not forthright, neither trivial as it seems. In research, have been identified many forms of rationality, no-one of them is valid or right and no-one is false, but all of them aims at validity claims [108]. There are three main approaches to rationality (these approaches are "different" from those shown in the previous chapter because here we talk about public policies while before we talked about decision-making in decision theory) :

- economic rationality (homo economicus),
- bounded rationality [255],
- communicative rationality [108].

Considering that public policies are characterised by complexity and there are several non homogeneous stakeholders, we consider that an over-simplification is not allowed, thus we adopt the communicative rationality, the only one which contemplate multiple rationalities. The concept of multiples rationalities has been introduced first by Max Weber [305]; Habermas bring to it the idea that there are four kinds of "validity claims" linked to different rationalities which are:

- to truth,
- to meaning,
- to normative rightness,
- sincerity or to truthfulness.

The existence of multiple rationalities implies that the evaluation in the context of public policies can and should face this feature of complexity, through the modification of some of its usual hypotheses. When we suggest that evaluation can be considered as a decision-aiding process, it implies that the constructivist approach could internalise the multiple rationalities assuring legitimation to the policy-making process, so to decision.

Talking about *accountability* we refer to openness and transparency: public administrations can, should and sometimes must show and justify the reasons that bring to a decision, to some policy or any allocation of public resources: the 2008 EVALSED guide of European Union [133]defined it as:

> *"Obligation, for the actors participating in the introduction or implementation of a public intervention, to provide political authorities and the general*

public with information and explanations on the expected and actual results of an intervention, with regard to the sound use of public resources. From a democratic perspective, accountability is an important dimension of evaluation. Public authorities are progressively increasing their requirements for transparency vis-a-vis tax payers, as to the sound use of funds they manage. In this spirit, evaluation should help to explain where public money was spent, what effects it produced and how the spending was justified. Those benefiting from this type of evaluation are political authorities and ultimately citizens."

We want to highlight that the European Union definition put stress on the concept of accountability as an avoidable dimension of evaluation, from a democratic point of view. This statement make us come back to the concept of legitimation and let us understand that these two concepts are integral part of the same matter. The definition also emphasises that evaluation should aim at helping the accountability of public policies: which are the public resources used and how they are managed, what are the effects of the implemented policy, why do the policy-makers choose for one alternative among others.

We want to add that this aspect of legitimation and accountability is mostly overlooked by existing evaluation models and tools. Actually, they are focused on "retrospective evaluation" aimed at analysing outcomes and processes with a learning purpose, in order to improve future applications; not in order to justify and support the decision. In this framework we will propose to evaluate the policy-making process as a decisional one, being oriented to rationality.

2.4 Evidence-Based Policy-Making: An Overview

2.4.1 Premises

"Evidence-Based Policy-Making" (EBPM) is a "new" topic that pervades the last decade of social sciences' debates. Of course there is nothing new in the idea of using "evidence" to found decisions. As far back as Aristotle claims that decisions should been informed by knowledge. Later, this way of thinking and acting has dug its deeper roots in the Enlightenment age, it has created several philosophical movement as "positivism", "neo-positivism" and "post-positivism", until "constructivism". When the idea of scientific method and process has been stated, the commitment to change and improve the world through the application of reason became crucial [241]. In such movements, the interest towards the use of knowledge, as rational and logical reasoning has grown until the second half of the XX Century, when rational and logical reasoning are intended both as the relationships between cause and effect [76], and also as the ability to rank all known available alternatives [212] (see also [37, 38]). At the beginning the concept of rational decision was central both for the economic dimension of problem solving and the scientific management of enterprisers

[291].

It was during the II World War, that for the first time this scientific approach has been used in order to support military and intelligence activities. In this contest the idea that decision making can be studied in a scientific and rational way arose. From such premises, since the 40's, science and policy started to be studied within the same framework. It was considered possible to use a scientific method to improve policy-making, in order to pursue social perfection. One of the most important figure in this field is Harold Lasswell, who was committed to the idea of a "policy science democracy" [162, 164, 167]. During the '60s and '70s, the faith in science and rationality grew up until its highest point. At that moment anything rational was considered achievable, and any problem was considered solvable if it can be managed in a rational and scientific way. This is part of a more wide movement: the "post-positivism", built as an evolution from the "positivism" (see Comte [57, 58]and Saint-Simon [70]), which involved the whole Europe in the nineteenth century.

Speaking about policy and public administration it is important to underline that in 1963 James Buchanan and Gordon Tullock organised a conference in which the shared interest was the application of "economic reasoning" (commonly considered as good example of rationality) to collective, political or social decision-making. Only in December 1967 it was publicly adopted the term "public choice" in order to indicate this topic [212].

The public choice approach is related to the theoretical tradition in public administration, formulated by Wilson [310] and those who followed, which were later criticized by Herbert Simon. Wilson's major thesis was that *"the principles of good administration are much the same in any system of government"* [212], and *"perfection administrative organisation is attained in a hierarchically ordered and professionally trained public service. Efficiency is attained by perfection in hierarchical ordering of a professionally trained public service"* [212]. Wilson gave also a strong economic conceptualization at the term efficiency. He said *"the utmost possible efficiency and at the least possible cost of either money or of energy"* ([310] cited in [212], see also [307, 212, 310]).

In the '60s Herbert Simon [255, 256, 257, 258, 259, 260] move his strong critique at the theory implicit in the traditional study of public administration. He said that there is no reason to believe *"that perfection in hierarchical ordering would always be the most efficient and organisational arrangement"* [212], because there is no reasons to believe at one *"omniscient and benevolent despot"*. On the contrary, Simon makes a first distinction between facts and values that are considered in choosing among alternative possibilities. Then, he focus on the construction of a bridge to link theory and empirical studies. Moreover, he defines the criterion of efficiency *"as a norm for evaluating alternative administrative action"* [212]. He also argued that the *"criterion of efficiency dictates that choice alternatives which produce the largest result for the given application of resource"* ([258] cited in [212]). Thus, in order to use this criterion, the administrative's results must be defined and measured.

After the first years, the post-positivist approach has been criticized by some authors [33] and above all by policy analysts. Such critiques *"can be positioned in terms of explicit rejection of both technocratic and accommodative images"* [76].

Our claim is that this focus on "scientific" and "rational" was in general misunderstood, because interpreted as a shift of decisional power from politics to science, from elective bodies to experts, from subjective to objective: instrumental rationality completely governed the policy process. In post-positivist policy making there was the illusion that policy-makers, with their competence, information and set of tools, could solve in an optimal way problems, with given resources and constraints. Under such a perspective *"policy problems were technical questions, resolvable by the systematic application of technical expertise"* [102]. But, *"full information is always an illusion"* [102] and we never really have the complete knowledge to "optimise" our goals. In fact decisions, and thus policies, are undertaken partly under "ignorance" or underestimating the importance of some variables. This is often related to "learning by doing", which will become a foundational concept of the renewed interest towards rational decision. In spite of such criticism as Dryzek [76] said:

> *"these dreams may be long dead, and positivism long rejected even by philosophers of natural science, but the terms "positivist" and "post-positivist" still animate disputes in policy fields. And the idea that policy analysis is about control of cause and effect lives on in optimising techniques drawn from welfare economics and elsewhere, and policy evaluation that seeks only to identify the causal impact of policies."*

Dryzek's sentence puts in evidence that "positivism" and "post-positivism", in spite of all, are still alive. Actually, we believe the promotion of EBPM has been a return to such approaches.

2.4.2 Evolution

From medicine to social science

Evidence-based policy-making is born on the roots of evidence-based medicine (EBM) and evidence-based practice (EBP). In fact, it is easy to find these roots in EBPM logic, kind of analysis and way to understand problems and solutions. EBM and EBP are based on a simple concept, that is to find the best solution integrating past experience. The practice of EBM needs to integrate individual clinical expertise with the best available external critical evidence from systematic research, in consultation with the patient in order to understand what alternative suit the patient best. In this sense, we can say say with Solesbury [269] that EBM and EBP have both educative and clinical function. In other words, this kind of evidence is based on a regular assessment through a defined protocol of the evidence

coming from all the research. In fact, in order to face this need of EBM for systematic up-to-date review, in 1993 in the UK has been founded the Cochrane Collaboration, which deals in the collection of all such information.

Subsequently, considering the good results obtained in medicine with the evidence method, there was the will of politicians to use the same scientific method in order to support public decisions and legitimize the policies building. Thus, give the success of the Cochrane Collaboration in the production of a "gold standard", it has been established in 2000 the Campbell Collaboration, which provides for systematic review on social science in the field of education, crime, justice and social welfare.

EBPM in the UK

In 1994, the Labour party termed itself as "New Labour" in order to announce a new era: "New Labour" is a party of ideas and ideals but not of outdated ideology. What counts is what works. The objectives are radical. The means will be modern" [28]. In this first announce it is possible recognize the same roots and philosophy that pervade the EBM and EBP. Moreover, in 1997 when they won the general election the decide to open a new season of policies, and in order to organize and promote it, they published the Modernizing Government White Paper [46], in which they argue that:

> *"government must be willing constantly to re-evaluate what it is doing so as to produce policies that really deal with problems; that are forward-looking and shaped by the evidence rather than a response to short-term pressures; that tackle causes not symptoms; that are measured by results rather than activity; that are flexible and innovative rather than closed and bureaucratic; and that promote compliance rather than avoidance or fraud.To meet people's rising expectations, policy making must also be a process of continuous learning and improvement. (p.15)*
>
> *better focus on policies that will deliver long-term goals. (p.16)*
>
> *Government should regard policy making as a continuous, learning process(...)We must make more use of pilot schemes to encourage innovations and test whether they work.(p.17)*
>
> *encourage innovation and share good practice (p.37)"*

In this document they describes the goals of the new government changing the approach towards public policy, and it is clear that this change implies the adaptation of evidence-based method and logic. In fact, we can consider the Government White Paper as the Manifesto of United Kingdom's EBPM, where the EBPM cover the same role of EBM, that is to give accountability at the field of policy. This accountability is promote by two main forms of evidence [241]:

- the first one refers to results and then to the effectiveness of the work of the government;
- the second one refers to the improvement and consequently the knowledge on how well policy works in different circumstances.

In practice, they consider the policy process as a learning process that has to be studied, analyzed and monitored in order to get new evidence for building future policies. With this new way to understand the policy process there is a shift of goal, from a short term policy founded on ideology and no-scientific knowledge to a long term policy founded on identified causes of the social problems to face. Thus, under such a perspective, any other no-scientific components of the policy process are considered a misappropriation from the "truth/reality" of the problems. In fact, David Blunkett, in his speech in 2000 [29], emphasized that:

> *"This Government has given a clear commitment that we will be guided not by dogma but by an open-minded approach to understanding what works and why. This is central to our agenda for modernising government: using information and knowledge much more effectively and creatively at the heart of policymaking and policy delivery."*

"What works and why" became the UK slogan for EBPM promotion, and also the following government put emphasis on EBPM, but with some difference. This following government shift from policy learning to policy delivery, so the need to go away from experimentation and the awareness that what matters most is hard quantitative data. In fact, in the last years EBPM has evolved from a generic attention for any kind of scientific analysis to an higher attention to quantitative and economic analysis [120, 220].

2.5 Criticism towards EBPM

In the EBPM debate the authors cast doubt on whether introducing evidence in the policy making process is really innovative. If before policy-making could be described as a "swamp" [248] characterised by complexity, uncertainty and ignorance; then EBPM should help to move it towards firm ground in which sound evidence, rather than political ideology or prejudice, could drive policy. The question is whether this confidence in the power of evidence is a step forward or backwards, because EBPM could appear a return to the old time trust in instrumental rationality. In fact Parson [216] states that:

> *"EBPM must be understood as a project focused on enhancing the techniques of managing and controlling the policy-making process as opposed to either improving the capacities of social science to influence the practices of democracy".*

Sanderson [241] argues that: "the resurgence of evidence-based policy-making might be seen as a reaffirmation of the modernist project, the enduring legacy of the Enlightenment, involving the improvement of the world through the application of reason ".

Actually, in the UK evidence-based practice the focus was on effectiveness, efficiency and value for money. This experience is characterised by a managerial emphasis [289]. Evidence-based policy making, in its effort to implement accountability, is linked to an instrumentalist mood of managerial reforms that have infiltrated public administration practices in many western democracies over the past three decades. Managerial reforms and evidence-based policy can be assimilated by the same technocratic logic, concerned with procedural competence rather than substantive output [178]. In the following we introduce the main issues for which EBPM has been criticised.

2.5.1 Many evidences

There is a very big amount of typologies of evidence: the most used distinction is between hard/objective and soft/subjective. The first one includes primary quantitative data collected by researchers from experiments, secondary quantitative social and epidemiological data collected by government agencies, clinical trails and interview or questionnaire-based social surveys. Other sources of evidence, "typically devalued as "soft" [178], are photographs, literary texts, official files, autobiographical material like diaries and letters, the files of a newspaper and ethnographic and particular observer accounts. Davies defines a scheme [69] in which he shows that there are seven kinds of evidence originated by scientific research: impact evidence, implementation evidence, descriptive analytical evidence, public attitudes and understanding, statistical modelling, economic evidence, ethical evidence. Moreover, Davies states that in policymaking "privileging any one type of research evidence or research methodology, is generally inappropriate" [69]; thus, it's required a balance between social researchers and a general understanding and competence of the full range of research methods. Otherwise, Sanderson [241] states the need for developing just impact evidence in order to build policies through long term impact evaluation; he argues also the use of theory based evaluation, considered more correct in order to understand how policies achieve their effects.

Due to different opinions in the debate, in order to avoid some misunderstanding in practice, the UK Cabinet Office clarify the meaning of evidence in the White Paper on Modernising Government [46] in which evidence is defined as:

> "*expert knowledge; published research; existing research; stakeholder consultations; previous policy evaluations; the Internet; outcomes from consultations; costings of policy options; output from economic and statistical modelling*"

From this definition it seems that this conception of evidence privileges "conventional scientific methods", and it is evident that UK social policies use a limited range of evidence. The concept of evidence-based policy is assumed to be a rational and scholarly approach [178, 241], which aspires to "goes beyond political ideology" (Latham, cited in Marston e Watts [178]). Nevertheless, this kind of policy, that evaluate and hierarchies the knowledge, is far to be neutral or objective. In this case, the selection of the "right" evidence is necessarily a limited view of what counts as a valid knowledge, in fact the building of a hierarchy of knowledge means that we can consider some forms of knowledge more related to reality/truth. Privileging one form of knowledge or methods over other is not a neutral fact. Every theory is based on some assumptions or interpretations of the complex reality and they are not omni-comprehensive. In choosing what counts as the valid knowledge for policies, policymakers implicitly states their interpretation of reality. Said that we can deduce, by the recommended and adopted evidences in UK experience, that its interpretation of reality could be intended as post-positivist, in the sense that the stress is on the relationship cause and effect. Besides, this claim is supported by the importance given at the concept of effectiveness and efficiency. In fact, these two concept become in the UK policy evaluation often the first, if not the only, qualification needed at one policy in order to be implemented [121]. For all these reasons policymaking has the attitude of disregarding past research, because it might have been built according to different opinions and think; thus as we have seen above the government demand for new evidence through the creation of organizations and the financing of research.

In our opinion, using this kind of strict selection is an oversimplification, that involve the concept of whether other aspects count. In several fields, many theories have been developed on what counts or not and how much. In EBPM framework, however, only Davies [69] says something about the importance of all kind evidences, the need for them to be balanced and managed in a coordinated way. Nevertheless, the condition of "to count" has an intrinsic importance and not to explicitly face it could produce mistake and misunderstanding. In the field of medicine there is a hierarchy of evidences; but in social sciences deciding and defining what is the right evidence has implication on what social science approach has to be chosen. Evidence does not exist in a social constructive approach in which reality is socially built: every single research is based on different assumption so it privileges an aspect-interpretation of the reality.

Despite all that, we believe that there is another more important aspect that policymaker need to consider when talking about evidence and specially scientific evidence: that is the way in which scientific results are used. In fact, whether to choose a kind of evidence, and so a kind of knowledge, is not neutral; the way in which are used the results of scientific methods and tools, so what it is called evidence, it is even less. Results, data and so evidence can be manipulated or also their different presentation can produce opposite reactions. In order to better explain this concept we decided to show some examples of it.

Example 2.1: Air Quality

Our first example is about the air quality, the way in which it is calculated and the way in which this data are used in policy-making.

In a hypothetical city in France, the mayor decides to implement a set of policies in order to reduce the pollution and improve the air quality. After a year he check the ATMO index an air quality indicator developed and used in France, but the ATMO index has not changed, it is the same as the year before.

Checking the various item that compose the ATMO index we have:

pollutant	CO_2	SO_2	O_3	dust
t_1	3	3	8	8
t_2	3	3	8	2

At the time t_1 there are the data for the period without reduction policies, and at the time t_2 there are the data after one year of reduction policies. As we can see from the real data, in one year of reduction policies the "dust" value is greatly reduced moving from 8 to 2. Hence, did the air quality improved? Observing the pure data the answer is obviously "yes", but for the ATMO index did not, the reductions was not so great to move the index. Thus, what is the truth? Are the implemented policies appropriate? Should the policies be maintained or not?

Example 2.2: Burkina Faso Poverty

Our second example is about Burkina Faso Poverty. In this example we will show as the idea and the perception of poverty change betweens cultures and also stakeholders.

An English NGO want help people in Burkina Faso building aqueducts, because they think that do not having available tap water at home is an evident symptom of poverty that causing problems to the development. Thus, they decide to conduct a research and they discover that **95% of rural households in Burkina Faso do not have tap water available**, but at the same time they discover that **for the locals is not a problem**, so they decide to implement a different project. In this case the question is: How the research was conduct? Who were the locals interviewed? How the research is conduct, in this case, become very important. In fact, if we interview the local men they will told us that not having tap water at home is not a problem, because take and carry water is a woman's task. Thus, if we had asked to the women we might discovered that not having tap water available at home is a very big problem, and the NGO would have implemented some project to realize the aqueducts.

Example 2.3: Good Researcher

Our third example is about who is a good researcher, what good researcher means and who decides and for what purpose about research quality.

In this example we are in an University where a group of executive, professor and researcher have to decide who is the best researcher. In this situation above all it is need to define what good researcher means and how to measure it. Thus, they start to discuss about what they take into account to do it, and i.e.:

- Values and preferences of relevant stakeholders;
- Individual values and social values;
- Judgements (experts, politicians, opinions).

At the end of the discussion they choose to be democratic and to decide through a vote; everybody express his preference:

$$\begin{aligned} \text{10 voters have preferences} \quad & aPbPc \\ \text{6 voters have preferences} \quad & bPcPa \\ \text{and 5 voters have preferences} \quad & cPbPa. \end{aligned}$$

Now they have this list of preference, but who is the winner? who is the good researcher? Most electoral systems will choose a, which is the one the majority does not want, because actually the Condorcet winner is b.

What we can conclude? We believe that these three simple examples have several implications. Starting with the first "the air quality" we can say that information needs to be manipulated in a coherent and consistent way (measurement theory). Moreover that information needs to be manipulated in order to be useful for who will use this and for those purposes for which this was designed. This example should us allow to reach a coherent conclusion. In fact, using an index create by someone with different goals or just for a different context and situation could be dangerous and counterproductive.

From the second example we can understand that using methods and data requires knowledge and critical view because it is important to consider:

- different standards and thresholds;
- different cultures;
- different stakeholders;
- different concerns;
- different resources.

Because otherwise we will be unable to use information and data to achieve our goals.

The third example at the end allows us to reflect about the voting system, method that usually is believed neutral and objective. This method, as we saw in the example, is not neutral because there are:

- different ways to establish a majority;
- different ways to compute an average;
- different ways to take into account the importance of positive and negative arguments.

Methods offer many possibilities to manipulate or misunderstanding information and data. Thus, believing to be neutral or objective just using a scientific method is unrealistic.

Knowledge is only one form between others to understand the reality and not the universal truth. In selecting knowledge, so kind of information and method the policy-makers privileges one interpretation over one another, without assuming the basis as a critical issue. There is a sort of double filter: first one when researchers select assumption for their analyse and discourse, the second one that select the knowledge outcomes of these researches. In this sense, EBPM is a powerful metaphor in shaping what forms of knowledge is more linked to the truth, or, we can say, to the useful truth. In order to do that, the evidence must be built answering some questions like:

- Who needs this evidence?
- Why (s)he needs this evidence?
- What is the purpose?
- Who other is affected by such evidence and how?
- What resources do we commit and what do we expect?

Moreover, we must remember that constructing evidence is a field of scientific investigation, where are involved many field and topics like: measurement theory, decision analysis, social choice theory, computer science and artificial intelligence, and also political sciences and economy, etc.

The main problem in policymaking is not whether there is enough relevant information, but of managing the excess of evidence, " the danger is not that one uses no evidence at all, but that one uses simply the most readily available" [221]. Also Keynes, cited by Davies [69] said:

> "*There is nothing a government hates more than to be well-informed: for it makes the process of arriving at decision much more complicated and difficult"*

2.5.2 Policy-making as a result of many factors

"Evidence" is not the only determinant of policy-making, but it is just one of several factors that could help policy-maker to choose and determine policies. In fact, we can describe the EBPM as the breaking point with the traditional approach that identifies in power, people and politics the only policy-making factors [216]. With that in mind we can overcome the "naïve" concept of Evidence-Based, where research replaces policy, and experts/technicians replace the politicians. Policies are complex "objects" and the policy-making process is influenced by several relevant factors. [69] indicated the following ones:

- *Experience, Expertise and Judgement.*
  Policy making implies several stakeholders each carrying different types of knowledge such as ground experience (of local groups, citizens, economic actors), expertise (of technical staff, scientists, experts) and judgements (public opinion, elected bodies, committees). Such knowledge is expected to be integrated in the policy making process [204]. This could add significance when the existing information is imperfect or non-existent [107].

- *Resources.*
  Establishing a policy mobilises material and immaterial resources (knowledge, authority, capital, land etc.) and results in allocating resources aimed at implementing a plan of actions. Both such resources are bounded (and scarce). The result is a quest for efficiency both as far as the policy making process and its outcomes are concerned. This "economic" aspect of the policy making process is perhaps the most studied in terms of supporting methodologies and practices [121, 47, 48, 206].

- *Values.*
  Values are the essence of policy making. They induce preferences, priorities, judgements and justify actions. They have several different origins: ideology, culture, religion, beliefs, knowledge, discussion etc.. It is unlike that any policy making process can be legitimated without making reference to some set of values. However, it should be noted that values evolve over time in unexpected directions (consider the cases of the value of the environment in the last 50 years, the value of women rights in the last 150 years or the value of individual freedom in the last 250 years).

- *Habit and Tradition.*
  Political institutions have their own organisational inertia. The policy making process is characterised by procedures and patterns often rooted in culture and history, but nevertheless constraining the potential outcomes. Several times such constraints appear under form of fundamental laws (such as constitutions), but equally likely they can appear as socially constructed legitimation processes and outcomes.

- *Lobbyists, Pressure Groups and Consultants.*
  Any policy making process mobilises groups of pressure, informal or organised lobbyists as well as the opinion of experts. Such stakeholders are not always visible and have a less systematic influence. However, the play a key role in the process allowing specific concerns, stakes and interests to find their way in the discussion.

- *Pragmatics and Contingencies.*
  Policy making, agendas and decisions are influenced by unanticipated contingencies and "emergency" procedures which do not necessary fit with rational policy making. Policies are expected to take into account long term uncertainties as well as the aspirations of the future generations. This can be in contradiction with a contingent, short term view of policy making [239, 222].

2.6 Conclusion

Concluding this chapter we want underline as the EBPM is fundamental in every situation, context and goals. It is not a tool but a one of the tenets that the policy-makers must follow to make "good" public decisions. Where "good" means legitimate and accountable, namely decisions accepted by the population and with a transparent decision process recognised as valid and rational.

We believed important to insert this chapter into the thesis because public policies are not a common field of research, and before to analyse, work and use some tool it is necessary to know well its peculiarities. In fact, many choice that we did are due or conditioned by the special public policies characteristics, and it is remembering all that that we suggest to reed the whole thesis.

CHAPTER 3

Cost-Benefit Analysis (CBA)

3.1 Introduction

In a trivial way, the CBA could be defined as an economic decision-making tool, and also a decision aiding method [37]. The CBA has very intuitive approach, where decisions are made weighing benefits and costs. It is used to understand if a project, policy, or in other words an investment, is worth doing, that is if benefits outweigh costs. Moreover, the CBA is usually used when we must choose, which one, among several alternatives should be implemented .Thus, in other words the CBA is useful to avoid the misallocation of resources in a world where these are scarce.

When we speak about private firms is easy to understand what means *cost* and *benefit*, because in this context the CBA is guided ultimately by the profit. In a different context as in public policy to define *cost* and *benefit* it is not so easy. Moreover, public policy involve many stakeholders and so it raises the problem to understand for who are the benefits and for who the cost, but using the CBA this distinction is hard to do. Kaldor in 1939 [141] underline that distribution and compensation between different actors should take place as a political question on which the economist could hardly pronounce an opinion. Nevertheless, the CBA has become an integral part of public policy, and in the 1996 Robert J. Brent [42] wrote :

> *"Welfare economics is at the heart of public policy and hence at the core of CBA"*

This sentence straightforward expresses how the CBA, from an economic tool has been transformed over time into an instrument of "social evaluation". In fact, CBA is also called social cost-benefit analysis [67, 188, 42], because it is an important tool for socioeconomic assessment of government projects and policies. Its aim is to help assess whether or not a given project or policy will benefit society. The EU [228] recognize the CBA as the only tool able to evaluate projects and policies in order to decide the funds distribution. For this reason, talking about public policy the CBA can not be ignored. We believe that all reasoning on the evaluation of public policies and public investment can not be separated from the understanding of the CBA underlying thought, and its formal characteristics. Therefore, only starting from that which makes the CBA so acceptable, we can think and propose possible alternatives, which will be accepted and used.

Said that, why the CBA is so important in public sector? Why not use another tool? We believe that the answers to these questions could be synthesized in three main motivation:

1. the economic rationality, on which the CBA is based, is accepted and recognized as universally;

2. the CBA provides, with is Net Present Value (NPV), a very concise performance indicator and so a concise information;

3. the CBA tool, both as logic and as formal elements, is easy to understand and follow also for not experts.

We will try to better explain this claims in the following, but before we getting into chapter, we would like to do two remarks. First is that the CBA and social CBA are primarily economic tools, and so based on economic assumptions. This means that CBA is based on economic rationality, and that makes CBA a normative tool. Second is to specify what we mean with *"social CBA"*. Social is a term used in literature to refer to three different aspects that consequently affect the CBA:

- it is used to emphasize the idea that the assessment may include the effects of decision, project, causes on all members of society and not only on the stakeholders;
- it is used to highlight that the distributional effects are considered to be included in the efficiency effects;
- it is used to emphasize that market prices are not always good indicators of willingness to pay. The social price also means that market price has been adjusted to include effects that market does not register or record imperfectly.

In order to better understand what we mean by this, we give just a brief suggestion. What is well-being? And what is social welfare? We can say that social welfare is the sum of the individuals' well-being composing the society? To the economists the answer to this last question is positive. Indeed, the rationality is exogenous and independent from people, because all people have the same utility, and since they regard the well-being as the increase of personnel utility it is easy to imagine social welfare as the sum of all personnel utilities. Otherwise, if we consider the well-being as something different and much more complex to understand, which can be different from individual to individual, namely, we imagine a different kind of rationality, the situation is much more complicated by taking ethical and moral values into account.

3.2 The CBA: an overview

The CBA is extremely popular among economists and politicians, but also among common people (even if in a mundane way). The CBA has a long history and a lot of different declination and approaches. Actually, there are different ways of seeing, defining and calculate the CBA. We have no illusion of being able to consider all given aspects, because of the vast existing literature and, because this is not one of our goals, but we will take into consideration just some of those which we retain important for our purpose.

Long its history, the CBA has been applied in a lot of different kind of decision, to solve very different problems and in a very far areas, some examples are [37]:

- Economics: determining investment strategies for developing countries, allocating budgets among agencies, developing an energy policy for a nation;
- Transportation: building new roads or motor ways;
- Health: building new hospitals, setting up prevention policies, buying new diagnosis tools, choosing standard treatments for certain types of illnesses;
- Environment: establishing pollution standards, creating national parks, approving the human consumption of genetically-modified organisms, or irradiated food.

These types of decisions are very complex, and they can affect our everyday life. CBA is view as the standard way of evaluating such projects and of supporting public decision. How we can use only one tool in so different situations? What are the elements that make the CBA a standard tool? In order to answer such questions we retain important know what is the CBA, what are its history, its principles and its hypothesis. For this purpose, starting with some definition, we quote Sen [251]:

> *"a tool used to assess the socio-economic impacts of public investment and it can be seen as a real discipline".*

and Momigliano et al. [190]:

> *"a tool that checks if the benefits (social benefits) that an alternative is able to bring to the community as a whole are greater than the costs (social costs)".*

By considering these two definitions we can understand some important aspects, which are: the social, that means the community as whole; the economic, that means money but also economic assumptions; and alternatives. When we speak about alternatives we want to underline the evaluation aspect of CBA. Indeed, the real purpose of this tool is to evaluate some different alternatives and indicate the best one. The CBA is done ex ante and aims to decide whether to allocate resources in a given investment, in order to achieve the objective, namely, to have social profit. It is worth to mention that the CBA is not a tool to discover or to produce alternatives. These exist before and out of the CBA. The CBA is not a process tool, is just a tool to assess.

3.2.1 Brief history

The CBA as currently practiced represents the culmination of more than a century of theoretical advances in economics as well as empirical improvements. The CBA was developed initially as a practice, and only later was organized as theory. The first work on the CBA is believed to be done by the French economist Jules Dupuit in 1844 published in his paper "On the Measurement of the Utility of Public Works" [80], however, as early as 1808,

the "Report on Transportation" by Albert Gallatin [155], the fourth USA Secretary of the Treasury, had recommended the comparison of costs and benefits for evaluating water related projects. In 1902, the federal government of the USA, where the CBA is more widely and systematically used, adopted a cost-benefit approach for the first time, in relation to the approval of the River Harbor Act [112]. However, it is during the years of the 1929 crisis that the use of the method starts spreading. Indeed, the widespread dissemination of unemployment as a result of the crisis, brings the government to use massive investment in public works, according to the Keynesian economic doctrine. *"Such constructive fervor involved the need to identify social-analytical-accounting procedures, that can provide qualitative and quantitative elements suitable to allow publics operators the best option, the most economic affordable but also in terms of utility social level"* [312]. Water resources were the first to be subjected to this type of procedure as a result of the approval by the Congress of the Law on Control of Flood Discharge (Flood Control Act, 1936). Europe needs to wait until the end of the second World War to see the implementation of this "new procedure".

It is from the 1950 and 1960s that economic science began to develop the theoretical cost-benefit analysis, and its methodology also spread to other disciplines, from law to political science and administrative science. It can be argued that the CBA finds its place in 1962 when President Johnson decided to adopt it as part of the new Planning-Programming-Budgeting System. This was intended not only to respond to the crisis of public funds, but also to the lack of consistency, timing and coordination that existed between the various departments of government. In other words, the CBA was introduced as decision aiding tool, able to help the decision-makers, and at the same time able to provide evidence, to support the decision itself. Since then, the CBA has become an inescapable element of all decisions at the government, and also of many decisions at state and "local". In 1972 in London during the project to build a third airport in the city, was established a study commission (Roskill Commission [1]), which had the task to indicate whether, where and when it would be convenient to realize the new airport. Then in the 1977, in an attempt to solidify executive branch control over federal regulatory agencies, President Nixon included CBA in his "Quality of Life Review" process for agency regulations [95]. The use of CBA in government decision-making was formalized in 1981 by President Reagan with an Executive Order (EO). This required that Regulatory Impact Analysis be conducted for major government initiatives [233]. After this first order each USA president from Clinton in the 1993 to Obama in the 2011 have used CBA in different governmental areas in order to assess the performance, to enhance accountability, and standardize the decision-making process [205]. The aim is to demonstrate that funding priorities are based upon credible empirical evidence, and to identify impediments to rigorous program evaluation in their statutes or regulations so that these might be addressed going forward [205]. For instance, the document notes [205]:

> "The Administration [...] has made a concerted effort to increase investments in early childhood education and home-visiting programs that are backed by strong evidence-because rigorous evidence suggests that investments in those areas have especially high returns"

Shabecoff in 1981 [253] said: "[President Reagan] transformed with a stroke of his pen what had been a useful economic tool into an imperative of Federal decision making". In the light of history, we can say today that he transformed much more of an economic tool, he with his act, has changed a whole way to seeing and working in politics.

In Italy, the CBA has had a slow development and only in 1982 it was constituted an evaluation group, to the "Fund Investment and Employment" (FIO).

Concluding this brief history of the CBA, we can write that the development of CBA has unsurprisingly coincided with the more active involvement of governments in economic affairs that started after the great depression and increased after World War II in the 50's and 60's [37]. Moreover, it coincided also with the "post-positivism" movement and so with the interest towards the use of knowledge, as rational and logical reasoning. In those years grew the idea and the concept of "rational decision-making", that at the beginning was central both for the economic dimension of problem solving and the scientific management of enterprisers [291]. Thus, it was in those years that the faith in scientific method and rationality grew up until its highest point. (For more details: [129, 42, 114, 188, 168, 67]).

We believe that the successful of CBA lies in its rationality. Indeed, nevertheless criticisms and limits, CBA is adopted and recognized as valid by its philosophic thought, which is based on ideas and assumptions collectively considered valid.

3.2.2 Principles and foundations

It is important to clarify that the term CBA has always been used with considerable flexibility, thus, over time under this term several specific procedures have been incorporated. However, there are both theoretical foundations and fundamental principles that form the underlying philosophical tenets of CBA, which might be considered the "non-negotiables" that underpin all CBA. However, we must remember that many aspects of CBA remain fluid and will continue to evolve in keeping with research findings and theoretical advancements.

Economic Foundations

> "*The important point here is that CBA conducts project evaluation within an "environment" in which markets are especially important instruments of social co-ordination" [37, p. 76]*

In this sentence is enclosed the whole theoretical basis of CBA, namely, that the market is the place and the instrument for the regulation and coordination of the society, and as noted above, CBA is an economic tool and as such is based on economic philosophy and theory. In a deeper meaning, there is agreement in recognizing and supporting the economic (normative) rationality as a good way to see and analyse the society.

The CBA's normative rationality is found in a subfield of microeconomics called welfare economics. The welfare economics was developed by Pigou [225] from the marginalist tradition and particularly from the Marshall neoclassical branch. Welfare economics began with the bedrock principle that an intervention or policy should be implemented if at least one person will be made better off and nobody will be made worse off. This criterion, named for the Italian economist Vilfredo Pareto, is called "Pareto improvement". From this criterion derives a second concept, "Pareto efficiency," that is a state attained when no further Pareto improvements are possible. There are two forms of Pareto efficiency: in its strong form, Pareto efficiency holds that state A is preferred to state B when state A is ranked higher than state B for one person and all other persons rank A at least as high as B. In its weaker form, the utility (well-being) of each individual must be higher in state A for state B to be preferred [30]. In practice, the unanimity requirement of the Pareto efficiency criterion is paralyzing as an empirical decision-making tool as almost every policy decision engenders winners and losers.

A more pragmatic substitute for the Pareto criterion, developed in light of this limitation, is the "Kaldor-Hicks" criterion. The Kaldor-Hicks (KH) criterion, overcoming any discussion about the interpersonal comparisons of utility by separating equity from efficiency, it says that a hypothetical investment is desirable if the money measure of gains exceeds the money measure of losses, because there is then the potential for a transfer between winners and losers that could satisfy the basic Pareto criterion [312]. However, the KH criterion did not truly obviate concern about making interpersonal comparisons of utility. The KH assumption of equal marginal utility of income in fact embraces such comparisons in a particular way, where all people are treated equally in terms of the value they place on changes in income. In recent years, CBA has continued to evolve in keeping with economic theory. For instance, growth in economic theory regarding the valuation of non-market goods and services has fostered increasingly comprehensive economic analysis. Valuation methods for non-market goods and services, such as the travel-cost method [122], hedonic valuation [235], and contingent valuation surveys (willingness-to-pay) [189] have increasingly gained acceptance, as means by which to estimate values for non-market resources in the absence of observable market transactions.

Although, the KH-criterion remains the standard for BCA, in recent years, it is of diminishing use in its restrictions. Analysts have increasing attention to ethical issues of distribution and intergenerational equity. Various approaches have been proposed to account for equity in CBA, including:

- distributional weighting, where net benefits, expressed in dollars, are weighted by income or some other metric to express an equity viewpoint [43];
- using unweighted net benefits, but applying the KH criterion separately within each income class as well as in society as a whole [201, 87, 104];
- using well-being rather than money as the metric, and employing a social welfare function that captures equity viewpoints [4];
- use benefits and costs expressed in dollars and measure willingness to pay for ethical sentiments to capture equity [313, 314, 315];
- taking a portfolio approach, whereby it is assumed that if a KH test is applied in multiple rule-makings, and that winners and losers are considerably mixed, then in the long run most (but not all) people will better off [118, 104].

What is most commonly advocated though is for CBA to analyze equity issues qualitatively and separately from efficiency, by presenting policy-makers with the best distributional information possible and letting them weigh equity concerns implicitly [312].

Fundamental Principles

The fundamental role of cost-benefit analysis is to provide information that serves to improve decision-making and facilitate better decision outcomes. By monetizing outcomes, CBA produces easy and comprehensive assessments of different interventions that can be compared both within and between areas. This method rather than focusing on specific area as health outcomes, educational attainment, or crime statistics as policy end-goals, it takes a broader approach to improving social welfare [312]. This allows decision-makers to weigh investment decisions more holistically and pursue alternative that increase efficiency and better outcomes. This is especially true for policy decision-making, where significant effects typically derive outside of the primary policy focus. However, these same demands of comprehensiveness and consistency make CBA a highly demanding and complex endeavor. In fact, given resource limitations and empirical realities, achieving uniformity of analysis is very difficult. Models are limited by the accuracy and availability of data, as well as by time and funding constraints. Moreover a large part of policy outcomes consist in non-market benefits, forcing analysts to develop means to quantify these impacts. Future outcomes are of course uncertain, and thus the analyst must predict expected policy effects.

All that, turns the CBA from an economic and "objective" tool into an economic but more "subjective" tool, it is defined by Zerbe et al. [312] as *"much an art as it a science, since addressing these difficulties requires creativity, expertise, and careful attention by the*

analyst".

The five foundation principles that follow form the basis for the CBA presented by Zerbe et al. in their work "Toward Principles and Standard in the use of Benefit-Cost Analysis" [312]. These foundational principles provide the underlying philosophical framework for CBA work generally.

- **Principle One:**
  The CBA is an economic evaluation tool that seeks to calculate values for all project inputs and outputs to determine the net benefit of a given investment. It seeks to provide a shared framework for discussion, and decision-making by providing an accurate representation of outcomes.

  "CBA is distinguished from other types of financial evaluations by the fact that it seeks to value inputs and outputs of all forms to derive a comprehensive summary of the net benefits associated with a decision [31]. Its purpose is to identify the most efficient decision option. For social policy, CBA reflects the extent to which the values that individuals place on program outcomes likely exceed program costs [111]. If a private firm might focus on financial benefits and costs to the firm, for policy we must incorporate all quantifiable outcomes, private and social, direct and indirect, and tangible and intangible [42], which are then monetized. Unfortunately, not all effects can be measured or estimated, thus any unmeasured or poorly understood effects thought significant must be addressed qualitatively or quantitatively within the analysis. CBA can either be ex ante, when considering an investment or choosing amongst policy options, or ex post, to measure project efficacy in order to guide future policy decisions".

- **Principle Two:**
  The CBA is an aid to public policy decision-making; it is not, and should not, be regarded as a substitute for democratic, legislative, and administrative decision-making. Likewise, political influence should not intrude into technical analysis decisions and the analysis process.

  "Properly used, CBA is not a mechanized decision-making tool, but rather a means of analysis that provides useful information to decision-makers [316]. CBA organize data and information in such a way that decision-makers can readily observe the tradeoffs of different decisions. CBA should present clear information and use transparent methodology such that it structures constructive debate. Likewise, just as BCA should allow for policy-makers to make policy decisions, political actors should not unduly influence analysis components or limit the range of alternatives considered. Although CBA is primarily used to provide information, many times the

CBA tool replaces or force the decision that it should remain a political issue".

- **Principle Three:**
  Transparency enhances the value of CBA for decision-making by facilitating a more comprehensive understanding of the analysis, and properly focuses the policy discussion upon political issues rather than technical aspects of CBA. Thus, both the analysis process and results should be made as transparent as possible.

  "Given the complexity of most CBA, and the large number of decisions that analyst must make when conducting an analysis, it is very important that both the analysis process and results be made as transparent as possible. Thus, it ensures that there is accountability. Moreover, eliminating the "black box" will allow the policy-makers to see where the data come from, what assumptions underlie the model, and what decisions were made regarding what values are included".

- **Principle Four:**
  Pursuit of the "perfect" analysis should not prevent completion of a useful analysis. A CBA that meets basic acceptability requirements regarding objectivity and appropriate methodology can still be released even if it does not conform to all best practices or is data-deficient.

  "Different situations may call for different styles or depths of analysis. For instance, there are numerous examples where we know that non-market goods and ethical considerations have value, but are unsure of what those values are. Any CBA is likely to encounter such instances where effects cannot readily be enumerated or valued, and thus the analysis becomes highly conjectural [105]. Under such aspect policy analysis can prove particularly complicated, as it involves many effects that are highly difficult to predict and value. In these situations, CBA can contextualize existing information and present the known implications of policy options to decision-makers, while acknowledging and discussing the implications of un-quantified and unknown effects. Incomplete knowledge and data-deficient aspects should not prevent an otherwise complete CBA from going forward, as long as appropriate measures for addressing and presenting uncertainty in are BCA are taken".

- **Principle Five:**
  BCA should be conducted in accordance with the "Principle of Proportionality". This principle states that the allocation analytical effort should be in direct proportion to the expected value of increased information, defined in this case as the extent to which it might affect a policy decision.

  "Primarily, an analysis should itself be subject its own internal CBA. Additional time and resources expended towards gathering data, building more complex models, or

disaggregating effects increase analysis costs. Thus, the cost of acquiring such information should at least be equaled by the expected decision-making benefit provided by the informational gain. Aspects that should influence the allocation of analysis resources include: (1) the magnitude of the program; (2) the significance of particular effects to overall model outcomes; (3) the context and relevance of affected markets".

In order to know more about principles and foundations of CBA we suggest some past publications: Arrow et al. [11], Stokey and Zeckhauser [273], Gramlich [105], Hanley and Spash [114], Brent [42], Jones [138], Boardman et al. [31], Mishan [188], Layard and Glaister [165], Schmitz and Zerbe [247].

In order to conclude this section we underline as CBA, which covers a role of standard tool since able to do an "objective" analysis and thus transparent and comparable, is not a so perfect tool. CBA has strong elements of subjectivity, and these aspects drive a great deal of the controversy surrounding, both in terms of the mechanics of performing an analysis and how the analysis is utilized in decision-making. Some CBA decisions are inherently "judgment calls", and unfortunately, the decisions and assumptions an analyst must make when conducting CBA can become a source of controversy that obscures the true policy debate. Moreover the debate can take also on an ethical component, for instance regarding the issue of intergenerational equity and discounting. [312].

Existing these limits, why and how the CBA has won overcoming many other tools? We believe that the secret of its success lies in its economic (normative) rationality. This kind of rationality has been able to establish itself as the dominant. The economy has emerged and has become known by the general peoples as an exact science and therefore worthy of trust. Dealing the economy the top step of the rational sciences becomes a natural consequence that its tools are the most reliable.

3.3 The model

Generally, the CBA procedure, which involves several benchmarks values and the specification of a large number of assumption, is seen as highly formal and technical.

In this section we will try to explain a CBA model, which makes a generic framework. We show the model developed by the European Union in the "Guide to Cost Benefit Analysis of Investment Project", namely, the model required to apply for European funding. Such model is divided into 6 consequential stages [228]:

1. Context analysis and Project objectives;
2. Project identification
3. Feasibility and Option analysis

4. Financial analysis
5. Economic analysis
6. Risk assessment.

We know that, for some aspects, this presentation is simple and does not include many adaptation techniques that over the years have been designed to make CBA much more precise and detailed, but our intent is not to be exhaustive (for this we refer to several manuals and text book existing (see: [190, 42, 198, 114, 188, 99, 11, 228, 273, 105]). Our aim is to give the reader a clear picture of the basic foundations of CBA. Moreover, for us seems much more appropriate to set the real techniques that administrations use in current practice, rather than academic formulations used only in the academic world. In fact , we should not forgotten that we talk about CBA in public policies.

1. Context analysis and Project objectives

   The CBA aims to assess the intervention impact on a community, thus, the first step of the project appraisal aims to understand the social, economic and institutional context in which the project will be implemented. In fact, the possibility of achieving credible forecasts of benefits and costs often relies on the accuracy in the assessment of the macro-economic and social conditions. Three important aspects that should be identify on a case-by-case are the identification both of geographical area, all the stakeholders, and the time interest. Another important point is a clear statement of the project's objectives, in order to understand if the investment has social value. The European Union said the broad question it should answer for any investment appraisal is *''what are the net benefits that can be attained by the project in its socio-economic environment?"* [228, pag. 28]. The benefits considered should not be just physical indicators but socio-economic variables. Social CBA aims to structure the expectations of the project in a "rigorous" way. It cannot answer all questions about future impacts, but it focuses on a set of microeconomic variables as a shortcut to estimate the overall economic impact. The key indicator for the net socio-economic benefit of the project is simply its economic net present value. We must keep in mind that the broad purpose of CBA is to facilitate a more efficient allocation of resources, demonstrating the convenience for society of a particular investment.

2. Project identification

   At this stage becomes important define the investment. Such can be defined as *"an operation comprising a series of works, activities or services intended to accomplish an indivisible task of a precise economic or technical nature; one which has well defined goals"* [228, pag. 30]. After having identified the investment, should be defined the boundaries of the analysis, that is the direct impact on the stakeholders, but

also indirect impacts on third parties. Thus, the risk of double counting investment benefits and cost should be carefully considered.

3. Feasibility and option analysis

   In this step it is important select a good project option selection. Do it is possible through a process that aims to providing evidence, in order to choice the best investment option among all feasible alternatives. This selection process start with an analysis of the socio-economic context and the potential demand for the investment output, then the next step consists of identifying the range of options that can ensure the achievement of the objectives of the project. The basic approach of any investment appraisal aims to compare the situations with and without the project ("business as usual" BAU). After having defined the BAU scenario and the "do-minimum" option, it is necessary to look for any other possible alternative. In fact, one critical risk of distorting the evaluation is to neglect some relevant alternatives. After having selected each alternatives, it is time to do the feasibility analysis. Feasibility analysis aims to identify the potential constraints and related solutions with respect to technical, economic, regulatory and managerial aspects. An investment is feasible when its design meets technical, legal, financial and other constraints relevant to the nation, region or specific context. At the end of this step the main result is to have identified the most promising option.

4. Financial analysis

   In this step we should do the investment financial analysis, its main purpose is to use the project cash flow forecasts to calculate suitable net return indicators. The most known indicators are two: the Financial Net Present Value (FNPV) and the Financial Internal Rate of Return (FRR). The methodology most used for the determination of the financial return is the Discounted Cash Flow (DCF) approach. The financial analysis should be carried out through subsequent, interlinked, accounts, that are:

   - **Total investment costs**:
     The first step in the financial analysis is the estimation of how large the total investment cost will be. The investment outlays can be planned for several initial years and some non-routine maintenance or replacement costs in more distant years. Thus we need to define a time horizon.
   - **Total operating costs and revenues**:
     The second step in financial analysis is the calculation of the total operating costs and revenues, if any. The operating costs comprise all the data on the disbursements foreseen for the purchase of goods and services, which are not of an investment nature since they are consumed within each accounting period.

Moreover, the investment may generate their own revenues from the sale of goods and services.

- **Financial return on investment cost**:
  After having collected the data on investment costs, operating costs and revenues, the next step in the financial analysis is the evaluation of the financial return on investment. The indicators needed are the financial net present value of the project (FNPV), and the financial internal rate of return (FRR). The financial net present value is defined as the sum that results when the expected investment and operating costs of the project (suitably discounted) are deducted from the discounted value of the expected revenues:

$$FNPV = \sum_{t=0}^{n} a_t S_t = \frac{S_0}{(1+k)^0} + \frac{S_1}{(1+k)^1} + \cdots + \frac{S_n}{(1+k)^n}$$

  Where $S_t = b_t - c_t$, namely, it is the balance between cost and benefit at time t and a_t is the financial discount factor chosen for discounting at time t, and k is the discount rate. Then, the financial internal rate of return is defined as the discount rate that produces a zero,namely, $FNPV = 0$:

$$FNPV = \sum_{t=0}^{n} \frac{S_t}{(1+FRR)^t} = 0$$

  The calculation of the financial return on investment measures the capacity of the net revenues to remunerate the investment cost. More specifically, the financial net present value, FNPV, and the financial rate of return, FRR, on the total investment cost, measure the performance of the investment independently of the sources or methods of financing. The FNPV is expressed in money terms, and depends on the scale of the project. The second indicator is a pure number, and is scale-invariant. The preferred indicator should usually be the net present value because the rate of return may be somewhat misleading and contains no useful information about the "value" of a project.

- **Sources of financing**:
  The fourth step in financial analysis is the identification of the different sources of financing in order to calculate the total financial resources of the project.

- **Financial sustainability**:
  After having determined the investment all the previous data it is now possible to determine the investment financial sustainability. A project is financially sustainable when it does not incur the risk of running out of cash in the future. Sustainability occurs if the net flow of cumulated generated cash flow is positive for all the years considered.

5. Economic analysis

   The economic analysis assess the investment's contribution to the welfare of the region or country. It is made on behalf of the whole of society instead of just the owners of the infrastructure, as in the financial analysis. The key concept is the use of accounting shadow prices, based on the social opportunity cost, instead of observed distorted prices. Observed prices of inputs and outputs may not mirror their social value (their social opportunity cost) because some markets are socially inefficient or do not exist at all. Prices as they emerge from imperfect markets and from some public sector pricing or rationing policies, may fail to reflect the opportunity cost of inputs. In some circumstances this may be important for the assessment of investments. Financial data, while important for budgetary reasons, are usually unadapt as welfare indicators. The standard approach, consistent with international practice (see [228]), is to move from financial to economic analysis. To do so, appropriate conversion factors should be applied to each of the inflow or outflow items to create a new account which also includes social benefits and social costs. Summarizing, the main differences between financial and economic analysis are:

   - goals: it assesses welfare, where the financial sustainability is just one aspect;
   - values: it recognizes that not everything has a price, so the values must be monetized in other ways.

   The methodology is summarized in five steps [228]:

   - **Conversion of market to accounting prices**:
     Otherwise the financial analysis, in CBA the objective is to appraise the "social" value of the investment, thus the observed prices, as set by markets do not provide a good measure of the social opportunity cost of inputs and outputs. Whenever some inputs are affected by price distortions, the proposer should address the issue in the project appraisal and use accounting "shadow" prices to better reflect the social opportunity cost of the resources. In the first step of the economic analysis, the observed priced used in the financial analysis should be replaced by shadow prices or should be subject to fiscal correction, when it is necessary.
   - **Monetization of non-market impacts**:
     In the second step of the economic analysis it is important to be able to include in the appraisal those investment impacts that are relevant for society, but for which a market value is not available. Such impacts were not included in the financial analysis. The analyst should check that these effects (either positive or negative) have been identified, quantified, and given a realistic monetary

value. In order to capture such impacts the most frequently used method is the willingness-to-pay (WTP) approach, which allows the estimation of a money value through users' revealed preferences or stated preferences. When non-market impacts do not occur in the transactions between the producer and the direct users/beneficiaries of the investment but fall on uncompensated third parties, these impacts are defined as externalities. In other words, an externality is any cost or benefit that spills over from the investment towards other parties without monetary compensation. Due to their nature, externalities are sometimes not well captured by the use of empirical WTP or by conversion factors, so that they need to be evaluated separately.

- **Inclusion of additional indirect effects**:
  Indirect effects are defined as quantity or price changes occurring in secondary markets. To better understand whether indirect effects can be ignored or not when conducting a CBA, it is important to distinguish between efficient and distorted secondary markets. A distorted secondary market is a market in which prices do not equal social marginal opportunity costs. The existence of taxes, subsidies, monopoly power and externalities is the main cause of distortion of a market. Thus, in this third step, the indirect effects that occurring in distorted secondary markets should be included in the CBA, but only when the size of the distortion is sufficiently relevant and measurable. In fact, in general, a good use of shadow prices and a good monetization of externalities are usually enough to account for indirect effects.
- **Discounting of the estimated costs and benefits**:
  Costs and benefits occurring at different times must be discounted. The discount rate in the economic analysis of investment, called the social discount rate (SDR), reflects the social view on how future benefits and costs should be valued against present ones. It may differ from the financial discount rate when the capital market is inefficient. For the 2007/2013 period, the European Commission has suggested using two benchmark social discount rates: 5.5% for the Cohesion countries and 3.5% for the others. These SDRs are based on estimates of long term growth potentials and other parameters.
- **Calculation of the economic performance indicators**:
  After the correction of price/wage distortions and the choice of an appropriate social discount rate, in the last step it is possible to calculate the investment's economic performance using some indicators:
  - economic net present value (ENPV): the difference between the discounted total social benefits and costs;
  - economic internal rate of return (ERR): the rate that produces a zero value

for the ENPV;

- B/C ratio, i.e. the ratio between discounted economic benefits and costs.

The ENPV is the most important and reliable social CBA indicator and usually should be used as the main reference economic performance signal for investment appraisal. Although ERR and B/C are meaningful because they are independent of the project size, they may sometimes involve problems. In principle, every project with an ERR lower than the social discount rate or a negative ENPV should be rejected. Like the FNPV the ENPV is:

$$ENPV = \sum_{t=0}^{n} a_t S_t = \frac{S_0}{(1+k)^0} + \frac{S_1}{(1+k)^1} + \cdots + \frac{S_n}{(1+k)^n}$$

Where $S_t = b_t - c_t$, namely, it is the balance between cost and benefit at time t and a_t is the social discount factor chosen for discounting at time t, and k is the discount rate.

6. Risk assessment

Investment appraisal is a forecasting exercise rather than the formulation of an opinion [228]. A risk assessment consists of studying the probability that an investment will achieve a satisfactory performance (in terms of some threshold value of the IRR or the NPV). The recommended steps for assessing the investment risk are:

- **Sensitivity analysis**;
  Sensitivity analysis allows the determination of the "critical" variables or parameters of the model. Such variables are those whose variations, positive or negative, have the greatest impact on a investment's performance. The analysis is carried out by varying one element at a time and determining the effect of that change on IRR or NPV.
- **Probability distributions for critical variables**;
  Sensitivity analysis have the major limitation of not taking into account the probabilities of occurrence of events. Thus, the next step is to assign a probability distribution to each of the critical variables, defined in a precise range of values around the best estimate, used as the base case, in order to calculate the expected values of performance indicators.
- **Risk analysis**;
  After,Having established the probability distributions for the critical variables, it is possible to proceed with the calculation of the probability distribution of the FRR or NPV of the project.
- **Assessment of acceptable levels of risk**;
  Often the NPV and IRR reported in investment appraisal refer to best or base-

line estimates, perhaps meaning "most likely" values. However, the criterion for project acceptability should be that of the expected value of such indicators, calculated from the underlying probability distributions.In conclusion, this procedure allows for the selection of investment not only on the basis of the best estimate, but also based on the risk associated with it, simply by weighting the performance with the risk.

3.4 CBA's Derivative Tools

The main alternative to CBA are the cost effectiveness analysis and the cost-utility analysis. These two methods are mainly used when there are constraints that make the CBA not satisfactory. There are cases in which such significant costs or benefits can not be monetized, or by the desire for objective difficulties of the analyst or policy maker. In such circumstances, it is possible to employ techniques for assessing policies that require clarification of the quantitative benefits, but not necessarily their monetization. The cost-effectiveness analysis as well as the cost-utility allow to compare the different alternatives to identify which intervention is preferred [190].

3.4.1 Cost-Effectiveness Analysis

The Cost-Effectiveness Analysis (CEA) allows to compare a number of alternatives based on their costs and a common measure of effectiveness is quantified but not monetized. Since the analysis involves a comparison of costs and benefits in monetary units, it is not possible calculate the balance between benefits and costs, or overall social net benefit, that in the CBA expresses in monetary units the advantage for the society. Instead, in the CEA we proceed through the construction of indices of cost-effectiveness that allows comparison between the alternatives. It is possible to use two different indices of cost-effectiveness. The first index calculates the average cost per unit of output produced, and C is obtained by dividing the cost of each alternative with the benefits (quantified but not monetized).

The index of cost per unit of output CE_i that results is as follows:

$$CE_i = \frac{C_i}{E_i}$$

Calculating this index for the different alternatives the investment are on convenience, starting with the lowest cost per unit of output, which is the best.

The cost-effectiveness analysis has some important limitations. First, while being able to produce a list of possible policy alternatives allowing the identification of the preferred, if not to define the overall social net benefit of the preferred option would be positive. This limit derives from the impossibility of obtaining a synthetic result in the presence of

benefits and costs calculated in different units of measure and is therefore related to the very reasons for which the CEA was held instead of the CBA.

Another limitation is that the use of CEA itself is generally considered a more limited number of impacts of the intervention compared to those included in the CBA. The CEA compares the different alternatives with respect to a single benefit, while each alternative usually has multiple benefits. It is also worth adding that in the Anglo-Saxon practice, for reasons of simplicity, the development of ACE is using a more restrictive view of cost, that is the only accounting costs, and leaving out the opportunity costs.

3.4.2 Cost-Utility Analysis

The cost-utility (CUA) is a technique of analysis used,especially, in Anglo-Saxon countries for the evaluation of health policies. In CUA the incremental cost of alternative investments is compared with changes in the health status of the community, which is measured with an indicator, the QALY Quality-Adjusted Life-Years, which considers both the quality and lifespan. In summary, the CUA is just a form of CEA that uses a more complex measure of effectiveness. The CUA is therefore mainly used for alternative interventions for which there is a trade-off between quality and length of life. Since the similarity between the CEA and the CUA, in this context we do not analyse this tool, but for the techniques and the limitations on the application of the CUA we refer to those for the CEA.

We can conclude this section pointing out that in order to avoid more philosophical and moral problems it has been lost one of the CBA's strength, that is the use of a single unit of measure: money. In saying this we do not want to belittle the problem of the inability to monetize untouchable values. We would like only to point out that it is almost impossible to have a tool that is ethically correct and functional.

3.5 Risk and Uncertainty

In this section we want highlight the importance of risk and uncertainty since these aspects can produce problems in using CBA especially in public context.

Synthesizing what we have said above, the first step in CBA is to identify and to quantify all relevant costs and benefits as seen from society's viewpoint. The NPV is then found as the sum of the discounted flows of costs and benefits over the presumed life of the policy or project. Absent risks and uncertainties, a NPV above suggests that the project entails a potential efficiency improvement as benefits exceed costs, implying that possible losers can be compensated from the gain of the winners. In practice all CBAs make use of estimates of variables which can only be assessed or forecast imprecisely. The risk or uncertainty of the variables entering a CBA will affect the precision of the estimated expected NPV and

often also the expected NPV itself. It is therefore important to consider the effects of risk and uncertainty when undertaking cost benefit analysis.

The returns on both private and public projects are affected by risk and uncertainty, but the main difference is that some of the costs and benefits in social CBA are very uncertain because they are non-marketed goods or services, moreover, the outcomes are very far into the future and with very complex cause-effect relations [113]. Where a private company might need to consider the sales prospects for few years, governments seeking to select socially beneficial environmental policies must incorporate a broad range of costs and benefits over a long time horizon. Other differences in policy or project assessments between a private and a public decision-maker include different attitudes to risk and uncertainty and different diversification possibilities.

For brief treatments of risk and uncertainty in CBA are available in many standard textbooks on cost benefit analysis, for example Campbell and Brown [49], Johansson [137], Brent [42, 44]. Several government guides to CBA also discuss the treatment of risk and uncertainty, CBA European Community Guide [228], Treasury Board of Canada [208], HM Treasury [280], U.S. Environmental Protection Agency [5]and NCEDR [200].

However, as write Staehr (2006) [271]:

> *no method of risk and uncertainty analysis fits all cases of CBA. Depending on the case it can be useful to apply various ad hoc methods. A risk averse decision-maker may seek to avoid overestimating the NPV by adjusting costs upwards or benefits downwards, by shortening the period for which benefits are counted or by discounting benefits heavily.*

3.5.1 CBA under risk and uncertainty

All the discussion above assumed that all variables are deterministic, i.e. there are no risks involved in the life of the project or policy. This is clearly not a realistic hypothesis in any case. The question is how the incorporation of risks changes the CBA and the normative use of the methodology. The NPV calculated above will now depend on the realization of the variables subject to risks. A natural starting point is therefore to consider the "expected net present value" of the policy. This means that the mathematical expectation conditional on information before to the initial period, i.e. before to the decision of whether or not to implement the project. Note that CBA assumes that the policy remains in place during the entire policy horizon and cannot be discontinued or reversed e.g. in case the performance of the project deteriorates. This assumption is reasonable for many policy, but not for others. The net present values presented in most CBA are actually expected net present values. The expected NPV is usually found by using the expectation to the value of all the variables entering the calculation. When two or more random variables enter the CBA calculation non-linearly, this method for estimating the expected net present value will

generally only approximate the mathematically correct expectation. If the random variables enter multiplicatively, the method of finding Expected NPV using expected values for all random variables will only be correct if the correlations between the variables entering non-linearly are zero. If a random variable enters as the denominator in a fraction, then the method generally produces a result which is not the mathematically correct expectation. Thus, the standard way of finding the expected NPV is usually only an approximation. To obtain a mathematically correct estimate of the expected net present value, one would need to include knowledge of the distributions of the variables entering non-linearly in the NPV calculation [271].

Now, let us now turn to the normative aspects of the CBA when random variables enter the calculation of the expected NPV. In order to do that we report the words of Staehr [271]:

> *In particular, is it in this case reasonable for a government to use the equivalent of the "Kaldor-Hicks compensation principle" and use Expected* $NPV > 0$ *as a condition for project selection? The question is still unsettled in the theoretical literature but it is possible to draw together some guidance. Social welfare is usually presumed to be an aggregate of the well-being or utilities of individuals in society. The starting point must therefore be the attitude of individuals toward risk. It is generally assumed that individuals are risk averse and concerned about their expected utility. Individuals are willing to pay for insurance which limits their loss in case an unfavorable event takes place, e.g. their home burns down. In other words, individuals usually do not only consider the expected return, but also the distribution of the return. Being exposed to a risk constitutes a cost to risk adverse individuals and they are willing to pay in order to reduce or eliminate the risk. Thus, assuming that individuals are risk adverse, the question is how to account for risk in a project or policy which affects all risk adverse individuals similarly.*

This problem was analyzed also by Arrow and Lind (1970) [12] where they derived the "Arrow-Lind theorem" based on the idea of risk spreading. In fact, they assume that all n persons in society are identical and that all benefits and costs are equally divided. Thus, when the number of persons increases, the individual risk decreases and, correspondingly, the individual's welfare cost from the risky policy decreases. Moreover, Arrow and Lind (1970) show that also society's total welfare loss (the aggregate loss of persons) from the risky policy decreases. They say that on the margin, when n approaches infinity, the randomness of the policy does not affect social welfare at all. In other words, the spreading of risks to many persons implies, under a number of conditions, that a project can be evaluated only on the basis of its expected NPV (see [93, 219]). However, the Arrow-Lind theorem builds on a number of assumptions which are unlikely to be met in practice [219]:

1. *in no cases can risks be spread among an infinite number of individuals. A country*

has always a finite number of individuals and, hence, there will still remain risks borne by society.

2. *the theorem assumes that all risks are shared equally by all individuals. In practice, this assumption is unrealistic. Most projects will likely expose some individuals to more risks than others, for example, the environmental problems associated to some particular plant. Arrow and Lind (1970) consider this situation and show that if there are actuarially fair insurance markets, then risk averse individuals will insure away the idiosyncratic risks, i.e. the risks specific to the individual, so that eventually all individuals will only be exposed to the economy-wide risks associated with the policy. It is clear, however, that insurance markets do not exist for very many contingencies, so in general risky projects will affect some individuals disproportionately so that the spreading of risks will be imperfect.*

3. *the risk spreading argument breaks down if the risks take the form of an externality affecting everybody equally, irrespective of the number of individuals in society. A project leading to ozone depletion will likely affect everybody independently of the number of individuals in society. When a risk in this way takes the form of a public good (or rather a "public bad"), then the societal risk will not be reduced when the number of individuals increases.*

In practice

Leaving aside the theoretical discussions we want present now a number of methods used in practice to incorporate risk and uncertainty into the CBA.

Adjusting the expected NPV to take account of risk aversion

There are number of methods used to adjust the calculated expected NPV in order to take into account risk aversion when assessing a project or policy. In other words, the methods are used to add "caution" to the decision-making process when risks and uncertainties are present. In practice, the specific form of the social welfare function and/or the preferences of the decision-maker are not known. These methods are:

- Cut off period
  Many projects and policies involve large negative net benefits in the early stages and positive net benefits in the later stages. A crude way to reduce the risk of adopting socially unfavorable projects or policies is to cut off the period of positive net benefit flows [188]. The method implies that net benefits beyond the cut-off period are perceived to have a social value equal to zero. Note that the cut off method will increase the risk of implementing socially unfavorable policies if the discharged periods are

mainly periods with negative net benefits. Usually, this method is used in private project assessments.

- Risk-adjusted discount rate
  It has been suggested that the discount rate used should be adjusted upwards to reduce the weight of later periods in the calculation of the expected NPV [188]. The reason is that in some cases it is easier to forecast developments in the near future than in more distant periods. The discount rate should be higher in the case with risk and/or uncertainty than in the deterministic case. The method is clearly not appropriate if the main risks and uncertainties derive from the early periods. More generally, the use of a higher discount rate than under certainty is based on the implicit assumption that the risk and/or uncertainty compound itself geometrically over time. The method is also conceptually a bit unappealing as it blends accounting for the true time preference and for risk aversion [208]. It is sometimes argued that it is reasonable to use a decreasing discount rate if the discount rate itself is subject to risk and the time horizon is long.

- Certainty equivalents
  The calculation of certainty equivalents is a method to adjust the expected NPV to take into account risky and/or uncertain net benefits based on an explicit welfare theoretic foundation. For each period of the policy life, the certainty equivalent is the fixed (non-random) net benefit, which would make the decision-maker indifferent between the fixed value and the random net benefits. The certainty equivalent is smaller than the expected (or average) net benefits if the policy-maker is risk averse. The difference between the certainty equivalence and the expected net benefit is called the risk premium. The main challenge of using the method is to find a reasonable estimate of the certainty equivalent. This would require knowledge about both the distribution of the net benefits in each period of the project life and also the policy-maker's preferences with respect to risk.

- Downward revision of benefits, upward revision of costs
  The use of certainty equivalents implies that a project with risky net benefits have a lower expected NPV than otherwise. The method, however, requires some computations and a prior knowledge of the distributions of the variables entering the CBA calculation. This has resulted in the suggestion that expected values of risky or uncertain benefits are adjusted downwards on an ad hoc basis. Experiences from other countries or previous projects might provide some guidance for the appropriate adjustments. In particular, the adjustments might be relatively small if the cost and benefit flows are known with a relatively large degree of certainty.

- Safety margin

A crude, but widely used, way to let risk and uncertainty affect the evaluation of the expected NPV is to demand a sizeable safety margin. Instead of requiring that expected NPV should simply be positive, it is often assumed that it should be larger than a preset positive value. Alternatively, a large positive expected NPV is interpreted as providing a desired "safety margin" for acceptance of a project with the implicit premise that the main result would not change had risk or uncertainty been incorporated.

Concluding this focus on risk and uncertainty we just quote a famous sentence of P.L. Bernstein [25]: *The revolutionary idea that defines the boundary between modern times and the past is the mastery of risk: the notion that the future is more than a whim of the gods and that men and women are not passive before nature.[...] Like Prometheus, they defined the gods and probed the darkness in search of the light converted the future from an enemy into an opportunity.*

3.6 Criticism

Given the role of cost-benefit analysis (CBA) in public decision-making and the significant implications of policy decisions informed by such analysis, it is easy to understand that both the process and application have long come under study. Actually, criticism might be divided into two groups:

- philosophical concerns, generally broad questions of ethics, morality, and CBA usage;
- economic/technical issues, usually more pointed critiques involving questions such as non-market valuation and discounting.

Much of the criticism directed towards the use of CBA are about its uses as a mechanistic decision-making criterion or as a method by which is possible to provide knowledge and inform possible outcomes. This dichotomy is by no means unique to the discipline of CBA; rather, it is one example of the broad debate surrounding science in many forms and across many disciplines. Sarewitz [243] writes that scientific inquiry is inherently and unavoidably subject to politicization in a controversial decision-making environment, and thus that "political controversies with technical underpinnings are not resolved by technical means". Fundamentally, most criticism of CBA stems from the pervasive and problematic notion that "science is a source of facts and theories about reality that can and should settle disputes and guide political action" [243]. Science will not furnish a decision without direction as to policy goals or social mores. However agreement can sometimes be reached about the means to reach a decision, even if not about the decision itself.

The decision to use CBA is itself both an ethical and technical decision, but the way in which it is used, however, can rest in considerable part on science. Concerns of intergenerational equity, discounting, and distribution are finally political or ethical questions, it is its analysis that maintain economic or scientific components. Certainly, the rationality under the BCA must be explicitly stated from the beginning to the end of the analysis. Thus, while decisions made by the analyst or policy maker are open to critique, it is illogical to condemn the tool itself on such grounds. It is important remarques that CBA is not a mechanistic decision maker, and should not be viewed or presented as such. The proper use of CBA is to furnish information and predictions. Thus, in reality, much disagreement surrounding CBA reflects democratic deliberation regarding values and usage, and does not speak to the legitimacy of CBA in and of itself [312].

Another general criticism contends that BCA is not sufficiently inclusive, encompassing, or informed, but such criticism is inappropriate given that CBA is fundamentally an application of deterministic modeling [312]. CBA is applied to complex social, political, economic and ecological systems; complex systems theory holds such systems to be nonlinear and intrinsically uncertain, inherently limiting the potential accuracy and holism of a CBA model relative to its real-world analog. Thus, any particular CBA model represents a simplification of the real world, intended not to reflect reality in comprehensive detail, but rather to inform decision-making about the efficiency of alternative policies. This is not so say that all criticisms of CBA are poorly founded; in fact, discerning critics have and continue to drive constructive growth and development within the field. The most trenchant criticisms are:

- First, recognition that the usage of KH and the potential compensation test (PCT) entails a value judgments in and of itself, even though the fundamental premise of practical welfare economists has been to avoid value judgments and interpersonal comparisons of utility in conducting analysis and making policy prescriptions.

- Second, there is widespread criticism that CBA is missing important values. This criticism reflects the valuation structure and scheme of classic KH and PCT analysis, which does not fully reflect the values and goals we hold as individuals and a society, as it often neglects equity and other moral values [314]. While including moral value and judgement in CBA analysis certainly cannot resolve moral issues, critics are correct in asserting that much past CBA work has failed to incorporate existing moral sentiment into the model and output [312]. Axiomatically, unless CBA includes values held for distributional effects and other "equity goods", then values will necessarily be missing [314]. And it is missing values that lie at the heart of most legal and philosophical criticism of CBA as a technique.

Changing kind of criticism we present something more specific of the CBA tool arises first from the managers, that is the static way of thinking related to the CBA. The future is

seen as certain sequence of events, where is impossible to change or to adjust a decision that has already been taken. Indeed the insight about NPV gained through the simplification comes at cost: any insight about what it means for a project to have different risks is completely lost [10]. Obviously this is an not negligible limit, because the risk is really function of how the payoffs differ across different states of the nature. This is overall true when the future depends on variables out of hand and therefore the uncertainty and the risks are relevant. We believe that the impacts of this limit is still more serious if the valuation's object is a policy investment. Where the variables are numerous, in steady evolution is fundamental to have more flexibility in order to be able to adjust the strategy during the policy evolution and when the information becomes available.

Concluding this section we want underline two things that will be very important in the following and that are fundamental for our research. The first thing is that CBA is a tool that inform and help the decision-maker in order to decide where and when is better to do an investment; and second that the real CBA problem is not the unsuitability to incorporate moral and value judgements, but its lack of managerial flexibility. These two aspects play an important role in our research. In fact, we retain that as a tool the CBA makes clear useful investment aspects, and it is possible because the tool uses a normative rationality, which is recognized as true by the community. Then the absence of flexibility makes the policy assessment too rigid and misleading, and to overcame it we will present the Real Options Theory. Such theory is based on the same rationality, while the tool allows to incorporate the flexibility.

3.7 Conclusion

This chapter has focused on the most used evaluation tool: the Cost-Benefit Analysis, called just CBA. Within the chapter many aspects have been reviewed and analyzed, but all under a public policy perspective. This is also the reason for some theoretic and practice simplifications and for some presentation choice. From the this research we had the opportunity to understand some important things:

1. The normative rationality of CBA has been of great importance for its achievement in the history. It was such rationality has let that the CBA would be universally accepted and recognized as legitimate. Since, once accepted a particular way of thinking and seeing the world, its tools will seem the only acceptable, all its consequences will be justifiable, and its results the only rational and logic.

2. The relative simplicity CBA's logic makes the tool easy to understand for everybody politicians and common people, but at the same time its theoretical aspects are coherent and rigorous for experts. Such aspect is very important in order to ensure

transparency (at least in appearance), but also reproducibility and verifiable. These last two feature, in an organization as the EU, are of great importance. In fact, since EU is composed of many country, with difference habits in decision process, evaluation tools, and benchmark of choice, it becomes important have one method equal for everybody and if necessary verifiable by the Union.

3. The NPV (or ENPV) is a clear, defined and very synthetic indicator of performance. This indicator is easy to understand, and moreover, it is very useful to take and communicate decisions, and in order to compare alternatives or different investments.

4. The CBA has a static vision of investment decisions, it does not consider the possibility of changing some parameters of the analysis in the future, or to incorporate new information in it. This make the CBA a tool all now or never. In this way the tool is not able to account policy-makers managerial power and flexibility; losing opportunity and value.

5. The CBA logic is done to just evaluate and give a "yes or not" suggestion. The tool is not able to stimulate the decision-maker in finding other alternatives, or structuring the problem in a different way, thus it can not be defined a real process tool. It could be put as evaluation tool in an already defined decision process, process build independently from the used evaluation tool.

Concluding this chapter we want overall remember the classic words of statistician George Box [96],

> "all models are wrong, but some are useful".

CHAPTER 4

Decision Theory (DT)

4.1 Introduction

In the previous chapter we presented the cost-benefit analysis as a decision aiding tool for public policies. Studying it we highlighted its strengths and weaknesses especially when applied to public policies. Now, in this chapter we will present the decision theory (DT), a field of study whose aim is to understand what is the meaning of "good decision-making",and what are its constituents.

However, differently from the other two chapters, in this case we will not present the topic with its history and an explanations as comprehensive as possible, but only with some concepts and tools, which will be useful to understand in the following our idea, model and demonstration. This difference is due to the fact that the decision theory is a huge and diversified field of study, which includes a number of theories and tools irrelevant for our research.

In decision theory the decisions are not just an "*act of choice*" [213], but they are something much more complex. Decisions can be seen as results of a "decision process", a set of cognitive activities enabling to go from a *problem*, namely, a state of the world perceived as unsatisfactory, to its *solution*, namely, a state of the world perceived as satisfactory, if any exist [213, 290]. Researches conducted in "Problem Structuring Methodologies" (see [236, 254, 254]) have shown that decision aiding is not just to offer a solution to well established mathematically formulated problems, but to be able to support the whole decision process: representing the problem situation, formulating a problem, and also constructing recommendations. In other terms, to the concept of decision process we can associate the concept of *decision aiding process* [290].

A decision aiding context and decision making context are different. In a decision making context we are only concerned by the decision-maker activities, and he might use a decision theoretic tools in order to establish possible action to undertake(there is no distinction between analyst and a client). However, in a decision aiding context there are at least two distinct actors: the *client* and the *analyst*, both playing different roles [290].

> *A decision aiding context only makes sense with respect to one or more decision process, the ones where the client's concerns originate. The set of activities occurring within such a setting is called "decision aiding process". The ultimate objective of this process is to arrive to a consensus between the client and the analyst. On the one hand the client has a domain knowledge concerning the decision process. On the other hand the analyst has a methodological knowledge, that is domain independent.* [290]

We want to highlight that the analyst here, differently from other fields, must use a formal language (mathematics) which reduces ambiguity and it is independent from the context.

He uses what is called a "decision support language", thus introducing a "model of rationality" in the decision aiding activity. Moreover, this language improve transparency and allowing the re-use of procedures and models, however it has beside advantages also some disadvantages.

In order to explain better advantages and disadvantages of formal language we follow the Bouyssou et al. presentation [38]:

Advantages

- *it allows the participants in a decision process to speak the same language, a fact that improves the transparency of the process and possibly increases participation* (see [14]);
- *it allows the identification of the underlying structure of a decision problem (if there is any) and therefore allows the re-use of procedures and models* (see any textbook of Operational Research, e.g. [308]);
- it is not affected by the biases of human reasoning that are due to education or tradition (see [234]);
- *it may help to avoid the common errors that are due to an informal use of formal methods; a typical case being the use of averages as a universal grading procedure* (see [37]).

Disadvantages:

- *it is much less effective with respect to human communication;*
- *it has a cost (not necessarily monetary);*
- *reducing ambiguity might not be desirable;*
- *it impose a limiting framework on people's intuition and creativity.*

Before getting to the heart of the chapter and of the decision theory, we want just highlight because we believe that the DT will be useful for this research:

- as we said in the previous chapter, in order to work in public policies field we need to support the policy-maker through the whole process, thus with a "decision aiding process" which is perfect for our purpose because it is not only an evaluation tool, but a process tool, where the evaluative aspects is just one of many;
- policy decisions must be legitimate and also accountable, in order to ensure that the process and the tools use normative and constructive rationality and the DT can do that;

- we believe that some DT concept as “multi attribute utility”, ”information value” or some way to consider “subjectivity”, “probability” and “uncertainty” would be very useful when applied to public policies.

4.2 Decision Aiding Process

> *“Making decisions is what you do when you don’t know what to do. Decision analysis is a process that enhances effective decision making by providing for both logical, systematic analysis and imaginative creativity. The procedure permits representing the decision-maker’s information and preferences concerning the uncertain, complex, and dynamic features of the decision problem.* [124]

In this section we will try to introduce a general description of what the decision aiding process is, and what are the tools and the models used within this process in order to construct recommendations. With the term “ model of decision aiding process” we want to indicate any process in which at least two different agents endowed with cognitive capabilities have to share some information and knowledge in order to establish some shared representation of the process object, which is a common representation of client problem and any potential solutions. These representations are called *shared cognitive artifacts*. The decision aiding process can be described and characterized by four such artifacts:

- representation of the problem situation;
- problem formulation;
- evaluation model;
- final recommendation.

Further on we will go through each artefact. In order to illustrate quickly the different models we will use an example 4.1, borrowed from Stamelos and Tsoukiàs [270] where the aforementioned concepts have been put into practice.

Example 4.1
A new mobile telecommunication operator has been established in a small but high competitive European market. One of the basic operational tools of such companies is their billing system *(BS). This system allows both a structured accountancy of the traffic and a flexible policy towards the existing and potential clients. Sone years after the establishment of the company the necessity to upgrade or to substitute the existing BS become evident to the management. A decision process has therefore been triggered and the authors have been asked to provide decision support.*

4.2.1 Problem situation

The first step of the process consists in offering a representation of the problem situation for which the client has asked the analyst to intervene. This representation is the result of an effort at answer to questions of the type: who has a problem? Why is this a problem? Who decides on this problem (who is responsible)? Who pays for the job? What is really important for the client? How is the client committed in this situation? The construction of such artifact allow, on the one hand at the client to better understand his position with respect to the decision process for which he asked the support. On the other hand at the analyst to better understand his role into the decision process.

A representation of the problem situation can be conceived as a triplet:

$$P = \langle A, O, S \rangle$$

where:
A: are the actors involved in the process (as described by the client and perceived by the analyst);
O: are the objects (stakes) of the different actors;
S: are the resources committed by each actor on each object of his concern.

We have to keep in mind now that a decision aiding process always refers to a decision process in which the client is involved. Decision support is always requested with respect to a decision process. Representing a problem situation corresponds to taking a picture of the decision process at the moment the decision support is requested. Here is important to recognize the actors involved, the reason why they participate and what their concerns (the objects) are and what their level of commitment (the resources) is. Several different representations of the problem situation can be constructed during a decision aiding process.

Example 4.2 (*Example 4.1 cont.*)

- *The actors A involved were: the acquisition manager; the information systems manager (IS); the marketing and sales manager; the software suppliers; the IS consultants.*
- *The objects O involved in the process were: the market share of the company; the policy towards the suppliers; the company's internal organization; the billing system itself.*
- *The resources S implied in the process included the necessary funds for the billing system, the knowledge about billing systems and the relations with the software suppliers. The available time was very short, since all decisions had to be made in the least possible time due to the extremely competitive environment.*

- *The problem situation P results from the explicit representation of the sets described above.*

4.2.2 Problem formulation

Given a representation of the problem situation, the analyst may provide the client with one or more problem formulations. This is a crucial point of the decision aiding process, that reduces the reality of the decision process within which the decision-maker is involved to a formal and abstract problem. The result is that one or more of the decision-maker's concerns are translated, by a decision support language, to "formal problems" on which we can apply a method and techniques. The problem formulations are not similar and are not neutral with respect to the possible final recommendation. Indeed we, want to emphasize that adopting a problem formulation implies adopting a precise *strategy* towards the problem situation.

A problem formulation can be conceived as a triplet:

$$\Gamma = \langle \mathbb{A}, \mathbb{V}, \Pi \rangle$$

where:
$\mathbb{A}$: is a set of potential actions that can be undertaken by the client with respect to the problem situation P;
$\mathbb{V}$: is a set of points of view from which the potential actions are observed, analyzed, evaluated, compared, etc.;
Π: is a problem statement which anticipates what is expected to be done with the elements of A (see: [13, 209, 238]).

The use of problem formulations aims to anticipate the possible conclusions of the decision aiding process.

Example 4.3 (*Example 4.1 cont.*)
The strategic decision with which the management was faced consisted in choosing one among the following options: upgrade the existing BS, buy and customize an existing BS, buy a BS created ad-hoc for the company by an external supplier (bespoke system), develop an ad-hoc BS in collaboration with an external supplier. However, the management was not able to choose an option without analyzing what the billing system would eventually be in all such options. Therefore, three problem formulations were provided. Here we present just the one concerning the developing option. $\mathbb{A}$*: a set of suppliers whom it could be possible to co-develop a new BS;*
$\mathbb{V}$*: costs, requirement analysis and satisfaction, timing, benefits, for the company etc.;*
Π*: selection of a co-developer to establish a co-makership policy and therefore a long-term*

collaboration .

4.2.3 Evaluation model

For a given problem formulation, the analyst may construct an evaluation model, that is to organise the available information in such a way that it will be possible to obtain a formal answer to a problem statement.

An evaluation model can be viewed as an 6-tuple:

$$M = \langle A, D, \mathcal{E}, H, \mathcal{U}, \mathcal{R} \rangle$$

where:
A is the set of alternatives to which the model applies. Formally it establishes the universe of discourse of all relations and functions that are going to be used in order to describe the decision-maker's problem.
D is the set of dimensions (attributes) under which the elements of A are observed, described, measured etc. Formally D is a set of functions such that each element of A is mapped to a co-domain that we denote as X_i.
$\mathcal{E}$ is the scale associated to each element of D.
H is the set of criteria under which each element of A is evaluated in order to take in account the decision-maker's preferences.
$\mathcal{U}$ is a set of uncertainty structures. Depending on the language adopted,U collects all uncertainty distributions or the beliefs expressed by the decision-maker.
$\mathcal{R}$ is a set of operators such that it is possible to obtain a comprehensive relation and/or function on A, possibly allowing to infer a final recommendation.

Example 4.4 (Example 4.1 cont.)
It is clear that each problem formulation may generate a quite different evaluation model. For instance for the developing option, the main elements of the evaluation models are: A: co-developing suppliers; H: the implication of the information system department in development process, the benefit of "selling" the new billing system; $\mathcal{R}$: procedure for a choice problem.

4.2.4 Final recommendation

The evaluation model will provide an output (Φ) which is still expressed in terms of the decision support language. Thus, the final recommendation is the final deliverable which translates Φ into the decision-maker's language. In other words, the final recommendation should be able to translate the conclusion of the decision aiding process into a format that can be used in the decision-maker's process.

4.3 Problem Structuring

The problem formulation is one of the many steps of the process. In fact, the idea to fit a decision situation to an already given decision model may result in solving the wrong problem correctly. To avoid this situation we need to give attention at the problem formulation through a careful *problem structuring*. Problem structuring is defined as the most important activity in decision making [187, 2].

About problem structuring usually considered more "art than science", there is a bit', but not so much literature. Here, we do not think to be exhaustive in presenting this topic, but our intention is to give just a general framework. Our aim is to show some specific aspects and methods, in order to explain in which way we imagine the some ROT's ideas as decision aiding tool.(To know more about problem solving see: [2, 21, 26, 45, 63, 64, 83, 84, 85, 145, 157, 166, 180, 186, 202, 224, 263, 264, 276, 311]).

Usually, talking about decision-making we talk about evaluation model, assuming the existence of well defined alternatives (or options), attributes (or objectives), outcomes and state of nature. However, many real decision tasks are "ill-defined" or "ill-structured", alternatives and outcomes have not been identified, and attributes and state of nature have been not defined. In this cases we should help in facing more *soft* decision situation that need to be structured [145].

Simplifying, the issue is: first set what the problem is, and then consider how to solve it. Remembering that these two stages are dynamic and iterative.

Problem structuring methods (term coined by Rosenhead [236]) aim to help decision-makers to better understand their concerns, in order to better justify and legitimate their conclusions (it is very important in our case). Indeed, they may not agree on the appropriate objectives, or even on the set of possible actions (or alternatives), and where it may be meaningless to talk about optimization, since a resolution usually involves a compromise.

Several problem structuring methodologies consider that decision aiding is problem structuring. In other words, the quantitative aspects on which evaluation models usually rely are considered irrelevant, neglected or not at all considered under the not unrealistic claim that once decision-maker has a definitely clear idea of what the problem is, he also knows how to solve it.

Over the years, many problem structuring methodologies have been developed. Such approaches to problem structuring are often extended procedures, emphasizing the creativity of a group of people, and are typically organized by a facilitator or an analyst. In the literature, the recommendations are often concentrate first on the attributes or values and objectives and then on defining alternatives. A typical example is Keeney's "Value-Focused Thinking" [142].

4.3.1 Valued-Focussed Thinking

Keeney in his book "Value-Focused Thinking" (VFT), claims that usually decision making methods put their attention on assessing alternatives (or options), considering that such alternatives have been already established and defined. Instead, he argues that the attention should be given to how such alternatives are or can be defined, and Keeney's suggestion is to think about values and objectives. His main idea is that as soon as the decision-maker has been able to structure his objectives he is also able to build, consider and compare alternatives that were not there at the beginning of the process, but appear desirable and feasible within the objectives and values structure. For Keeney structuring objectives implies establishing a hierarchy of values starting from "fundamental objectives", which should be:

- essential: indicate consequences in terms of the fundamental reasons for interest in the decision situation;
- controllable: address consequences that are influenced only by the choice of alternatives in the decision context;
- complete: include all fundamental aspects of the consequences of the decision alternatives;
- measurable: define objectives precisely and specify the degrees to which objectives may be achieved;
- operational: make the collection of the information required for an analysis reasonable, considering the time and effort available;
- decomposable: allow the separate treatment of different objectives in the analysis;
- non redundant: avoid double counting of possible consequences;
- concise: reduce the number of objectives needed for the analysis of a decision;
- understandable: facilitate generation and communication of insights for guiding the decision making process.

Fundamental objectives are then structured in attributes for which value functions (or utility functions) can be constructed in order to measure the desirability of the outcomes and achievements for each objective. Such attributes result in "decomposing" the fundamental objectives into "sub-objectives", dimensions that contribute in defining the decision-maker's values.

The resulting structure of objectives and attributes allow to the decision-maker to have an organized insight into the problem situation. Indeed, the decision-maker might be able to concentrate his attention on high-valued alternatives or make use of generic alternatives, in order to expand the decision context or even to consider each of his concerns as "decision opportunities" rather than as "decision problems", thus allowing to take into account a new unforeseeable paths of action. Keeney claims that by structuring the decision-maker's values his approach enables to expand the set of feasible actions through structured desirability (from the highest to the lowest value).

Finishing this section we just want to underline the relevance of value theory and the importance to have a good set of alternatives. Indeed, without the assumptions of such theory it is impossible to find consensus on what it is better to do, and as a consequence, to build a shared evaluation model. At the same time, without a complete set of alternatives reflecting the value and preference of the decision-maker, we could not find a suitable solution to his problem.

4.4 Decision Under Risk and Uncertainty

As already mentioned when we talked of value, we consider to know with certainty what are the outcomes, namely the consequences of our choices. Usually, such assumption is unrealistic for many real decision problems. Indeed, in real life decisions choices are full of uncertainty. For this reason uncertainty assumes a great importance, and it should be considered in the analysis.

The study of risky decisions or decisions under uncertainty has a long, distinguished, and interdisciplinary history. The list of contributors include some of the most prominent figures in economics and psychology, including several Nobel Prize winners in Economics, and moreover their ideas have been applied with great success to business, law, medicine, political science, and also in public policies.

Usually in decision theory risk is analyzed and managed by using "the expected utility theory", Bayesian probability as (subjective probability), and by Bayesian decision tree. Before enter into the details with these theories and tools we believe important to make a distinction between risk and uncertainty.

Risk defines decision situations in which the probabilities are objective or already given. Instead, uncertainty defines situations in which the probabilities are subjective, that is the decision-makers must estimate or infer the probabilities. Based on this definition we can say that in our research we will deal with *uncertainty*.

4.4.1 Utility and Expected Utility Theory

It is no exaggeration to consider expected utility theory one of the most important paradigm in decision making since the Second World War. It has been used prescriptively in management science (especially decision analysis), predictively in finance and economics, descriptively by psychologists, and it has played a central role in theories of measurable utility. The expected utility model has consequently been the focus of much theoretical and empirical research, including various interpretations and modifications as to its mathematical form.

The theory, that we want to describe here, is known as expected utility theory. This can be divided in two: "decision-making under risk", due to von Neumann and Morgenstern [299], where the probability of the outcomes are known; and "decision-making under uncertainty", due to Ramsey [232] and Savage [244], where the outcomes are tied to uncertain events whose probabilities are not known. The main ideas is to define the utility of an outcome equal to the probability of winning a standard prize in a gamble, such that the decision-maker is indifferent between receiving the outcome for sure and accepting the gamble [302]. The primitive notion of expected utility theory is an individual's preference relation $\succ$ (is preferred to) on a set of risky, or uncertain, alternative decision. The principles of the theory are statements about $\succ$ that are referred to *axioms*.The implications of the axioms are further statements about $\succ$ that are deduced from the axioms. Some of these show how preferences correspond to a numerical structure that give rise to an expectation operator that lies behind the name "expected utility" [20].

Bernoulli (1738) is the first that discuss about utility in order to explain the St Petersburg paradox, which involves the proper evaluation of a particular uncertain gamble. Bernoully's explanation was that money was not an adequate measure of value. Instead he suggested that the worth, or utility, of money for each individuals was non-linear and had a decreasing slope. That is, marginal utility decreased as wealth increased.

In the 1920s, many economists argued that the economic theory could be founded on a less demanding assumptions about measuring utility (see in particular Pareto 1927). But, it was not until the 1940's and 1950's that the concept of utility resurrected. In these years, in fact, the mathematician von Neumann and economist Morgenstern axiomatized the modern expected utility model to prescribe how people should evaluate options about which they were uncertain [299]. Whereas Bernoulli assumed the expected utility representation, von Neumann and Morgenstern provided an axiomatic system: a set of conditions that were necessary and sufficient for expected utility. Axioms have a descriptive as well as normative benefit: they decompose a complex theory into smaller pieces, each of which can be tested empirically or scrutinized as normative principles. In their own words they "*prac-*

tically defined numerical utility as being that thing for which a calculus of expectations is legitimate" [299].

Subsequently Savage in 1954 [244], starting from the definition and axiomatic system of utility given by von Neuman and Morgenstern, proposes another axiomatization which combines the subjective probabilities and utility. Therefore, Savage extend the theory of risky choice to allow the simultaneous determination of subjective probabilities for outcomes and for a utility function u defined over these outcomes. Deduced probabilities in Savage's model are personal or subjective probabilities, and the model itself is a subjective expected utility representation.

An important concept in expected utility theory is the risk aversion. If some gamble is less (or more) preferred than its expected monetary value for sure, the preference is said to be risk-adverse (or risk-seeking). A concave utility function implies risk averse preferences for gambles within the range of concavity: i.e., their certainty equivalences will be less than their expected monetary values [249].

The expected utility model, as normative theory, has played an important role, but at the same time has been severely criticized and challenged by empirical studies. Here, we not discuss the critics, paradox and the relative new theory, because for us, it is important to note that despite all this, expected utility theory remains the foundation of all that is called rational. Rationality recognized and regarded as legitimate.

4.4.2 Value Functions

Talking about value function means talk about decision-maker's preferences, or also about their perceptions. Value functions are some of the more widely applied decision theory and have benefited from the long-standing interests of psychologists, engineers and management scientists who have been nurtured through a continuing awareness of behavioural and social issues as well as the underlying theory [21]. In practice, the value function $v(x)$ assigns a number, namely a "value", to each attribute level x, and this value describes the decision-maker subjective desirability of the corresponding attribute level.

Usually, the value functions are common in Multi Criteria Decision Analysis, where they are used in order to build a common scale of evaluation. In fact, when we must make a decision and we must choose among several alternatives, we select some criteria by which to evaluate the alternatives. However, sometimes this criteria are very different some are qualitatively and others quantitatively. Thus, how to compare them? We can compare them using the value function. In order to better explain this we propose a simple example.

Example 4.5 We imagine having to decide a holiday for the next month. We are very stressed by the work and so we decide to leave alone for a relaxing week. We are undecided whether to do a week in a cabin in the mountains in strictly contact with nature, or a week in a European capital to see some museums. How evaluate these two alternatives? In order to evaluate them we choose three criteria:

1. cost;
2. relax;
3. culture.

Now, we must compare these three criteria for the alternatives, but if comparing and sum different costs is easier, what to do with relax and culture? In order to do that we build three value functions, one for each criterion (fig 4.1).

We have build these value function asking ourselves what was the value of a given thing (euro, n. people, n. museum) on a scale from 0 to 1, then that we had transformed anything in a unique unit of measure, we can add all the value and compare the two alternatives. In this way we are sure to choose the best alternative.

For a more exhaustive explanation about this topic see: [37, 38, 144, 143, 230, 231, 302, 20, 142, 21].

4.5 Bayesian and Subjective Probability

If we want to incorporate uncertainty into our analysis we must develop and adopt some kind of calculus for handling it. The theory that is most commonly employed to do this is the one of probability. Probability theory is not very old, being usually dated back to the study of games and chance by seventeenth and eighteenth-century mathematicians such as Pascal, the Bernoulli, and Laplace.

Even if we decide to adopt probability theory as our tool for describing and incorporating uncertainty, we must also decide which of the many versions of that theory is better to employ. Indeed, over the last two centuries, theories of probability have been many and varied. Here, we will not treat the different theories, but we still want to make some remarks. It is important to note that the original ideas of classical theorists were found inadequate in dealing with the real world, since these theories did not incorporate a satisfactory method for measuring the probabilities. The a priori, or logical, theories of Keynes and Carnap, the relative frequency theories of Venn, von Mises, and Reichenbach, and the subjective theories of Ramsey, De Finetti, and Savage all claimed to improve on these ideas, but in different way [302].

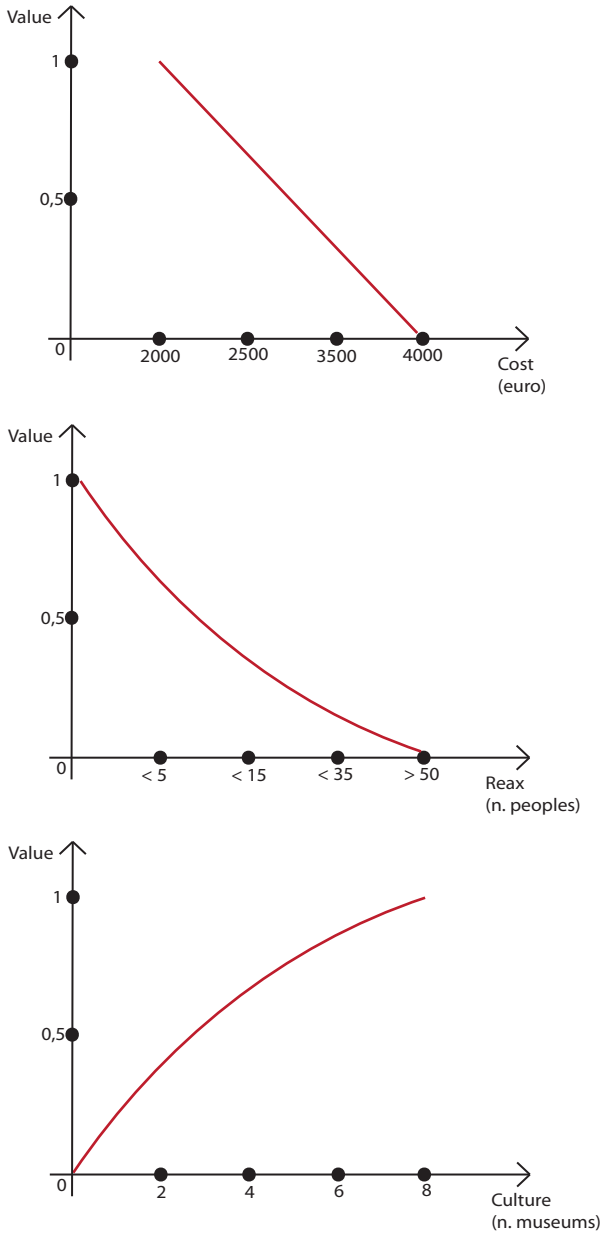


Figure 4.1: Value Functions

In our work we decide to present and use just the *bayesian probability* as *subjective probability*. In fact, it is recognized that a decision model needs to have a subjective component to be a valid framework for an inference: at least in operational setting

Bayesian statistical techniques are applicable when the information and uncertainty with respect to the parameters or hypotheses in question can be expressed by a probability distribution. The Bayesian paradigm is based on an interpretation of probability as a *rational*, *conditional measure of uncertainty*, which closely matches the sense of the word "probability" in everyday language. Statistical inference about a quantity of interest is described as a modification of the uncertainty about its value in the light of evidence, and Bayes' theorem precisely specifies how this modification should be made. Moreover, Bayesian methods reduce statistical inference to problems in probability theory, thereby minimizing the need for completely new concept, and serve to discriminate among conventional statistical techniques, by either providing a logical justification to some, or providing the logical inconsistency of others [24].

A fundamental element of the Bayesian paradigm is the use of the probability distributions to describe all relevant unknown quantities, interpreting the probability of an event as a conditional measure of uncertainty, on a $[0, 1]$ scale, about the occurrence of the event in some specific conditions. The value 0 and 1 respectively describes impossibility and certainty of the occurrence of the event.

4.5.1 Bayes' Theorem

"Bayes' theorem" or "Bayes' formula" is named by an English clergyman, Thomas Bayes (1702-1761), whose ideas were published posthumously in 1763. Bayes' theorem will be used as a normative tool, which tells how to revise the probability assessments, when new information becomes available.

The key idea is that the probability of an event A given an event B depends not only on the relationship between events A and B but on the marginal probability (or simple probability) of occurrence of each event. Thus, this theorem shows the relation between two conditional probabilities which are the reverse of each other. Bayes addressed both the case of discrete probability distributions of data and the more complicated case of continuous probability distributions (not discussed here). In the discrete case, Bayes' theorem relates the conditional and marginal probabilities of events A and B, provided that the probability of B is not equal to zero:

$$P(A|B) = \frac{P(B|A)P(A)}{P(B)}$$

where:
$P(A)$ is the prior probability or marginal probability of A (it does not take into account any information about B);

$P(A|B)$ is the conditional probability of A, given B (called the posterior probability because it is derived from or depends upon the specified value of B);
$P(B|A)$ is the conditional probability of B given A (called the likelihood);
$P(B)$ is the prior or marginal probability of B.

Bayes' formula in this form gives a mathematical representation of how the conditional probability of event A given B is related to the converse conditional probability of B given A (To reed more about Bayes' theorem see: [126, 135, 82, 17, 272, 24, 268]).

In this way Bayesian methods can be used to combine old and new information sequentially over time. By using the Bayesian methods the decision-makers will be able to capture the real option value changes over time as a result of uncertainty resolution.

4.5.2 Theoretical framework to Subjective Probability

Probability theory is an obvious construct for describing subjectively perceived uncertainty. When we looking for a subjective methodology which can systematically incorporate expert judgements and decision-maker's preferences the prime candidate to try out first is the Bayesian framework [268]. To apply it, it is needed a set of assumptions about an individual's judgements which, if satisfied, leads us to infer that a set of numbers must exist which describe that individual's perceptions of uncertainty. Moreover, these numbers should be combined using the rules of the probability calculus to infer what numbers should be used to describe other uncertainties.

The behavioural supposition are set out as axioms [302]:

1. For any two uncertain events, A is more likely than B , or B is more likely than A, or they are equally likely.

2. If A_1 and A_2 are any two mutually exclusive events, and B_1 and B_2 are any other mutually exclusive events; and if A_1 is not more likely than B_1, and A_2 is not more likely than B_2; then (A_1 and A_2) s not more likely than B_1 and B_2. Further, if either A_1 is less likely than B_1 or A_2 is less likely than B_2, then (A_1 and A_2) is less likely than B_1 and B_2.

3. A possible event cannot be less likely than impossible event.

4. Suppose A_1, A_2,. . . is an infinite decreasing sequence of events; that is, if A_i occurs, then A_i occurs for any i. Suppose further that each A_i is not less likely than some other event B, again for any i. Then occurrence of all the infinite set of events A_i, $i = 1, \ldots, \infty$, is not less likely than B.

5. There is an experiment, with a numerical outcome, in a given range, is equally likely.

If an individual is able to, or wishes to, express his judgements of likelihood according to these axioms, then numbers which describe his perceptions of the uncertainty of any event which satisfies the rules of the probability must exist. Conforming to these rules is the definition of what it means to be rational in evaluating uncertainty. Moreover, these numbers must satisfy the property of probabilities, that is:

1. $0 \leq p(A) \leq 1$;
2. $p(AorB) = p(A) + p(B) - p(AandB)$;
3. $p(AandB) = p(A)p(B|A)$.

Where:
A and B are any events, and we represent the probability of an event X by $p(X)$;
the probability of B occurring conditional on A occurring is written $p(B|A)$.

4.6 Decision Tree Analysis

Decision trees is a very famous an used tool that found its roots in decision theory. The literature on such tool is huge, and our aim is not to present them, but just to show what DTA is, how it works and why it is important for us. (To read more about DTA see: [231, 103, 240, 19, 94, 223, 302, 300, 252, 20].

The decision tree analysis most important things is that it can be extremely useful in helping decision-makers and thus the policy-makers in problem structuring. Decision tree can serve a number of purposes when complex multi-stage problems are encountered. They can help the decision-maker to develop a clear view of the structure of a problem and make it easier to determine the possible scenarios or alternatives which can result if a particular course of action is chosen. This can lead a creative thinking and the generation of options which were not previously being considered, like the value-focused thinking. Furthermore, decision trees can help the decision-maker to manage uncertainty and to judge the nature of the information which needs to be gathered in order to tackle a problem, and because they are generally easy to understand, they can be excellent mediums for communicating the perception of a problem [231, 103] .

Decision trees are also very useful in order to identify the best sequence of decisions. In fact we can consider a decision tree as a set of policies. A policy is a plan of action starting which option is to be chosen at each decision node, that might be reached under that policy.

Usually, in “bayesian decision tree” Two symbols are used in decision tree. A square is used to represents an option (decision fork), and the decision maker can choose which branch to follow. A circle, on the other hand, is used to represent a chance node, and the

branches which stem from this sort of node represent the possible outcomes of a given course of action, only that the branch which is followed will be determined, not by the decision maker, but by circumstances which are beyond any control.

The technique for determining the optimal policy in a decision tree is known as the "rollback method". To apply this method, we analyze the tree from the right to the left by considering the later decisions first. It can be seen that the rollback method allows a complex decision problem to be analyzed as a series of smaller decision problems.

4.7 The value of information

One of the most valuable insights provided by the expected utility theory, and also by the Bayesian probability is their ability to manage the value that some potential information might have.

Indeed, when we are involved in difficult and uncertain decisions it is common to try and reduce uncertainty before making the decision, thus looking for information. However, often gathering information might cost you money or time. Therefore, before collecting the information it would be good to assess whether the cost is worth the value gained. In this context the information is often seen as relevant or valuable only to the extent that it facilitates better probability estimates (or equivalently limits uncertainty) of t hose events which affect a decision problem.

The value of information is a concept studied in the literature of the various scientific fields, as economy, statistic, decision analysis, game theory and also psychology. Value of information concepts have developed most thoroughly in information economics which stems from statistical sampling concepts, Bayesian statistics and statistical decision theory. In our context, information is valuable when a message changes our expectations concerning events in a manner that facilitates decision and improves expected payoffs. The most typical model of the economic value of information is exemplified in works in which it is discussed the expected value of perfect information (EVPI) [194, 88, 246]. In these cases information is valuable only when the decision-maker can be expected to improve his prediction of an uncontrollable event such as market demand. Moreover, the information value is a subtle concept; it is not something which can be permanently attached to an item of information, since value depends on context.

Example 4.5

We consider a situation in which the decision maker is confronted with a decision problem. This problem is modeled according to the following decision tree.

Where:

$p(A) = 0.5$ and $p(B) = 0.5$

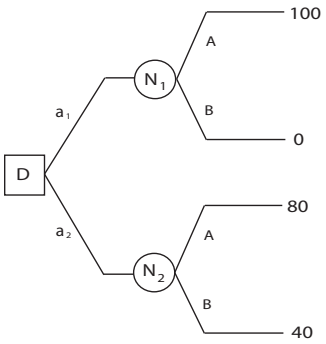


Figure 4.2: Decision tree

N_1 and N_2 are Nature's decisions

Assuming that the decision-maker think in terms of expected value (EV) the best decision is a_2, that has EV$= 60$ versus EV$= 50$ of a_1. Thus this value is called "Expected Value without Information"(EVWI). The EVWI represent in terms of expected value the best decision before the acquisition of any kind of information.

4.7.1 The value of perfect information

The value of perfect information about some uncertain events is equal to the maximum amount that is paying for the uncertainty to be resolved prior to making the relevant decision. It is that sum which, when deducted from all possible outcomes on the decision brunch "buy information", reduces the expected utility of that branch to be equal to the next highest expected utility on other branches [302]. When we talk about purchasing information, we talk about what in literature is called "clairvoyance". In literature the clairvoyance is defined as an useful concept in discussing the possible information. The oracle or clairvoyant is an individual (or a market) who can tell us the precise value of any uncertain variable.

Example 4.6(Example 4.5 cont.)
We suppose that someone give us a contract that allows us to know with certainty, before deciding, what will happen (the Nature's decision - A or B). Such contract allows to acquire the "perfect information".

What is the maximum price we are willing to pay for such a contract? In order to find the price of such contract we joint a new branch at the tree as shown in the figure, where we have an information by the "Oracle" (O), that could be OA or OB.

In this new branch we have the perfect information, thus:

$$p(A|OA) = 1$$

$$p(B|OB) = 1$$

$$p(OA) = p(A)$$

therefore we have:

$$p(A) = p(A|OA)p(OA) + p(A|OB)p(B) = p(OA)$$

Now the resolution of this branch of tree is easy. In fact, if the oracle tells us OA, namely that the nature's decision in the future will be assume the state A, we will choose a_1, that is $100 - x$. Accordingly, if the oracle tells us OB we will choose a_2, that is $40 - x$. The total value of the branch "perfect information" will be $70 - x$. This value is called "Expected Value With Perfect Information"(EVWPI) with a price x.

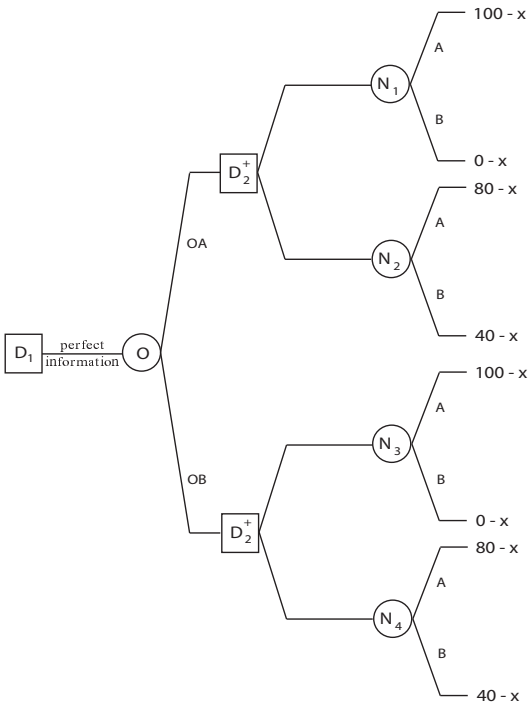


Figure 4.3: Decision tree: perfect information

At this point it is easy to show that the contract is profitable if $EVPI(x) > EVWI$. The maximum price we are willing to pay for this contract is therefore the value of x, such that:

$$EVWPI(x) = EVWI$$

thus:

$$x = EVWPI - EVWI$$

This value x is called "Expected Value of Perfect Information" $(EVPI)$

In this case we have:

$$EVPI = EVWPI - EVWI = 70 - 60 = 10$$

4.7.2 The value of imperfect information

In practice, perfect information is very rarely available, typically, the uncertainties are reduced rather than removed. In this case we talk about the value of imperfect information, namely our oracle is imperfect and its forecast may be incorrect.

To better explain this concept we consider the follow example.

Example 4.7

An analyst prepares a 1000 ballot box (opaque), which can be of two types. The ballot box of type I contains 10 balls of which 4 are red and 6 are black. The ballot box of type II contains 10 balls of which 9 are red and 1 is black. In total there are 800 ballot box are of type I and 200 are of type II. Subsequently, the analyst chooses an ballot box and asks us to bet: we bet on what type of ballot box is, type I or type II. We can say:

- a_1: bet that the ballot box is of type I;
- a_2: bet that the ballot box is of type II;
- a_3: no bet.

Thus we have the following tree:
Where we have:

$$p(I) = 0.8, p(II) = 0.2$$

Then with a simple calculation we know that without information the best decision is a_1 that have as expected value 28. Thus we can write that $EVWI = 28$ and that $EVPI = 24$. At this point the analyst asks us to take a ball from the ballot box before deciding. What we are willing to pay to do this? It is clear that this proposal allows us to have an imperfect information and therefore its value is less than $EVPI = 24$.

This information give us the tree where we have:
$R = red$ and $B = balck$
$p(I) = 0.8$ and $p(II) = 0.2$
$p(R|I) = 0.4$ and $p(B|I) = 0.6$

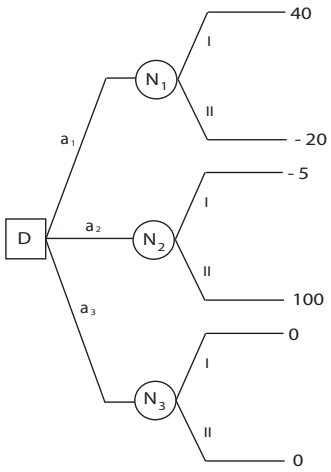


Figure 4.4: Decision tree

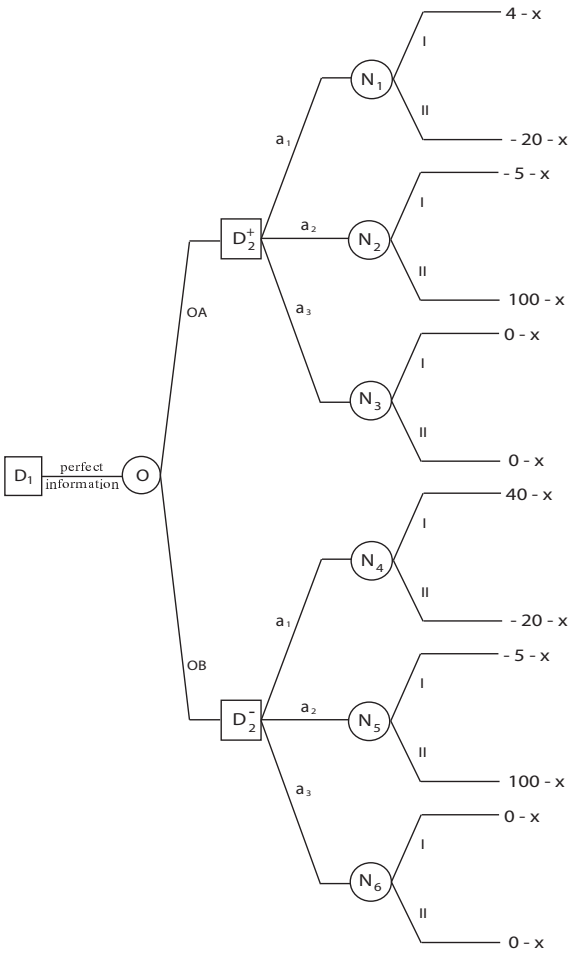


Figure 4.5: Decision tree: imperfect information

$p(R|II) = 0.9$ and $p(B|II) = 0.1$

Thus we get:

$$p(R) = p(R|I)p(I) + p(R|II)p(II) = 0.5$$

$$p(B) = p(B|I)p(I) + p(B|II)p(II) = 0.5$$

$$p(I|R) = \frac{p(R|I)p(I)}{p(R)} = 0.64 \longrightarrow p(II|R) = 0,32$$

$$p(I|B) = \frac{p(B|I)p(I)}{p(B)} = 0.96 \longrightarrow p(II|B) = 0,04$$

Now the tree's solution is easy. If the information is R we will choose a_2 that have $32.8 - x$; if the information is B we will choose a_1 that have $37.6 - x$. At the end in D_1 the expected value of the tree with the imperfect information is $35.2 - x$. This value is called "Expected Value with Imperfect Information"(EVWII). To conclude, to purchase the information is profitable if $EVWII > EVWI$ and the maximum cost of x that we are willing to pay is such that:

$$EVWII = EVWI \longrightarrow x = EVWII - EVWI$$

thus, x that we call "Expected Value of Imperfect Information" (EVII) is:

$$EVII = EVWII - EVWI = 35.2 - 28 = 7.2$$

Thus the value of the perfect information is un upper bound on the value of imperfect information.

4.8 Criticism

Writing a section of criticism about decision theory is not easy, because as we have said at the beginning of this chapter it is a huge and diversified field of study, which includes several theories and tools, and each of these theory and tools have been criticized and challenged. Thus, for an exhaustive discussion about that we refer to the consultation of the mentioned literature for each topic and in general to see [38, 37, 94, 20, 302, 231].

In this section we prefer highlight the general critical point that can affect our research:

- problems structuring less rigorous than a normative one;
- time is not considered as fundamental feature;
- the results are recommendations and not strong synthetic indicators.

In decision theory as we wrote above problem structuring is considered more "art than science". This means that there is not a standard procedure, or a standard formulation as in a normative tools (CBA or ROT where the problem structuring is entrusted to the costs and benefits), but there are several methodologies among the analyst can choose. On the one hand, this allows flexibility and adaptability to the specific context and policy-maker, but on the other hand this makes all discretionary. However, in a field as public politics where it is needed legitimation and accountability, and so transparency and reproducibility of the procedures and process, too much discretion by analyst and policymaker may not be well accepted. In fact, even though flexibility is important, in a fundamental step as problem structuring a more rigorous procedure, that use cost and benefit, will be more easily accepted, because:

- costs and benefits, as any other normative concept, are seen as foundation of rationality and logic, thus our mind associates with this the objectivity and so the reason;
- costs and benefits, differently from DT structuring methodologies, can be repeated for every situation and context without specific changes;
- using money as unit of measure is immediately understandable for everyone, it is not linked with culture, education or situation.

In other words we want underline as in public policies context some characteristics of decision theory could not be fully appreciated, but they could be considered as weaknesses. For these reasons, in our model, we try to mitigate this decision theory aspect with some normative concepts.

The second aspect in decision theory that we underline as critical point is "the time". In fact, in decision theory the time factor is poorly considered especially in relation with other aspects or in some tools. This means that usually time is seen as a factor almost irrelevant that we can not eliminate, but which at the same time does not affect other factors or decisions. Moreover, in decision tree where there is a structuring for subsequent steps, time is seen just as a sequence of action with one before and one after, but never as a dense and binding structure. This is clearly a limit especially in contexts like public policies, where factor time is basic. In public policies and for policy-makers time is one of the most important factor, by time depends policy design, policy founds, implementations and of course political elections. In policy-making time is dense and binding, it is a factor that can not be underestimated. For these reasons in order to use decision theory in policy-making it is necessary recognize and joint this element at its theories and tools.

The last critic point that we underline in this research is the outcome of the decision aiding process, namely the recommendations.

First because, if for a private decision-maker a recommendation or suggestion is enough to make a decision, in public context for the policy-maker it is not enough. Recommendations are not enough because policy-maker must be convinced and he must convince allies and opponents of the goodness of his choices. Thus the recommendations, giving him total freedom on the choice, are not strong enough in order to justify a choice as objective and rational. Moreover, usually recommendations do not give only one possibility, but they suggest a set of consistent and reasonable opportunity.

Second because, in a policy context like European Union, it is important to have the possibility to compare different policy-process and policy-results. This means that having a synthetic indicator (as NPV), as results of decision aiding process, makes the comparison easy and immediate. While with a recommendation the comparison becomes more complicate if not impossible, since probably it could only be made by the interaction of the different analysts, and this makes the comparison almost impossible.

4.9 Conclusion

The aim of this chapter was to present the Decision Theory (DT), showing those aspect and features relevant to our research. We start with a general introduction to explain what means for us "decision aiding". Then we explain the decision aiding process, with its steps and its methodologies. We shown the process because we believe very important understand how the different steps work both alone that related to each other.

Then, we focus our attention on the "problem structuring", especially presenting the "value-focused thinking" methodology, where great attention is given to the alternative creation. In fact, as we see in the following this is an important aspect in policy-making and in our model. Moreover, the alternative creation itself is view as an iterative process, that evolves continuously. Such ability to evolve is the flexibility needed in the design and planning of public investment, which involves space and time, and where the uncertain variables or out of the decision maker control are many.

After, we present also the utility theory, the utility expected theory, and the value functions, which are important in order to understand the evaluative theory on which we build our idea and model.

At the end we wrote about decision tree, subjective probability, Bayes' theorem and the value of information. Thus, through these we introduce models and tools in order to manage uncertainty, flexibility and set of subsequent decisions.

Introducing these kind of theories and tools we show in this research some "constructive" elements. These elements, as we explain better in the following, will be a central part of our model in order to evaluate public-policies and support policy-makers in the whole policy-process.

Concluding, we shown the three most important decision theory weaknesses related with our research and policy-making context.

CHAPTER 5

Real Options Theory (ROT)

5.1 Introduction

> *"Risk and time are the opposite sides of the same coin, for if there was no tomorrow, there would be no risk. The time transforms risk, and nature of risk is shaped by the time horizon: the future is the playing field. Time matters more when decisions are irreversible. And yet many irreversible decisions must be made on the basis of incomplete information [...]"*[7].

Every day we make a decision in order to achieve a goal. We analyse the situation to make a better decision but usually our data are not complete and exhaustive. We are full of all kind of *uncertainties*. Hence decisions are based on our knowledge and on our future expectations, namely on the imperfect information that we have. Information can change over time and we must be able to recognize these changes and make our decisions accordingly. This is even truer if we are talking about the decisions of policy-makers. We will have to manage information from different administrative sectors, and we will be able to provide and incorporate the results of other policies in place. Policies are made in a context constantly evolving. In economics this ability is called managerial flexibility. In other words, managerial flexibility is *"the capacity to adapt"* [101] a decision to the new available information. For instance, if we look to the simple decisions of everyday life, we can observe that decisions are made considering many variables. Indeed, we can change our conclusions and move from one decision to another simply because a new information is available, i.e. when the variable changes. Thus when decisions that we must make are irreversible the managerial flexibility has a lot of value that we must consider by assessing the alternatives.

The Longman dictionary [169] tells us that an option is a choice made in a particular situation, that keeping open an option means to wait before making a decision, and also that an option is something additional, something that is offered in addition to the standard decision. From these definitions we can deduce two important things. First, options and decisions choice are strongly related, when they are not the same things, and in this sense we can say that options and alternatives are synonymous. Second, that options and alternatives have an intrinsic value that can give something more than the standard. This means that having more choices, options or alternatives has an intrinsic value.

In economics an option is defined as the right, but not the obligation, to take an action in the future. In this definition the economists introduce with the concept of option the character of time. More explicitly the options are seen as the connection between today and the future, or between when we decide and when we find out the consequence.

The option concept represents what the economists use in order to explicitly incorporate the managerial flexibility into an analysis, overcoming in this way the classical cash flows techniques considered static. In the last decades managerial flexibility and option concept

were studied as an important and exciting growth area in the theory and practice of finance (options) first and in the business economy (real options) afterwards. In business economy the first person that understood the importance of this subject is Stewart Myers in 1984 who stated:

> *"Strategic planning needs finance. Present value calculations are needed as a check a strategic analysis and vice versa. However, the standard discounted cash flows techniques will tend to understate the option value attached to growing, profitable lines of business. Corporate finance theory requires extension to deal with real options[...]"*[196]

Myers also coins the term *"Real Options"* as opposed to *"Financial Options"*. He has seen and understood the existing close analogy between real investment or real option and financial or call option on the stock market. Indeed we can see this analogy in fig. 5.1 where the call options have been transposed into strategic business planning.

Stock Call Option	**Real Option**
Current value	(Gross) PV of Expected cash flows
Exercise Price	Investment Cost
Time to espiration	Time Until Opportunity Disappear
Stock Value Uncertainty	Project Value Uncertainty
Risckless Interest rate	Risckless Interest rat

Table 5.1: The comparison Call-Real Options [250]

Afterwards, the greatest achievements in this area were obtained by the Nobel Prize Black, Merton and Scholes for derived a mathematical formula that allowed the growth of option markets, which became the basis for valuation and pricing [27], and by Cox, Ross and Rubistein for the general Binomial Option-Pricing Mode [66].

Example 4.1

We propose now a simple case in order to better understand what we mean with option and decision flexibility. We imagine that you have won a movie ticket, and now you have to choose between two movies, one with Angelina Jolie and Brad Pitt, and one with Clint Eastwood. You think that both could be interesting but also very different, and you want to use your ticket to see the best movie because you cannot buy another thicket. Your investment is irreversible. In this moment you have two possibilities:

- to choose to flip a coin;
- to wait until tomorrow, read the criticism and then choose according to the new information.

In the second case you have the option of waiting, and this option has value until you decide to use your ticket.

The aim of the following chapter is to show the theory and the logic underneath the real options. Indeed real options provide an alternative way to design, plan and evaluate. Specifically *real options thinking*, as Amram and Kulatilaka [7] call the process of reflection related to the real options, can give us the possibility to conceive the construction of alternatives as value creation process. Moreover, since the options are link to the information concept these can be associated and evaluate using the information value. We will show how this tool does not upset the premise and assumptions related to the CBA, but may be regarded as an extension most richest and flexible. On this way, the use of ROT is legitimated to all cases in which it is considered legitimate to use the CBA.

5.2 Real Option Theory: an overview

A lot of research efforts have already been done in the analysis and evaluation of investment. Traditional investment evaluation approaches involve the net present value (NPV) to estimate the extent to which the benefits of a project exceed its costs, as the CBA shown in chapter 3. The NPV framework has been criticized claiming that it cannot cope with the potential flexibility that comes with investment projects, resulting in changes in the original cash flow pattern (To read more about early critics see: [71, 116, 117]). Trigeorgis [286] claims that traditional capital budgeting methods or discounted cash flow (DCF) approaches cannot cope with the operation flexibility options and other strategic aspects of various investments, but that the application of option techniques results in the correct solution. Also, Dixit and Pindyck [75] affirm that the NPV rule is easy to use, but it is based on false assumptions, that are the investment reversibility and that it cannot be delayed. What is claimed is that even if an investment has a positive NPV, this does not necessarily mean that the investment should be taken on immediately, because delaying an investment with a positive NPV can further improve its value [128].

The general interest in *"real options"* is justified by the fact that NPV rule and other DCF approaches to capital budgeting ignore, or cannot properly capture management's ability to adapt and revise its original operating strategy if and when, as uncertainty is resolved, future events turn out differently from what management expected at the outset. In other words in response to an unexpected development of the situation, and the main theme is the predictability of such situations. Indeed, using a NPV or other DCF approaches future events are considered certain, there are no uncertainty to be resolved over the time, thus each investment is without risk. Unfortunately, predict the future with certainty is almost impossible, and we know that every investment is risky.

For a policy-maker where the variables to predict are many and economically speaking markets, on which to base, do not always exist. Moreover, usually the time horizon is very long. Thus, in a framework characterized by changes and uncertainty costs and benefits realization will probably differ from what the policy-maker expected initially. As new information arrives and uncertainty about some aspects conditions is gradually resolved, policy-makers may have valuable flexibility to alter its operating strategy in order to capitalize on favorable future opportunities or mitigate losses. For these reasons, it is necessary a theoretical framework where the policy-maker (management) may be able to defer, expand, contract, abandon or otherwise alter the investment project at different stage during its life.

The managerial flexibility to adapt future actions, contingent on future events, introduces an "asymmetry" in the distribution of the value of the project. This asymmetry results in an expansion of the investment opportunity value, because future management decisions can improve upside potential while at the same time limiting downside losses. This asymmetry calls for an Expanded NPV criterion that reflects both a value component - the traditional "static" NPV of direct cash flows - and a premium for the flexibility embedded in its operating options [250]. That is:

Expanded (strategic) NPV = Static NPV (of expected cash flows) + Value of options (from active management)

Options literature emphasizes that real options are more valuable under greater uncertainty based on the premise that the managerial flexibility provided by real options is of value when there is considerable uncertainty surrounding a project [23, 127]. Uncertainty can arise from technical sources and from evolving business needs related to a project. Both might be present in the context of a given project, with the total uncertainty compounded when both are simultaneously present. The concept of *parametric uncertainty*, which is defined as the degree of technical and business uncertainty associated with a project, captures such uncertainty [309, 297]. According to options theory, real options are more valuable under greater uncertainty because managerial flexibility is more valued [23, 128, 22]. Thus, we expect that policy-makers will ascribe more value to the real options created by a project under greater parametric uncertainty. However, uncertainty is a necessary but insufficient condition for managers to ascribe value to real options [278].

The option value is manifest as a collection of different real options embedded in capital investment opportunities. Many of these real options occur naturally during a project life, while others may be planned and built-in at some extra cost.

Public policies and thus public investments are full of uncertain elements and therefore risk. This kind of investment lives in a changing environment and to succeed must be able

to mutate and adapt to the environment. For these reasons we believe that the use of real options concept can help the policy-makers to implement flexible and effective strategies. At the same time we believe that its hypothesis based on market and derived from the CBA's expansion can also be a good basis easy to accept as evidence by the different sectors working with policies. Moreover, we believe that these concepts and hypothesis can be used in order to build a procedural tool for creating and evaluating different strategic alternatives.

In the next paragraphs we will describe the most common typologies of real options encountered and the models to evaluate them. However for an historical account of the development of the subject we suggest: [262, 52].

5.2.1 Real Options as Strategic tool

The real options are technically defined by investment decisions that are characterized by uncertainty, irreversibility, and the provision of future managerial discretion to exercise them at an appropriate time [149]. All these elements are required jointly for applying real options. An option has value only if there is uncertainty, though defining the relevant source of uncertainty is not trivial. Irreversibility is an easily overlooked feature and signifies the inability to costlessly revisit an investment or decision. Irreversibility is accentuated if the divesting of an investment also engages cost attached. The concept of irreversibility is critical to why inertia of organizational capabilities is the source of the value of real options, but irreversibility does not means that firms cannot change, or that transformation is not possible.

In this kind of framework, as said by Amram and Kulatilaka [7], the more important think is not the mathematical or technical model that the real options suggest, but "the real options way of thinking". In fact, only with a right way of thinking about future and risk it is possible to build a good strategic planning. This feature of ROT defined by Amram and Kulatilaka [7] "way of thinking", for us, it is the most important and relevant in order to aid the policy-making.

In this paragraph we would like to put in evidence that the real options theory can be used not only as an assessment tool, but also in a procedural tool, or to be more precise as a tool able to aids the policy-maker thinking of new strategies, or new alternatives. We imagine this approach as a *"strategy"* in the sense that it gives policy-makers a right way to think about how to create value from uncertainty and how to identify the risks and the potential pitfalls of the complex contingent opportunities. This approach can change the strategy creation process and can also lead to different strategic policies or investments.

The real options "way of thinking" is based on three components [7]:

- *Options are contingent decision. An option is the opportunity to make a decision after we see how events unfold. On the decision date, if events have turned out*

well, we will make one decision, but if they have turned out poorly, we will make another. This means that the payoff to an option is nonlinear, it changes with the decision. Fixed (noncontingent) decisions have linear payoffs because no matter what happens, you'll make the same decision.

- *Option valuations are based on market valuation.*

- *Options thinking can be used to design and manage strategic investment proactively. The nonlinear payoffs can also be a design tool. In fact we can see the process divided in steps:*

  1. *to identify and value the options in a strategic investment;*
  2. *to redesign the investment to better use the options;*
  3. *to manage the investment proactively through the options created.*

With these three components the policy-maker is called upon to interpret its role in an ever-changing situation, where he is no longer just a helpless spectator, but he can and should seek to influence the situation through specific behavior and targeted decisions. Furthermore, the ROT provides a strategic view that can be used to expand the set of alternatives considered in the process, and also provides a tool kit to help map strategy concepts into strategic investments. Thus, ROT concepts not only allow an organization to more accurately assess uncertain investments, but can guide the policy-makers in how to actively create and extract value. This is the heart of real options strategy. The key to understanding how options create actual value lies in the distinction between what a policy-maker must do on an investment, versus what he should do. What he should do is structure the investment elements as an option.

Considering ROT in this more broadly way, it can revolutionize, compared to the DCF methods, the entire decision aiding process. We believe that such approach could add many benefits as:

- expand the menu of resources and strategic alternatives evaluated;

- expand the range of markets evaluated (markets are related);

- illuminate the risk of strategic alternatives;

- provide consistent comparison of internal investments;

- acknowledge the role of luck.

5.3 Real Options Typologies

A real option refers to the opportunity without an obligation to take some action in the future in response to endogenous or exogenous developments [23, 277, 22]. First of all, we want to distinguish between two basic types of decision problems that a manager may face [282]:

1. *"games against nature", in which the manager's problem is to optimize in the face of random fluctuations in the (gross) value of cash flows from the investment, V;*

2. *"strategic games against competition", in which the manager's investment decisions are made with the explicit recognition that they would invite competitive reaction that would in turn impact the value of the investment opportunity.*

Moreover, most investment decisions share three important characteristic in varying degree [74]:

1. the investment is partially or completely irreversible;

2. there is uncertainty over the future rewards from the investment, and the best you can do is to assess the probabilities of the alternative outcome;

3. you have some leeway about the timing of your investment.

At the project level, real options often exist in bundles wherein a project can create multiple distinct real options [183, 184, 22]. Prior research has identified six real options based on the type of flexibility that is associated with each option [285, 89]. Thus, starting from this point we suggest the below options-based classification, and the representative authors that have analyzed them.

Option to defer (Waiting to)

The option to defer an investment is equal to a call option on stock. Management holds the possibility to buy, rent or develop something. It can wait (x years) to see if output prices justify one of these actions, it wait to acquire information. Deferring an investment is not without cost, wait has always an opportunity cost, and if the deferring cost is too high, the decision maker may want to exercise the option before its relinquishment date.

This kind of option is important in natural resources, extraction industries, real estate development, farming and also paper production.

Some of the authors that have analyzed this domain are: Tourinho [279]; McDonald and Siegel [182]; Paddock, Siegel and Smith [214]; Ingersoll and Ross [134]; Hubbard [127]; Benaroch and Kauffman [23].

Compound Options (stage investment)

Almost all capital expenditure decisions are phased investments, and all phases investments are compound options. The decision to spend money on early phased amounts to the exercise of options that unlock the opportunity to complete later phases. Each phases is an options on another option whether it's for research and development, new product innovation, energy exploration and production, or construction of new facilities.

Some of the authors that have analyzed this domain are: Majd and Pindyck [175]; Carr [50]; Trigeorgis [284]: Kulatilaka and Trigeorgis [152]; Copeland [59]; Brennan and Schwartz [41]; Trigeorgis [286]; Kulatilaka [154]; Myers and Majd [197]; Geske [100]; Benaroch [22].

Option to alter operating scale (to expand; to contract; to shut down and restart)

If market conditions are more favorable than expected, the firm can expand the scale of production or accelerate resource utilization. Conversely, if conditions are less favorable than expected, it can reduce the scale of operations. In extreme cases, production may temporarily halt and start up again. Thus with an option to adjust investment or production, a company has flexibility in choosing the scale, scope, lifetime, or raw materials for its production process.

This kind of option is important in natural resource industries such as mine operations, facilities planning and construction in cyclical industries, fashion apparel, consumer goods and commercial real estate.

Some of the author that have analyzed this domain are; Brennan and Schwartz [41]; McDonal and Siegel [181]; Trigeorgis and Mason [288]; Pindyck [227]; Pindyck [226]; Fichman [89].

Option to abandon

The option to abandon (or sell) a project is equivalent to a put option on a stock. If the project proceeds poorly, the decision maker may abandon the project and collect the liquidation value. The expected liquidation (or resale) value of the project is equivalent to the exercise price. When the present value of the asset falls below the liquidation value, the act of abandoning (or selling) the project is equivalent to exercising a put.

Some of the author that have analyzed this domain are; Myers and Majd [197]; Hubbard [127]; Fichman [89].

Option to switch

Switching option is the right, but not the obligation, to alter models of operation by paying a switching cost. If prices or demand change, management can change the output mix of the facility ("product" flexibility). Alternatively, the same outputs can be produced using different types of inputs ("process" flexibility).

Some of the authors that have analyzed this domain are; Margrabe [177]; Kensinger [146]; Kulatilaka [153]; Kulatilaka and Trigeorgis [152]; Copeland [59].

Growth options

An early investment is a prerequisite or a link in a chain of interrelated projects, opening up future growth opportunities. Thus these follow-on options are options on options (so called compound options). An example would be phases investments, such as a factory that can be built in stages, each stage supported by the preceding one. At each decision point management can continue the project by investing additional founds (an exercise price) or abandon it for whatever it can fetch.

Some of the authors that have analyzed this domain are; Myers [196]; Brealey and Myers [40]; Kester [147]; Trigeorgis [283, 285]; Pindyck [226]; Chung and Charoenwong [53]; Benaroch and Kauffman [23]; Kogut and Kulatilaka [149].

5.4 Real Options Models

In the last forty years a lot of models and technique have been developed and studied to quantitatively evaluate the real options. This paragraph is a brief survey of the available solution methods. These methods involve the use of mathematical techniques developed in other fields, but their implementation for the option evaluation is guided by the no-arbitrage arguments. The solution methods differ among approaches, but in many cases, if the inputs and application frame are appropriately structured, they will give the same option value. Hence, the choice of solution method should not influence the results.

The origin of quantitative models of real options derive from the seminal work of Blach-Scholes (1973) [27] and Merton (1973) [185] in pricing financial options. Then in 1979 Cox, Ross and Rubistein [66] have developed a binomial approach enabling a more simplified valuation of options in discrete-time. In the same period Margrabe (1978) took into consideration an option to exchange one risky asset to another, Stulz (1982) analyzed options on the maximum or minimum of two risky assets and Johnson (1987) extended it to several risky assets. These papers opened the road to the analysis of the generic option to switch among alternative uses and related options. Geske (1979) gets to a compound option, then Carr (1988) combines these two blocks to value sequential exchange options, involving an option to acquire a subsequent option to exchange the underlying asset for another risky alternative. Thus, such works opened up the potential to evaluate investment with a series of investment outlays that can be switched to alternative states of operation (for more information see [250, 7, 287, 195, 286, 75, 74, 130, 173]).

We can summarize all methods in three principal groups [7]:

1. *The partial differential equation (pde) approach solves a partial differential equation that equates the change in option value with the change in the value of the tracking portfolio.*
2. T*he dynamic programming approach lays out possible future outcomes and folds back the value of optimal future strategy.*
3. *The simulation approach averages the value of the optimal strategy at the decision date for thousand of possible outcomes.*

For each of these solution methods there are many alternative computation techniques in order to solve the mathematical models.

The pde approach is based on the mathematical expression of the option value and its dynamics through a partial differential equation and the boundary conditions. The pde is a mathematical equation that relates the continuously changing value of the option to observable changes in the market securities. In analytical terms, the option value is written in one equation as a direct function of the inputs. If available , the analytical solution is the easiest and fastest way to obtain the value of the option. The most famous analytical solution to a pde and set of boundary conditions that define a European call option is the Blach-Merton-Scholes equation. Numerical solutions are used to solve the pde when an analytical solution is not possible and is based on converting the pde into a set of equations that must hold over short time intervals. Computational algorithms are used to search for the option value that solves the equations simultaneously. Finite difference methods are the most widely used numerical solutions to the pde approach.

Dynamic programming solves the problem of how to make optimal decisions when the current decision influences future payoffs. This solution method rolls out possible values of the underlying asset during the life of the option and then folds back the value of the optimal decisions in the future, using the risk-neutral approach. Central to dynamic programming is the principle of Bellman, which defines an optimal strategy as follows: Given the choice of the initial strategy, the optimal strategy in the next period is the one that would be chosen if the entire analysis were to begin in the next period. The solution solves the optimal strategy problem in a backward recursive fashion, discounting the future values and cash flows and folding them into the current decision. Solving the one period optimization problem and then moving back ensures that the entire problem is solved optimally. Dynamic programming is a useful solution method for option valuation because it handles various real asset and real options features transparently.

Simulation models roll out thousands of possible paths of evaluation of the underlying asset from the present to the final decision date in the option. In the commonly used Monte

Carlo simulation method, the optimal investment strategy at the end of each path is determined and the payoff calculated. The current value of the option is found by averaging the payoffs and discounting the average back to the present.

In the following we will show three models, such models will be presented briefly, because we are not interested in their mathematical or theoretic aspect, our objective is to give just an idea of them. However, for whom might be interested to explore these topics we reported several references.

5.4.1 Blach, Scholes and Merton's model

In the Black-Scholes and Merton model [27, 185, 130] the evaluation of options is extended to a continuous-time setting. Assuming that the option is a function of a single source of uncertainty, namely the underlying asset price, and using a portfolio which combines options and the underlying asset, Black-Scholes and Merton constructed a riskless hedge which allowed them to derive an analytical formula.

Moreover Black and Scholes give a set of assumptions or "ideal conditions" where the value of the option will depend only on the price of the underlying asset S, time t and on other variables assumed constants. These assumptions are:

1. The Short-term interest rate is known and is constant through time.
2. The stock price follows a random walk in continuous time with a variance rate proportional to the square of the stock price. Thus the distribution of possible stock prices at the end of any finite interval is lognormal. The variance rate of the return on the stock is constant.
3. The stock pays no dividends or other distributions.
4. The option is "European", that is, it can only be exercised at maturity.
5. There are no transaction costs in buying or selling the stock or the option.
6. It is possible to borrow any fraction of the price of a security to buy it or to hold it, at the short-term interest rate.
7. There are no penalties to short selling. A seller who does not own a security will simply accept the price of the security from buyer, and will agree to settle with the buyer on some future date by paying him an amount equal to the price of the security on that date.

For clarity in exposition we briefly present this model in the context of European options. We employ the following notations:

C: value of a call option;
S: value of option's underlying risky asset (stated in terms of the present value of expected revenues from the operational project);
σ: volatility, the standard deviation of the expected rate of return on S;
X: option's exercise price (cost of converting the investment opportunity into the option's underlying asset, i.e., the operational project);
r: the risk-free interest rate (usually implemented as the rate of return on Treasury Bills);
T: option's time to maturity or expiration (i.e., the maximum length of the deferral period).

In this model the value of a call option is its discounted expected terminal value, $E[C_T]$. The current value of a call option is given by $C = e^{-rT}E[C_T]$, where e^{-rT} is the present value factor for risk-neutral investors. A risk-neutral investor is indifferent between an investment with a certain rate of return and an investment with an uncertain rate of return whose expected value matches that of the investment with the certain rate of return. Given that $C_T = max[0, S_T - X]$, and assuming that ST is log-normally distributed, it can be shown that:

$$C = SN(d_1) - e^{-fT}XN(d_2), d_1 = \frac{ln(S/X)rT}{\sigma\sqrt{T}} + \frac{1}{2}\sigma\sqrt{T}, d_2 = d_1\sigma\sqrt{T}$$

where N is the cumulative normal distribution. Call option value, C, calculated using the Black-Scholes and Merton model, denoted C^{BSM}, can also be written as the implicit function $C^{BSM} = C^{BSM}(S, s, X, T, r)$.

For more information about this model see [27, 185, 41, 175, 226, 283, 227, 74, 286, 75, 18, 130, 23, 218, 131, 150]

5.4.2 Cox, Ross and Rubistein's model

"The general Binomial Option-Pricing Model" (BOPM) was popularized by Cox, Ross and Rubinstain in 1979 [66]. BOPM is a simple but powerful technique that can be used to solve many complex option-pricing problems. In contrast to the Black and Scholes and other complex option-pricing models that require solutions to stochastic differential equations, the binomial option-pricing model (two state option-pricing model) is mathematically simple.

The binomial pricing model uses a "discrete-time framework" to trace the evolution of the option's key underlying variable via a binomial lattice (or tree), for a given number of time steps between valuation date and option expiration. Each node in the lattice, represents a possible price of the asset, at a particular point in time. This price evolution forms the basis for the option valuation. The valuation process is iterative, starting at each final node, and then working backwards through the tree to the first node, where the calculated result is the value of the option.

For clarity in exposition, we discuss also this model in the context of European options. We employ the following notation:
C: value of a call option;
S: value of option's underlying risky asset (stated in terms of the present value of expected revenues from the operational project);
X: option's exercise price (cost of converting the investment opportunity into the option's underlying asset, i.e., the operational project);
r: the risk-free interest rate (usually implemented as the rate of return on Treasury Bills);
T: option's time to maturity or expiration (i.e., the maximum length of the deferral period).

The binomial model assumes that S follows a binomial distribution.

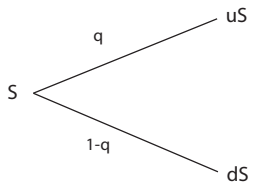


Figure 5.1: Binomial distribution

Starting at time zero, in one time period Δt, S may rise to uS with probability q or fall to dS with probability $1-q$, where $d < 1$, $u > 1$, and $d < r < u$. The terminal value of a call option on S which matures in Δt is:

$$Cu = max[0, uS - X]$$

or

$$Cd = max[0, dS - X]$$

with probabilities q and $1-q$, respectively.

By setting $p \equiv (1+r)d/(u-d)$, the current value of the call option can be written as:

$$C = \frac{pC_u + (1-p)C_d}{1+r} = \frac{pmax[0, uS - X] + (1-p)max[0, dS - X]}{1+r}$$

This equations can be applied to determine the two possible values of the call option at time 1, Cu and Cd, if the option's underlying asset is uS or dS at time 1, respectively. Similarly, the equation can be applied to an option that matures in n time periods (where $\Delta t = T/n$). The price of a call option calculated using the binomial model, denoted by

C^{BN}, can be written as the implicit function

$$C^{BN} = C^{BN}(s, X, T, n, u, d, p, r).$$

For more information about this model see [66, 65, 75, 115, 286]

5.4.3 Contingent Claim Analysis

A contingent claim is any financial asset whose future payoff depends on the value of another asset. The prototypical contingent claim is an option, the right to buy or sell the underlying asset at a specified exercise price by a certain expiration date. A call is an option to buy; a put is an option to sell. Contingent claims analysis is a generalization of the option pricing theory pioneered by Black-Scholes [27] and Merton [185]. In fact, in their seminal work Black and Scholes provide a significant insight which is arguably of more academic and practical value than their famous option pricing model. They demonstrate that corporate liabilities can be viewed as combinations of simple option contracts. This generalization of option pricing as refined by Merton is now known as Contingent Claims Analysis (CCA).

CCA has been used by researchers as a theoretical framework in which the pricing of corporate liabilities can be viewed: it's the model's ability to predict prices for dual purpose funds and call policies for convertible bonds respectively. In fact, the Option-based technique of CCA explicitly recognizes the management's flexibility to adapt its future actions, contingent on future events, and introduces "asymmetry" in the distribution of the value of the project.

Contingent claims analysis is based on three simple principles:

- the value of liabilities flows from assets,
- liabilities have different seniority (and thus have different risks related to their seniority),
- there is a random element to the way asset value evolves over time.

Debt is a senior claim on the asset value and equity has a junior or residual claim on the asset value. Debt is risky because asset value may not be sufficient to meet the promised debt payments. The value of risky debt, therefore, can be seen as having two components, the default-free value of the debt (promised payment value) and the expected loss associated with default when the assets are insufficient to meet the promised payments on the debt. The value of the junior claim (equity in the case of firms) is derived from the residual value after the promised debt payments have been made.

If the value of assets has a random component (e.g., price changes, shocks and other factors affect asset value), higher asset volatility means a greater probability that assets will

fall below the level necessary to meet the senior debt payments over the horizon period. Consequently, higher volatility means higher expected loss and a lower value of risky debt, other things equal. Financial techniques, namely option pricing relationships, have been developed to measure the expected losses as a function of the asset value, asset volatility, the default free value of debt, and the time horizon. Similarly, the value of equity and junior claims can be measured as a function of the same variables. The expected loss in risky debt is an implicit put option. Equity and junior claims are implicit call options.

Here we briefly illustrate the contingent claims methodology as applied to a simplified corporate balance sheet consisting of senior debt and junior equity. At any point in time, the total market value of assets, S, of a firm financed with debt, D, and equity, E, is equal to the market value of equity plus market value of risky debt. Fundamental analysis dictates that firm asset value is derived from the stochastic discounted present value of income minus expenditures with the potential for asset value to decline below the point where scheduled debt payments can be made. If assets fall to a level where debt cannot be serviced, then default is the result. This level is often referred to as distress barrier, DB, and is equal to or close to the default-free value of debt. Equity holders have a junior contingent claim on the residual value of assets in the future. In this manner, the value of equity can be viewed as an option where holders of equity receive the maximum of either assets minus the distress barrier, or nothing in the case of default. The value of equity, therefore, is

$$E = max[S - DB, 0]$$

The standard option pricing formulas can then be used to relate changes in the price of firm assets to changes in equity. Given the relationship between firm equity and firm assets, changes in the value and volatility of traded equity can be used via option pricing relationships to infer changes in the market value and volatility of firm assets.

The option pricing formula is used in a two step process. First, the observed market value of equity and the distress barrier are used with the call option formula to derive the value of firm assets. The value of firm assets and the distress barrier are then used with the put option formula to derive the implied market value of risky debt. Thus, the CCA uses call and put option pricing formulas to develop a market value balance sheet based on observed financial market variables and financial statement information [97].

Example 4.2

To better explain this technique we propose here the example presented by Trigeorgis and Mason [288].

Consider an opportunity to invest $I = 104$ euro (all equity) to realize a project that a year later will have a realizable value of either 180 euro or 60 euro with equal probability.

For simplicity, assume that, once realized, the project will operate indefinitely, and continuously, at the constant output rate and require no future follow-on investment. Let S be the listed stock price of an *"identical"* project. Recall that the existence of such "twin security" is implicitly assumed in traditional NPV analysis for purposes of estimating the required rate of return on a project. The twin security is assumed to have a value of 36 euro if the realized value of the project is 180 euro and a value of 12euro if the realized value of the project turns out to be 60 euro, as show in the figure 2.1. Then we assume that both the plant and its twin security have an expected rate of return K (or discount rate) of 20%, while the risk-free interest rate r is assumed to be 8%.

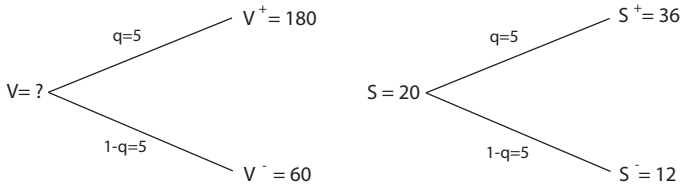


Figure 5.2: Project and twin security

Using the traditional DCF technique, including the NPV analysis, would discount the project's expected rate of return of the plant's twin security as appropriate discount rate. The discount rate would be estimated by determining the project's beta coefficient from the price of its twin security and applying the Capital Asset Pricing Model (CAPM). The gross value of the project, V, would then be given by the expression:

$$V = \frac{E(V_1)}{(1+K)} = \frac{[qV^+ + (1-q)V^-]}{(1+K)} = \frac{[(0.5 * 180) + (0.5 * 60)]}{(1+0.20)} = 100$$

Thus the present value of investment costs gives the project's NPV:

$$NPV = V - I = 100 - 104 = -4$$

indeed the value of this investment opportunity is -4 euro. In the absence of managerial flexibility, traditional DCF would correctly reject this project. However, if managerial flexibility or various kind of operating options are present, investment in the plant may actually become economically desirable despite its negative static NPV.

Traditional DCF in unable to capture Properly the value of operating options because of their dependence on the future events that are uncertain at the time of the initial decision. Thus we can use the CCA that enables to quantify properly the additional value of a project's operating flexibility, but in the absence of such flexibility CCA gives results identical to those of the traditional DCF.

As we said above the economic foundation of CCA rests with the explicit recognition of market opportunities to trade and create desired payoff patterns through securities transactions. Thus we suppose that the gross value of the project, fully constructed, V , and the price of the project's twin security, S, moves over the next year as follows:

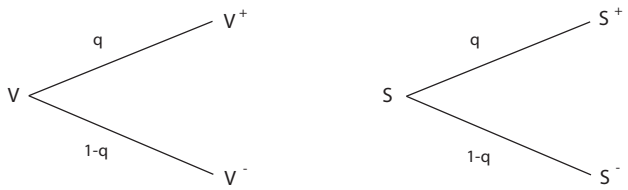


Figure 5.3: Project and twin security (2)

The gross value of the completed project should not be confused with the value of the (possibly complex) opportunity to initiate the construction. The value of the opportunity to start the construction, E will then move in a manner that is perfectly correlated with the movements in (S^+) or (S^-).

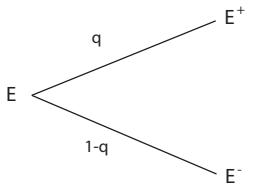


Figure 5.4: Opportunity

Considering now some of the open market transaction that would be possible. Specifically, following a standard option pricing hedging strategy, management could construct a portfolio consisting of n shares of the twin security S partially financed by borrowings the amount B at the rate r. This portfolio can be chosen such that it will exactly replicate the opportunity to build a new project, independently of whether the project does well (S^+) or poorly (S^-):

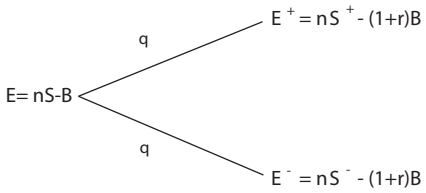


Figure 5.5: Replicating Portfolio

Thus such portfolio can be specified, then the investment opportunity, E, must have the same value as the equivalent portfolio. Taking the conditions of equal payoffs as two equations, the two unknowns n and B can be solved as follow:

$$n = \frac{E^+ - E^-}{S^+ - S^-}$$

$$B = \frac{E^+S^- - E^-S^+}{(S^+ - S^-)(1+r)}$$

In other words, management can replicate the payoff to the new investment opportunity by:

- purchasing n shares of the twin security, and
- financing this purchase in part by borrowing an amount B at the risk free rate r.

The current value of the opportunity (obtained by simply substituting for n and B in the equation $E = nS - B$ and then arranging terms) is given as follows:

$$E = \frac{pE^+ + (1-p)E^-}{(1+r)}$$

with

$$p = \frac{(1+r)S - S^-}{S^+ - S^-}$$

Note that the value of the opportunity does not explicitly involve the actual probability $(q)a$. Instead, it is expressed in terms of "risk-neutral" probabilities $(p)a$, that is the adjusted probabilities that allow expected values to be discounted at the risk-free rate. Essentially, instead of discounting expected future values using the actual probabilities of 0.5 at the expected risk-adjusted rate of return (in this case 20%), CCA equivalently discounts expected future value using the risk-neutral probability of 0.4 at the riskless rate (here, 8%). For demonstration purposes, by substituting within the expression for the risk-neutral probability,

$$p = \frac{(1+r)S - S^-}{(S^+ - S^-)} = \frac{(1.08 * 20) - 12}{(36 - 12)} = 0.4(distinct from q = 0.5)$$

and applying this probability and the risk-free rate we obtain

$$V = \frac{pV^+ + (1-p)V^-}{(1+r)} = \frac{0.4 * 180 + 0.6 * 60}{1.08} = 100$$

This is identical with the gross project value obtained using traditional DCF with the actual probability q and the discount rate K.

As this example illustrates, in the absence of operating flexibility or asymmetry, CCA gives the same results as traditional DCF. When operating flexibility is present, however,

such as in those case when management has the option to defer, abandon, expand or contract a project, traditional DCF is unable to handle the resulting asymmetries and may result in significantly misleading prescriptions for capital budgeting.

Continuing with this basic example, we will assume throughout that the value of the project, V, and its twin security, S, move through time as follows:

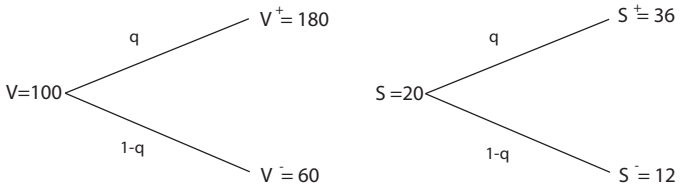


Figure 5.6: Project and twin security (3)

supposing that the firm has a one-year license granting it the exclusive right to realize a project, what is the value of the investment opportunity provided by the license, given that undertaking the project immediately was shown to have a negative NPV (-4)? With the flexibility to defer management maintains the right to benefit from favorable random movements in project value, and at the same time they cannot be hurt by unfavorable market circumstance because they have no symmetric obligation to invest. In order to determine the exact positive amount of the option to defer we simply substitute the appropriate values for the payoffs to the investment opportunity, E^+ and E^-, in the risk-neutral relationship above. Because the option to defer the project for a year gives management the right, but not the obligation, to make the investment by next year, they will wait and make the investment if the project value next year turns out to exceed the necessary investment at time. In other words, the option to wait can be seen as a call option on the project V with an exercise price equal to the required outlay next year (I_1). Thus, with $I_0 = 104$ growing in one yaer 8% to $I_1 = 112.32$.

$$E^+ = max(V^+ - I_1, 0) = max(180 - 112.32, 0) = 67.68$$

$$E^- = max(V^- - I_1, 0) = max(60 - 112.32, 0) = 0$$

Thus, with the option to defer the investment, the payoff structure would be as follows:

Again, with $p = [(1 + r)S - S^-]/(S^+ - S^-) = 0.4$, the total value of the investment opportunity (the expanded NPV that incorporates the value of the option to defer) can be expressed as follows:

$$E = \frac{pE^+ + (1 - p)E^-}{(1 + r)} = \frac{0.4 * 67.68 + 06.0}{1.08} = 25.07$$

Although the project per se has a negative(static)NPV of 4 if taken immediately, the invest-

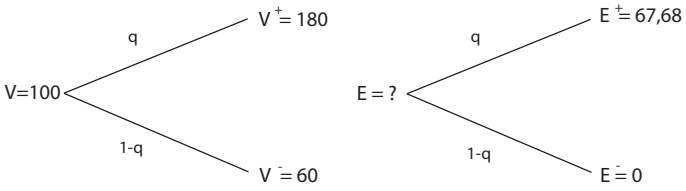


Figure 5.7: Project and Opportunity

ment proposal should not be rejected because the opportunity to invest in the project within a year is worth a positive 25.07 euro. Thus, the value of the option to defer is:

$$OptionPremiun = ExpandedNPV - StaticNPV = 25.07 - (-4) = 29.07$$

Trigeorgis and Mason at the end of this example, extracted from their paper [288]), claim that CCA is operationally identical to Decision Tree Analysis (DTA), but with the key difference that the probabilities are transformed so as to allow the use of a risk-free discount rate. After, other authors ([74, 75, 286, 287, 7, 8, 250, 261, 195])expressed their opinions on the comparison between ROT and DTA. In the next chapter we will analyse such positions.

5.5 Criticism

Early discussion that were raised against the real options theory comes from a separate field, namely decision analysts, who question the originality and, in some cases, the appropriateness of ROT. After all, the idea of systematically mapping out a range of scenarios over time and analyzing how managers should react under these different scenarios was developed by decision analysts four decades ago. Furthermore, some real options analysis have been criticized as inappropriately bundling together "private" and "market" risks, thereby sacrificing some of the specific information that pertains to each of these types of uncertainties. [265, 288, 250, 281]. Although, it is true that decision theory had already studied this problem, and that ROT can be considered as a particular section of Decision Theory, there are some differences. We Will analyze this issue in the next chapter (chapter 6).

Another common objection to real option analysis is that option pricing models require certain assumptions that are not met in real asset markets. For example, one often hears the ritual protest that options on real assets cannot be priced because the real asset is not traded, and hence cannot be held in an arbitrage portfolio. Arnold and Shockley [10] respond to this objection, arguing that is completely unfounded in any situation where DCF and the NPV

rule can be applied. They claim that as long as you are willing to make the assumptions necessary for application of the NPV rule to an illiquid asset, you have made assumptions that are sufficiently strong for application of option pricing to value that asset, even though the asset is not traded. In other words, if you reject real options analysis because the project has no cash flow, you must also reject DCF and the NPV rule as well.

This objection could be decisive in a policy-making context where many goods do not have market. Therefore, we claim that the answer given by Arnold and Shockley is appropriate because where the market does not exist we can use an artificial market, which if well realized could be a good proxy. Moreover, we can support this point arguing that, in policy-making such artificial market could be built in a subjective way .

Triantis [281]in the annual conference of real options (2005) argued that the more significant critiques are two. The first is that real options models tend to reflect a perfect situation rather than the reality. In fact decision-makers are assumed to be completely rational. Furthermore, they can be counted on to make the right decisions at exactly the right time. The right times to invest in options and to exercise them are in turn all based on managers having perfect information about the relevant parameters that determine the underlying project's value and volatility. He responds that while such assumptions clearly simplify the job of modeling investment decisions, they obviously fail to capture important realities of corporate decision making. The other objection to real options would appear to come from the opposite direction. That is, rather than criticizing the simplicity and artificiality of the models, many practitioners view the existing models as too complicated to use and even more so to explain.

Connected to the latter two objections, there are also others critics of options based approaches, which sustain that there is a world of difference between relatively simple financial options and highly complex real options. These difference make it practically impossible to apply financial-option models to real-option decisions. Copeland and Tufano [62] assert that these critique are right about the difference but wrong to assume that they are insurmountable. Since valuation models can accurately capture even the most complex real options. It is true that the value of underlying asset is not so clear, as in financial options, but the value of comparable asset can be observed or guessed. Certainly to do it we need to make assumptions, but these assumptions do not make the model useless, and option models are not alone in requiring assumptions. (For more information see: [156, 148, 36]).

At the same time, as we said above,there are many criticisms that come from practitioners. They argue that the methodology and the mathematical application is too difficult to put into practice. The opposite of DCF. About these criticism Copeland and Tufano [62], but also Mun [195] argue that the great mathematical difficulty due to the known formula of Black-Sholes and Merton, can be overcome. Both claim that, for the problem structuring, binomial, or lattice, models that are built around decision tree are ideally suited to real

option valuation. These models have practical advantage over the calculus-based on Black-Sholes and Merton model, because the math is much less complicate, although there may be more of it. Their relative transparency and flexibility mean that you can thinker with a binomial model you have created until it closely reflects the project you wish to value. In this way we avoid both the extreme simplification and the black box formula.

Related to these last criticisms our response is to find a useful compromise between the mathematical complexity model and the simplify assumption. In fact, we need to make assumption that obviously simplify the reality in order to have *models* that by definition are simple and general. At the same time, we need a simple mathematical model easy to use by the policy-maker (usually not mathematicians). In order to obtain such result we aim at combining the simply assumptions of ROT and the more simply math of DT and DTA.

5.6 Conclusions

In the previous chapter we presented the real options theory (ROT), it is the last tool that we show in this thesis. As for the decision theory and cost-benefit analysis the presentation aims to introduce briefly both the theoretical and the methodological aspects. The presentation was designed with specific reference to the public policy context and with the ultimate goal to give the reader the basic notions in order to understand our idea and our model, which connect together some concepts of these three tools.

For us in our research, the most important aspect of ROT is what it was defined "way of thinking" [7], namely the strategic aspect of ROT. In fact, we think possible to understand a policy or a social investment as a dynamic investment, where the uncertainty is important and grows with increasing decision levels. Moreover, the policy-maker can manage a certain number of factors related with the uncertainty, creating and using the different type of option. Thus, whether it is true, using some ROT concepts in a decision aiding process can aid the policy-makers to implement the policy flexibility, the creative process of alternative creations and also the assessment. In this way there is the possibility to rethink the policy process leading to make public decision.

Concluding, we want to say that in the next chapters we will present:

- the literature between decision theory and real options theory, showing as these are similar but also different, and as the idea to use them together is not really new;
- our policy decision aiding model, showing the decision theory and real options theory interactions, but also highlighting the differences and the innovations from the literature.

CHAPTER 6

Decision Theory and Real Options Theory in Literature

6.1 Introduction

After showing the context in which we join, the problems we face and the objectives that we set, we presented the real options theory, cost-benefit analysis and decision theory. These three arguments are the "theoretic pillars" on which we based our proposal, namely our thesis. At this point, before explain our idea and show in details our model, we would like to present a summary of the literature on our pillars together.

In this chapter we will briefly present what is already done and said about decision theory and real options theory. We focus our attention on them because ROT could be consider a sort of evolved CBA, and because in developing of our ideas the ROT had a bigger role.

In this section we will show what some authors wrote about the relationship between DT and ROT. In order to do that we have decided to divide these authors in two groups. In the first one, we present authors that come from economic field, while in the second one authors that come from decision aiding field. We have made this subdivision because their opinions and criticisms are strongly associated with their training

6.2 On ROT Literature

Since the 80s (in 1977 the term "real options" was coined by Stewart Myers) to now, in ROT literature there were many references between ROT and DT. Almost all the authors made reference, at least small, to DT [74, 75, 286, 287, 7, 8, 250, 261, 195].

The most known and studied of these reference was presented by Trigeorgis and Mason in 1987 in their famous paper "Valuing Managerial Flexibility" [288]. In this paper they compared first the CBA with the ROT, and then the ROT with the DT. They discussed the differences and the similarities of these approaches, in order to demonstrate that the ROT is superior to the NPV and DT, because it has a better accuracy and precision of calculus. The same arguments were also used by Mason and Merton in 1985 [179], and some years later by Copeland et Al. [61], and Amram and Kulatilaka [7]. They said that the problem is to understand which type of discount rate is appropriate for defer alternative in DT. Copeland et al. [61] write:

> *"The problem with the decision-tree approach is that we do not know the appropriate discount rate. The 20 percent rate derived from our NPV comparable is inappropriate, because the comparable security is not even approximately correlated with the payouts from the [Defer] option"*

Differently, others authors like Nau and McCardle in 1991 [199], Smith and Nau [267] in 1995, Howard in 1996 [123] and Makropoulou in 2011 [176] studying the relationship

between ROT and DT shown that the two approaches yield the same results when applied correctly. Namely, in the first case introducing the subjective discount rate, and in the second case using the Capital Asset Pricing Model (CAPM) in order to compute the appropriate discount rate.

In any case, in our opinion, the fundamental question is not which is the more accurate tool, because they have two different goals, and two different fields of applications. The ROT is an economic/financial tool that aims to produce an economic assessment able to aid firm's manager. While the DT is a decision aiding tool that aims to produce a recommendation, based on an assessment, which is not necessarily economic, but it is certainly subjective. Smith and Nau in their paper "Valuing Risky Projects: Option Pricing Theory and Decision Analysis" [267] highlighted this fundamental question, namely, that the ROT is an economic tool and DT does not. This is the most important difference. In fact, in ROT as in CBA the used data came from the market while in DT usually data came from the decision-maker. To be more precise, in ROT the expectations are computed using the risk-neutral probabilities and cash flows are discounted using the risk-free rate; but in DT we must use subjective probabilities and subjective discount rate, capturing time and risk preferences using decision-maker utility function.

Using subjective data in situation in which: markets are not complete and no arbitrage arguments are satisfied, or the private risk is dominant, is not a new idea. In fact, also in ROT field there were some authors that proposed some different approaches based on subjective data. These approaches have been well presented by Borison in his paper "Real Options Analysis: Where are the Emperor's Clothes?" [36]. He present four kind of "subjective" approaches,

- The Subjective (No Arbitrage, Subjective Data) Approach
  The classic approach makes explicit use of no-arbitrage arguments, and a clearly identified replicating portfolio to provide the inputs into standard financial option-pricing calculations. Other authors have proposed a closely-related approach that is also based on no-arbitrage arguments and the use of standard option-pricing tools from finance, but does not include the explicit identification of a replicating portfolio. Instead, this approach is based entirely subjective estimates of inputs. [36]
  The main proponents of this approach are Howell [125] and Luehrman [171, 172].

- The MAD (Equilibrium-Based, Subjective Data) Approach *The subjective approach takes a half-step away from standard option pricing. It is based on the existence of a traded replicating portfolio, but built on subjectively assessed data ...although the use of this data is not explicitly justified.The MAD approach extends this progression. It takes a full step away from standard option pricing, and it justifies this step explicitly. Specifically, the MAD approach does not rely on the existence of a traded*

replicating portfolio as with option pricing. Instead, proponents of this approach argue that the same, weaker assumptions that are used to justify the application of net present value (or discounted cash flow) to "fixed" corporate investments can be used to justify the application of option value (or real options) to flexible corporate investments. Furthermore, they argue that the same source of input data for the valuation calculations ... namely subjective assessment ... is appropriate. [36]
The main proponents of this approach are Copeland and Antikarov [60], but a similar view is taken also by Trigeorgis [287] and even by Brealey and Myers [40].

- The Revised Classic (Two Investment Types) Approach
  The classic and subjective approaches are based on fairly limiting no arbitrage assumptions, but leave unsaid what to do when those assumptions do not apply. The MAD approach, on the other hand, states very explicitly that the assumptions are not restrictive, and that real options can be applied to all corporate investments, irrespective of the existence of a replicating portfolio. In contrast, the revised classic approach states explicitly that the assumptions underlying real options are restrictive. They suggest that the classic finance-based real options approach can be applied where these assumptions apply, and that management science based approaches such as dynamic programming and decision analysis be applied where they do not. Real options should be used where investments are dominated by market priced or public risks, and dynamic programming/decision analysis should be used where investments are dominated by corporate-specific or private risks. [36]
  The main proponents of this approach are Dixit and Pindyck [74], and Amram and Kulatilaka [8].

- The Integrated (Two Risk Types) Approach
  The integrated approach [...] resulted primarily from practitioners in management science looking to incorporate capital market considerations, and shareholder value in particular, into their evaluation of corporate strategy. [...] the integrated approach acknowledges that there are two types of risk associated with most corporate investments: public or market and private or corporate. However, rather viewing private risk as a source of error as in the classic approach or forcing investments entirely into one category or the other, the integrated approach acknowledges that most realistic problems have both kinds of risk and is designed to address that situation. [36]
  The main proponents of this approach are Smith and Nau [267], and in Smith and McCardle [266].

(To read more about these approaches see [36])

Smith and Nau [267] demonstrated that if market opportunities to borrow and trade are included in the decision tree, and if time and risk preferences are captured using a utility

function and not by a single risk-adjusted discount rate, decision trees and real options give results that are consistent. They wrote: "Rather than defining the value of a project as the price the project would have if it were traded, value is typically defined subjectively in terms of the firm's *breakeven buying price* or *breakeven selling price*" also called the certainty equivalent.

Moreover, we would like to point out Makropoulou paper [176]. Also in this very recent paper titled "Decision Tree Analysis and Real Options: A Reconciliation" it is underlined as the difference between the two approaches results is given from using an incorrect discounting rate. Makropoulou wrote: "The reason is that the value of the option to invest does not have the same riskiness as the value of the project cash flows, i.e. the underlying asset". However, the author beginning from the work of Smith and Nau [267] and Brandão et Al. [39] show a reconciling way from the approaches. In fact, using the CAPM we can find the correct discounting rate in order to obtain the same results.

Now an important point to emphasize is that economists and managers have felt the need to mitigate the ROT with subjective perspective. Obviously, their actions were not aimed to change the tool, as we present in this thesis, with a DT tool, but they wanted to introduce specifications and distinctions within the economic perspective, also find a way to reconcile the two approaches, as shown above. Another very important matter, that we would point out now, is that our tool revolves entirely around the decision-maker (or policy-maker), the most important data for us is the policy-maker subjectivity, and the fact that under some hypothesis DT and ROT give results that are consistent [267] or equal [176] is just *something more*, which gives greater normative strength to the tool. Nevertheless, our scope is not to use the decision tree analysis as a financial or economic tool, but as decision aiding tool.

6.3 On DT Literature

In DT literature the reference to ROT are not so many, this tool, presented as revolutionary in economic context, until now has not attracted great attention in decision-making field.

At the beginning, the most common reaction by DT authors was to not understanding if there is anything new in real options or if real options is "*just decision analysis dressed in new clothes*" [265]. Smith [265] explained that ROT and DT have very similar purposes. Indeed, both are aimed at modeling uncertain decisions related to some investments. To be more precise, in ROT the focus is on options, namely, decisions that are made after that some uncertainties have been resolved, but options (or "downstream decisions") have always been a part of DT [231]. However, on the other hand, proponents of ROT argue that the differences between the two theories are substantial.

However, Smith [265] said that in books and articles where ROT is defined as revolutionary, the revolution is presented against the discounted cash flow (DCF) or net present value (NPV) analysis, that summarizing combines all uncertainties and decisions down to a single scenario, and then adjusts them for risk by using some inflated discount rate. Simplifying, the key in order to valuing real options is to consider the uncertainty or "volatility" associated with the investment in the same way that Black, Scholes and Merton [27, 185] did (see chapter 5). However, this way to manage uncertainty using several scenarios has been long considered in DT by decision analysts. Unfortunately, the vast majority of analysis done in corporate contexts are precisely the single scenario cash flow analysis which are contested in the real options literature.

Then, Smith [265] continues his analysis about ROT and DT saying that, despite the similarities in goals at the generical level, real options and decision analysis are different in style. Real options analysis tend to drown heavily on analogies with financial options. Indeed, a common theme in option models is the use of continuous-time stochastic process and frequent decision making. The models are often formulated using the stochastic differential equations' language and solved using binomial trees or lattices, which are in essence, recombining decision tree or dynamic programs. Because of the difficulties in solving these models, ROT usually focus on the evolution of a few (one or two) stochastic factors that determine the value of the investment over time and the cash flows are usually simple functions of these factors. The models thus tend to focus on "dynamic complexity" at the expense of "detail complexity". In contrast, DT models tend to consider great detail in the cash flows models and many uncertainties, but relatively little in the way of dynamic decision-making or downstream decisions [281].

In order to conclude what decision analyst believe about ROT we use Smith's words [265]:

> "*fundamentally, this difference between the real options and decision analysis approaches reflects a difference in the definition of "value" being considered. In decision analysis are considered the individual preference, and in the real options the market, or better the value that would have if it traded in the marketplace*".

Concluding this brief presentation about ROT and DT in literature, we want to underline that as at the end everyone agrees in saying that the difference between the two theories is on their nature, and so on their perspectives: one is economy and the other is decision aiding. Economists and decision analysts, in fact, have the same way of working, what changes is the perspective. Economists seek preferences, values and utilities in the market, because market is considered as a perfect mirror of society, and so its data are a perfect

proxy of preferences of the decision maker. Otherwise decision analysts seek preferences, values and utilities directly with the decision-maker, because they believe that the market is not a good proxy.

Before to start with the explanation of our ideas we just want to clarify a possible mistake. In our research we decide to work on DT field, so our perspective is related to the policy-maker subjectivity and our goal is to build a decision-aiding tool.

6.4 Rates

We have discovered from the literature that the "rate" plays a very important role in differentiating the three tools. In fact, remembering what we wrote in the previous chapters (chapter 3, chapter 4, chapter 5) and in the above sections, we know that using CBA we apply the *discount rate (k)*, instead using ROT we have to apply the *risk free interest rate (rf)*, and we have to apply the *subjective discount rate (sr)* when we use the DT. Such differences are due to the different nature and goals of these tools. However, what are these rates? Why are they different? How are they associated with the different tools nature?

- **Discount Rate (k)**
  In a very simple way, we can say that the discount rate is a rate used to discount future cash flows to the present value. In other word, it is a coefficient that allows to actualize the future value of an investment, it converts the future value in an actual value. This rate considers two components both the duration (time) and the risk of the investment. Usually, the discount rate can be defined as the opportunity cost of capital, that is related to the loss of value of resources for the public finances over time [92]. The discount rate that the EU Commission recommends in order to calculate investment projects is 5.5% [228].

- **Risk Free Interest Rate (rf)**
  Unlike the discount rate the risk free interest rate is the rate of return on financial assets offered by the risk free financial activity, typically these are the government bonds (usually set between 1 and 3%). In this type of rate is missing the risk component caused to the possible insolvency of the debtor.

- **Subjective Discount Rate (sr)**
  The subjective discount rate unlike the other two rates, is not only strictly connected with the economic and financial world. In fact, this rate is built using the subjective preference of the decision-maker. In this way the rate is able to reflect the specific preference about when receive benefit, today or in the future, and also the specific decision-maker preference about risk and his risk aversion. Thus, this discount rate

is calculated from the decision-maker's value function (as shown in the following section).

These three types of rates are different under two point of view. Between the discount rate and the risk free interest rate the difference is internal to the economic position, or rather both have the same economic nature, which recognizes in the market the only and correct source of information, but in the first case the risk is considered, while in the second is not. Instead, between these economic rates and the subjective discount rate the difference are more deeper, because this last rate is unrelated to the market. Its own nature is linked with a particular subject, whom does not recognize itself in the market. Then there is an extreme case in which one person recognize his preferences as perfectly aligned with the market, in this case we could have the subjective discount rate "equal" to the discount rate, if he is risk adverse, and equal to the risk free interest rate, if he is risk neutral.

In our case, namely, in a public policies context, we believe more credible that our policy-maker preferences are not perfectly aligned to the market. Thus we will use in our tree the subjective discount rate, because our tool is primarily a decision aiding tool, and for this reason built around the decision-maker.

6.5 Conclusion

It has been show in this chapter that there is a broad base of potentially relevant elements available in literature, which could be used to improve the study between decision theory and real options theory. Our research is clearly part of this context, and many of our ideas are arise from such literature, however as we will show in the following our work is different.

- First our work is entirely based on public policies characteristics, goals and mechanisms, and that make our work away from a purely economic and financial logics. In fact, we must consider as principal public goods, namely goods without market, and where the stakeholders and so the beneficiaries are many and very different.
- Second, our tool will be build around the policy-makers, with their subjectivity, objectives and priorities, and thus it will have to consider private risks and subjective perception of such risks.
- Third, our objective is to help the policy-maker with a decision aiding tool, which is able to drive them into the whole process of policy creation, namely design, evaluation, monitoring, because the whole life of a policy is much longer and complicated of an investment (also if it can be treated, for simplicity, as an investment).
- Fourth, we will try to introduce a kind of learning process.

Concluding we suggest at the reader to remember all these point reading the next chapter.

CHAPTER 7

Decision Theory and Real Options Theory

7.1 Introduction

Decision Theory (chapter 4), Real Options Theory (Chapter5) and Cost-Benefit Analysis (Chapter 3), all have the same ultimate aim, namely, to provide useful recommendations to someone who is making a decision (policy-maker, decision-maker or manager). In other words each of them could be considered as a decision-aiding tool.

Decision theory and economic theory are not so distant, they have "only" different perspective. In fact, under some specific assumptions considering the economic theory with its tools as a branch of decision aiding is possible and coherent . Economic theory (so CBA and ROT) seeks and finds its theoretical structure and its legitimacy in the market, because it is considered a perfect mirror of society and personal preferences. On the other hand, decision theory and decision aiding argue that each person has their own preferences which are not reflected by the market. In order to know the decision-maker's preferences the "analyst" should ask them directly, and only if the decision-maker's preferences are aligned with the market, the analyst may use economic instruments to analyse them. Instead, if the decision-maker's preferences are different from what the market reveals, the analyst must use another decision aiding tools. Talking about preferences of large groups of peoples or of whole societies in order to decide which approach is more appropriate it is difficult, and debates about it are open. For these reasons we believe it important to use both perspectives in order to construct processes and tools that support the decisions of the policy-makers. In other words, under the special condition of managing, overcoming this separation is fundamental.

In light of that, we believe that the decision aiding tools and the economic tools should be used together in a public context and we believe that some ROT ideas could be used within a DT tool. Firstly, the ROT coming from the CBA can be used to help the policy-maker in order to structure the problem in rigorous way. Secondly, the ROT introduces the idea that waiting can be used to generate alternatives and obtaining information. It connects the two central stages of the decision aiding process: "problem formulation" and "problem evaluation"; it allows the development of alternatives consistent with the evaluation model, which includes decision aiding's typical elements in an iterative process of context analysis. Third, from economic tools we take and use the concept of time as "real and consistent". Thus, we have to introduce the use of discounting rate, however, since we are in a public policies context, and we have defined this domain as heavily influenced by the decision-maker's subjectivity, such discount rate will have to be subjective.

We claim that it is possible using some ROT ideas within a decision tree to create a decision aiding tool in order to build and evaluate alternatives in a more coherent way with the public context and with the public policies nature. We claim to be possible to hybridize

the DT and more specifically the decision tree analysis with ideas and concepts arising from ROT and CBA. Summarizing, this is what we present in this chapter, but in order to be more clear we decided to present all that using two examples. With the first, we will show what we mean by talking about DT and ROT as problem structuring tools, therefore what we mean with "tool to create alternatives". We will also show how to hybridize the decision tree analysis by ROT ideas and concepts. Instead, with the second example we will show how to use this new decision tree with conditional probabilities, in order to consider a more realistic hypothesis according to which the received information is only partially true.

7.2 DT-ROT a New Decision Tree

At this point we would like to show how it is possible to use the real options idea in order to construct a legitimate decision aiding tool through a decision tree. Thus, in order to do this in a best way, in this section we will present first our *decision tree time*, supporting the theoretical explanation with two simple example, and then because our model is different from other existing tools. Finally, we propose a small demonstration of how the example would have been solved with real options theory, highlighting the difference in hypothesis and data.

7.2.1 The model

The *decision tree time* that we will present in this section is based on the following basic hypothesis:

1. public policy decisions could be at least an investment decision;
2. public policy decisions are affected by many different types of risk and uncertainty (public and private);
3. policy-makers are rational agents that maximize their expected social utility (but they are not private citizens or firms) ;
4. the market is not a perfect mirror of society and policy-maker preference;
5. capital markets are not complete with respect to all public investments.

These hypothesis are important and in some case restrictive in order to close and set the field of interest and application. With the (1) we are able to justify the use of monetized costs and benefits, like in a classic investment analysis (CBA). The (2) tells us that there are several kinds of risks and uncertainties (public and private). This means that we must be careful to use specific tools for a particular type of risk or uncertainty. The (3) is useful to restrict our field of analysis, since we consider rational only a specific kind of behavior (chapter 1). Beyond, we know that there are theories and authors (among all Simon

[256, 258, 260]) who doubt or deny the existence of fully rational agents. Anyway, we operated this choice for simplicity and because we do not believe that it may affect the model validity. With the (4) we joint us to the DT tradition that believes that each person has their own preferences different for all other, each person has his utility functions (MAUT). The (5) means that there is not a capital market for all goods, so we do not have the prices of all goods. Moreover, with this statement we eliminate the possibility that there is an asset or a portfolio of stocks able to perfectly replicate our project investment.

Having said that, we proceed explaining its applicability. The model can be applied in all situations where the policy-maker:

- has to choose among alternatives policies;
- can manage the policy implementation in a medium-long period of time;
- can find some information in order to solve uncertainties.

In a situation with these features the policy-maker can use time in order to redesign the policy implementation structure, generating alternatives just moving the implementation on the time line, or dividing the implementation in independent stages on the time line, and other things like these (this part will be explain with more details below).

We decided to analyse in detail a case where the policy-maker can decide when implementing the policy (today, in a year or in the future). Thus, in this case the policy-maker will be periodically in a situation in which the choice is between (at least) the same three alternatives. The situation is represented by the "temporal decision tree" in figure 6.1.

Being the situation reiterative, we will analyse the first part, namely two times, where there are all the characteristics of the model (figure 6.2). The following times do not add anything news; it is consists only in more complicated calculation.

Analyzing this two times tree we have three "branches" each of which represents an alternative:

1. **To defer**
   The first alternative is that the policy-maker may decide to decline the opportunity to implement the each policy, so he does not pay any cost and will not receive any benefit.

2. **To invest**
   The second alternative is that the policy-maker may decide to invest, and so to implement the whole policy. In this case, in order to realize this he has to invest I now at t_0 and in a period of time to implement the policy that later at t_1 will have a payoff C that will depend on several variables. In t_1 could be possible several nature states but

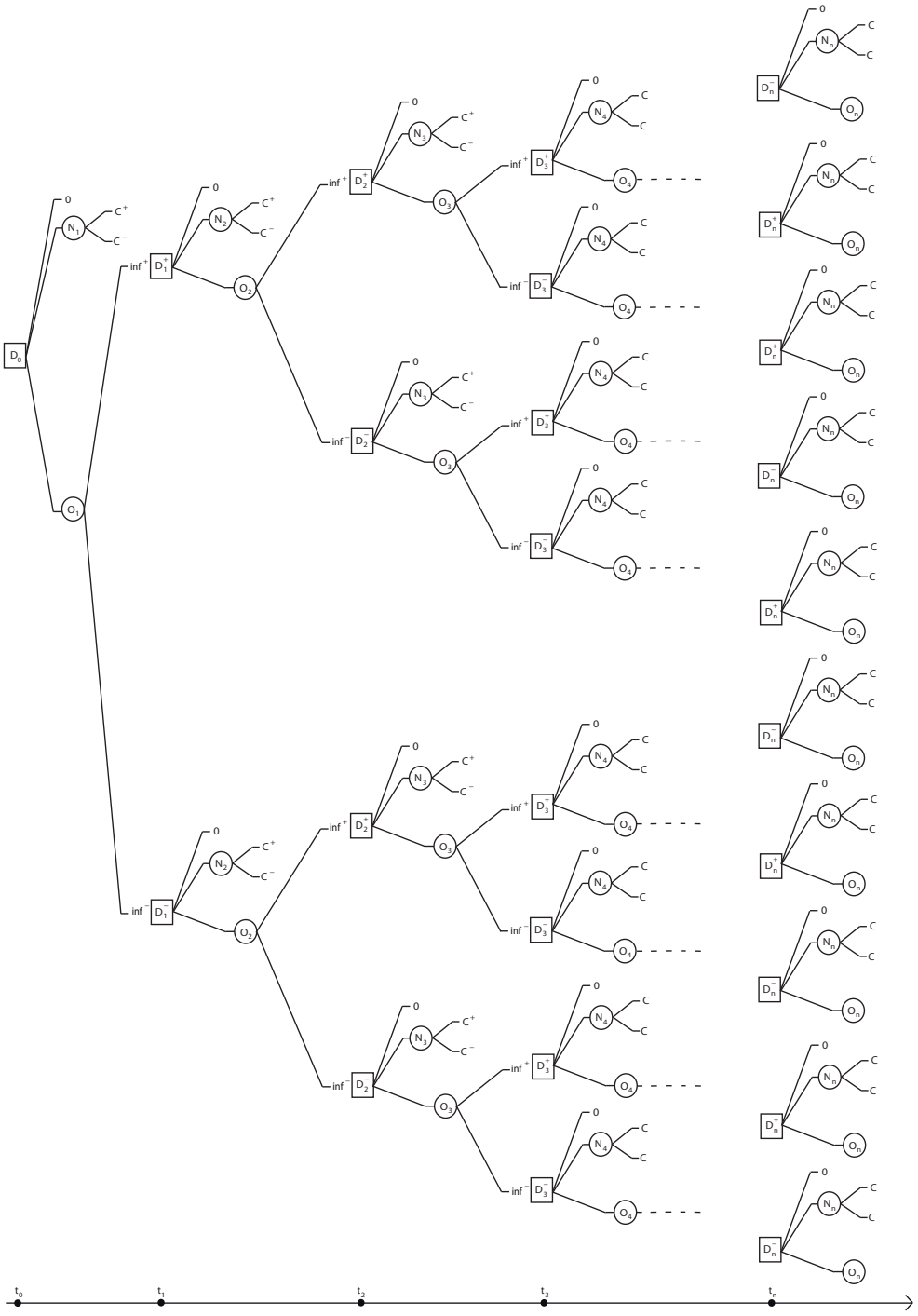


Figure 7.1: Decision tree time: complete

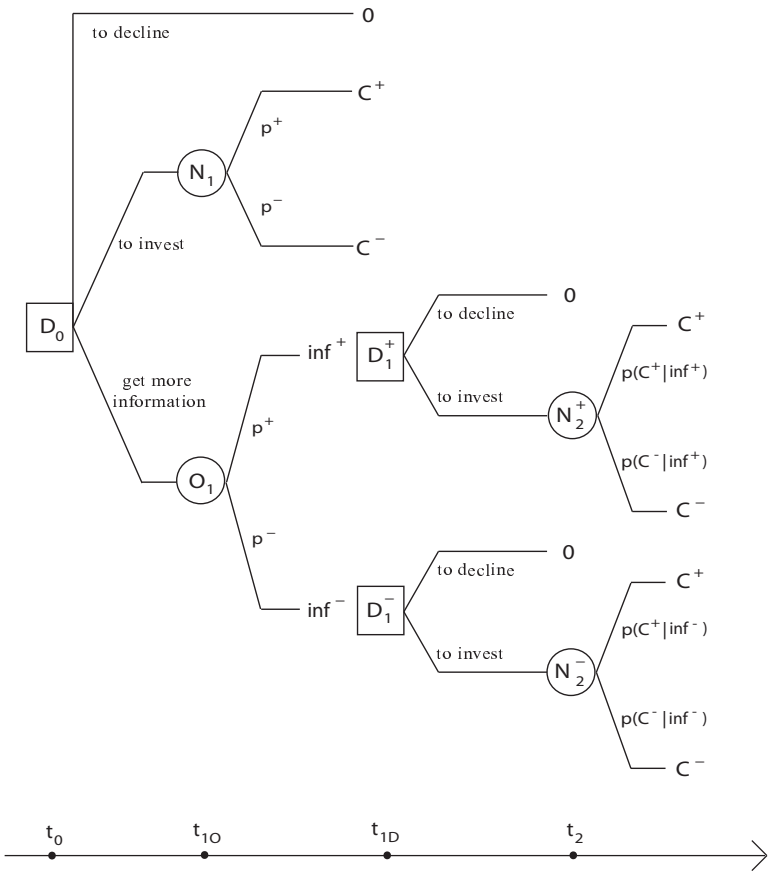


Figure 7.2: Decision tree time: two time

for simplicity in this case we consider only two states: the "positive" one C^+, and the "negative" one C^-. The possible nature states will have probability $p^1; p^2 p^3 ... p^n$, where $p^1 + p^2 + p^3 + ... p^n = 1$, but in our case we have $p^+ = p^-$.

3. **Get More Information**
   The third alternative is that the policy-maker may decide to not decide now at t_0 if implementing the policy or not, but waiting for a period of time, from t_0 to t_1, collecting more information, and only then decide what to do. In this case, he may postpone the implementation until he has had more detailed information about the future nature states. With this alternative, in t_1 he will decide whether to invest $I*$ (assuming that the cost to realize the whole work grows at the risk-free rate rf), and at time t_2 getting or C^+ or C^-. However, in this case the probabilities for the two states are different from $p^1; p^2; p^3 ... p^n$, because they were conditioned by the information received, so we have: $p(C^+|inf^+)$ probability to have a positive consequence having a positive information, $p(C^-|inf^+)$ probability to have a negative consequence having a positive information, $p(C^+|inf^-)$ probability to have a positive consequence having a negative information, $p(C^-|inf^-)$ probability to have a negative consequence having a negative information. Otherwise, he may decline to invest and let the opportunity expire.

Obviously, in the branch "get more information" we can always decide to wait for t_n periods of time, before takeing a definitive decision (where t_n is the maximum waiting time). Thus, we will have one more alternative, but, as we have said above, since this is simply an alternative that postpone the whole tree for each t_n periods time, we will not consider this alternative.

Let us explain now the component of the decision tree time.

Consequence C

The consequences that we generically called C are nothing more than monetized benefits minus costs as in a common CBA. These costs and benefits were found in the market when possible, and in a subjective way by the policy-maker when it is not. We imagine that these consequence could be two (but in a real situation could be many more), and these will be C^+ and C^-, where $C^+ > C^-$.

Probabilities p

In this model we have two type of probabilities, the prior probabilities $p^1; p^2; p^3 ... p^n$ that in a simple tree with two branches are p^+ and p^-, where $p^- = 1 - p^+$; and the a posteriori probabilities: $p(C^+|inf^+)$ probability to have a positive consequence having a positive information, $p(C^-|inf^+)$ probability to have a negative consequence having a positive

information, $p(C^+|inf^-)$ probability to have a positive consequence having a negative information, $p(C^-|inf^-)$ probability to have a negative consequence having a negative information, where $p(C^-|inf^+) = 1 - p(C^+|inf^+)$ and $p(C^-|inf^-) = 1 - p(C^+|inf^-)$ (calculated as explained in chapter 4).

Discount Rates k, rf, sr

The discount rate as we explained above is a core issue, and its goals is to catch:

- the risk of the policy implementation outcome; and
- the risk linked to the money worth (worth resources).

Usually, in economy it is used the risk free interest rate (rf) as benchmark, (where the decision maker is considered without risk) and the (economic or social) discount rate (K) in normal applications. In our case, where the model is build on the policy-maker preferences, it becomes essential that this two kinds of risk are caught by a specific discount rate, namely, the subjective (sr). We can not use the rf or k, because this would imply that our policy-maker have not his specific preferences, but a generic preference caught by the market. For theses reasons we need to use the utility functions. Obviously, the two kind of risk caught by the subjective discount rate are linked to the time, and to the policy-maker time preference. However, for the investment at time t_0 we can use a normal discount rate, coming from the market, because investing today many uncertainties are revealed. While investing in t_1 these uncertainty are not revealed, and the risk is totally linked to the subjective preferences of the policy-maker.

In order to calculate the subjective discount rate sr we propose to use the utility functions (obtained as explained in chapter 4)as follows. Before, we must ask to the policy-maker what is his willingness to have tomorrow a certain amount of money C_1 in order to give up today a certain amount C_0. In other words, we want to know for "how much" the policy-maker is indifferent between C_0 at time t_0 and C_1 at time t_1, this implies that exist a marginal time preference captured by a subjective discount rate sr.

For example, assuming that our policy-maker is risk adverse, his utility function, among many possible, could be (figure 6.3 - red):

$$U^a = \sqrt{\frac{C_i}{C_{max}}}.$$

or assuming that he is risk prone, his utility function could be for example (figure 6.3 - blue):

$$U^l = \left(\frac{C_i}{C_{max}}\right)^2$$

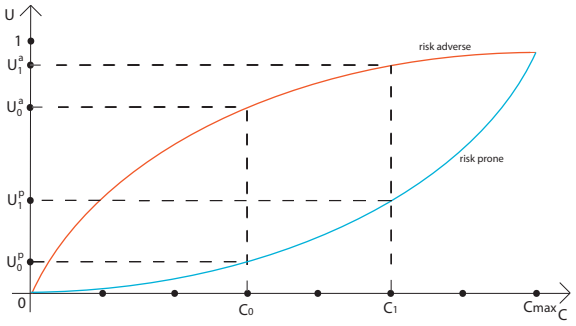


Figure 7.3: Policy-maker value function

Now, having the utility functions we can calculate the subjective discount rate sr namely, the value that makes our policy-maker indifferent between C_0 and C_1. Thus, for the policy-maker risk adverse we have:

$$sr \geq \frac{U_1^a}{U_0^a}$$

similarly, for the policy-maker risk-prone we have:

$$sr \geq \frac{U_1^p}{U_0^p}$$

where these means that he will accept to wait for C_1 only for a subjective discount rate higher than $\frac{U_1}{U_0}$, but since the ratio between $\frac{U_1^p}{U_0^p}$ is bigger than $\frac{U_1^a}{U_1^a}$ the subjective discount rate is greater. This means that a policy-maker risk-prone is willing to discount more of a future value.

At this point, we have structured the decision tree and found the necessary data. Thus, in order to resolve the tree let us calculate the value of each tree nodes, from the leafs to the root, with a rollback method.

At the first branch, “to decline”, the policy-maker has a certain outcome of 0, because in this alternative he decides to do nothing.

Let us study now the branch “to invest”, we have:

$$N_1 = \frac{p^+C^+ + p^-C^-}{1+k} - I \tag{7.1}$$

Let us study now the branch "get more information"; we have:

$$N_2^+ = \frac{p(C^+|inf^+)Max[C^+;0] + p(C^-|inf^+)Max[C^-;0]}{(1+rs)} \tag{7.2}$$

$$N_2^- = \frac{p(C^+|inf^-)Max[C^+;0] + p(C^-|inf^-)Max[C^-+;0]}{(1+rs)} \tag{7.3}$$

$$D_1^+ = Max[0; N_2^+ - I^*] \tag{7.4}$$

$$D_1^- = Max[0; N_2^- - I^*] \tag{7.5}$$

Thus the value of the node representing the "oracle" is:

$$O_1 = \frac{p^+D_1^+ + p^-D_1^-}{(1+rs)} \tag{7.6}$$

and the final decision is:

$$D_0 = max[0; N_1; O_1] \tag{7.7}$$

While the real value of information is given by the following equation:

$$Inf = O_1 - Max[0; N_1] \tag{7.8}$$

this because the value of information is given by the value obtained using the information less the other best value, that in our case could be N_1 or 0.

7.2.2 A Generic Example

In order to better explain the model shown above we propose in this section a generic numerical example. We will solve this in two way, in order to show first an extreme case, namely, when the "oracle" is perfect, and so its information reveal the truth. Then, the second case more credible when the "oracle" reveals only partially the truth.

Moreover, we would like to underline as with our hypothesis what we know are the prior probabilities, and only after with the policy-maker we find his subjective discount rate, namely, the rate that makes him indifferent to the choice between investing today and tomorrow.

Perfect Information

We consider a policy-maker that have the opportunity to implement an important infrastructure policy. Anyway, he is not sure of its success, because there are many variables (i.e. political uncertainty, policy agenda, introduction of new directive, implementation of other policies, etc.), and so much uncertainty. Analyzing the situation he concludes to have three alternatives to choose.

1. **To defer**
   The first alternative is that the policy-maker may decide to decline the opportunity to implement the infrastructure policy, so he does not pay any cost and will not receive any benefit.

2. **To invest**
   The second alternative is that the policy-maker may decide to invest and so to implement the infrastructure policy. In this case, in order to realize the whole project he have to invest 100 now and build the infrastructure, which a year later will have a payoff that will depend on several variables. A year from now could be two possible states of the nature, the "positive" one where the infrastructure pays 140, and the "negative" one where it pays only 72. These two nature states are equally likely with probability $p^+ = p^-$.

3. **Get more information**
   The third alternative is that the policy-maker may decide to not decide now at t_0 if implement the policy or not, but waiting for a period of time, from t_0 to t_1, collecting more information, and only then decide what to do. In this case, he may postpone the implementation until he has had more detailed information about the future nature state. With this alternative, in t_1 he will decide whether to invest 102 (assuming that the cost to realize the whole work grows at the risk-free rate 2%), and at time t_2 getting or 140 or 72. However, in this case the probabilities for the two states are different, because they were conditioned by the information received, and we have: $p(C^+|inf^+) = 1$ probability to have a positive consequence having a positive information, $p(C^-|inf^+) = 0$ probability to have a negative consequence having a positive information, $p(C^+|inf^-) = 0$ probability to have a positive consequence having a negative information, $p(C^-|inf^-) = 1$ probability to have a negative consequence having a negative information. Otherwise, he may decline to invest and let the opportunity expire.

The situation is summarized and illustrated with the decision tree in figure 6.4. Given this hypothesis, we try to help the policy-maker to chose the best alternative.
The parameters that we have are:
- $I = 100$ Investment

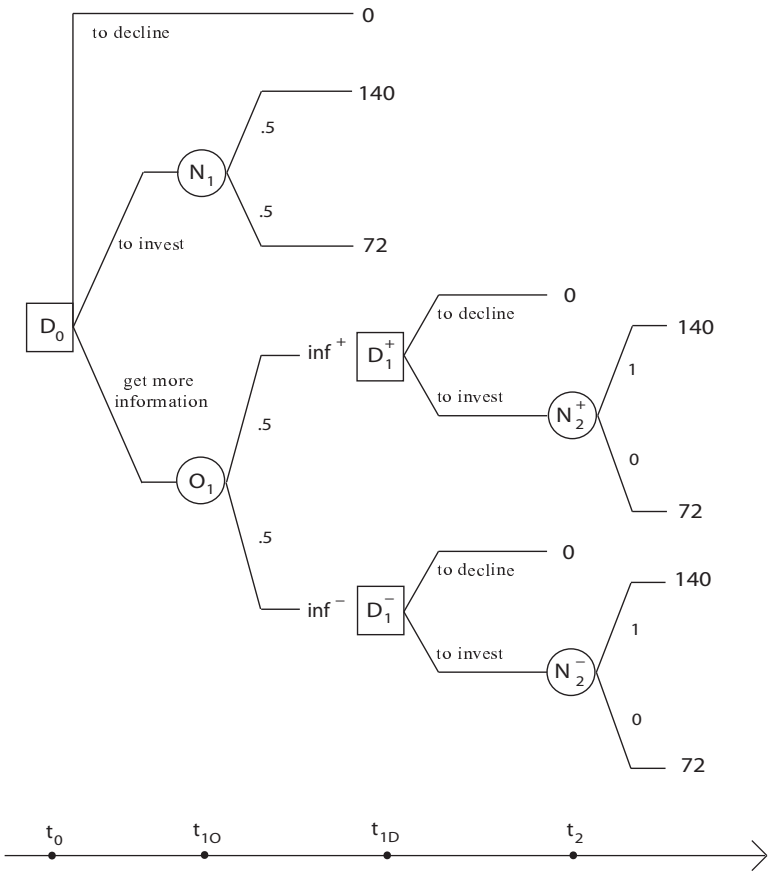


Figure 7.4: Decision tree with perfect information

- $I^* = 102$ Investment at time 1
- $C^+ = 140$ positive consequence
- $C^- = 72$ negative consequence
- $p^+ = 0.5$ priori probability of a positive consequence
- $p^- = 0.5$ priori probability of a negative consequence
- $rf = 2\%$ risk free interest rate
- $k = 6\%$ discount rate

and assuming that the "oracle" reveals exactly the true, namely, that waiting we receive perfect information about the future state of the nature, the conditional probabilities are:
- $p(C^+|inf^+) = 1$ Probability to have a positive consequence having a positive information
- $p(C^-|inf^+) = 0$ Probability to have a negative consequence having a positive information
- $p(C^+|inf^-) = 0$ Probability to have a positive consequence having a negative information
- $p(C^-|inf^-) = 1$ Probability to have a negative consequence having a negative information

Now in order to use our decision tree time we must find the subjective discount rate of our policy-maker, and to do this we use the policy-maker preferences captured by his utility function (fig. 6.5). Thus, assuming that the policy-maker is risk adverse we have:

$$U_1 = \sqrt{\frac{100}{140}} = 0,84$$

$$U_2 = \sqrt{\frac{120}{140}} = 0,92$$

and the subjective discount rate is:

$$0.84 = \frac{0.92}{sr}$$

$$sr = \frac{0,92}{0.84} = 1.095$$

so in our example we have $sr = 9.5\%$

At this point we have all the necessary data to solve the tree. Let us calculate the value of each tree nodes, from the leafs to the root, with a rollback method.

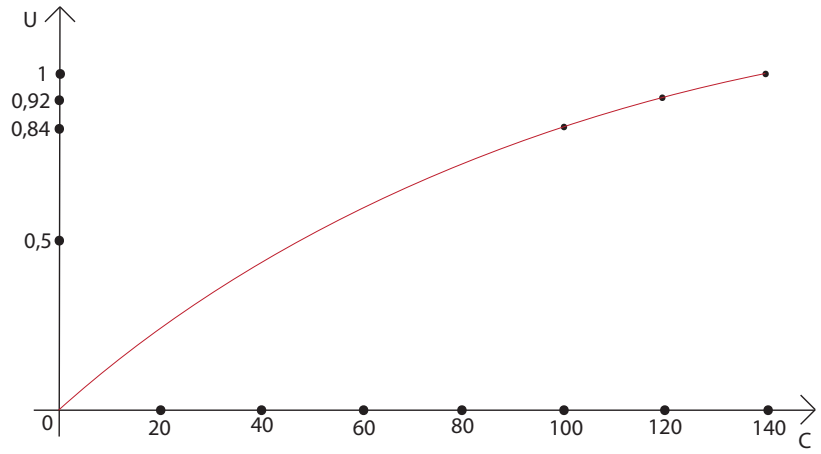


Figure 7.5: Policy-maker value function: example

At the first branch, "to decline", the policy-maker has a certain outcome of 0, because in this alternative he decide to do nothing.

Let us study now the branch "to invest"; we have:

$$N_1 = \frac{0.5 * 140 + 0.5 * 72}{1 + 0.06} - 100 = 0 \tag{7.9}$$

Let us study now the branch "get more information"; we have:

$$N_2^+ = \frac{1 * Max[140; 0] + 0 * Max[72; 0]}{(1 + 0,095)} = 127.85 \tag{7.10}$$

$$N_2^- = \frac{0 * Max[140; 0] + 1 * Max[72; 0]}{(1 + 0.095)} = 65.75 \tag{7.11}$$

$$D_1^+ = Max[0; 127.85 - 102] = Max[0; 25.85] = 25.85 \tag{7.12}$$

$$D_1^- = Max[0; 65.75 - 102] = Max[0; -36.24] = 0 \tag{7.13}$$

$$O_1 = \frac{0.5 * 25.85 + 0.5 * 0}{(1 + 0.095)} = 11.80 \tag{7.14}$$

and the final decision is:

$$D_0 = max[0; 0; 11.80] = 11.80 \tag{7.15}$$

While the value of information is:

$$Inf = O_1 - 0 = 11.80 \tag{7.16}$$

Concluding, the winning strategy for the policy-maker in this situation is waiting. In fact, the value of policy today is equal to 0, but waiting he removes any uncertainty (because we have assumed that waiting reveals the truth without margin of error) and in this case the policy becomes profitable. Thus, waiting (oracle) has a own value that is given by the information values that in this example is 11.80.

However, the possibility to remove completely any uncertainty is really unrealistic, thus more realistic is to imagine a situation where waiting reveals only partially the truth, in other words waiting is not a prefect "oracle". This means that our conditional probabilities are less than 1, as instead we have assumed in this example.

Imperfect Information

Now let us show the example where waiting reveals only partially the truth, in other words we receive from the "oracle" an imperfect information. In order to do that we will use the same above example only changing the conditional probabilities that become (figure 6.6):

- $p(C^+|inf^+) = 0.85$ Probability to have a positive consequence having a positive information
- $p(C^-|inf^+) = 0.15$ Probability to have a negative consequence having a positive information
- $p(C^+|inf^-) = 0.15$ Probability to have a positive consequence having a negative information
- $p(C^-|inf^-) = 0.85$ Probability to have a negative consequence having a negative information

These conditional probability created specifically for this example can be found before using a time series data, when these data exist, and then adjusted speaking with the policy-maker, in relation with his confidence about the chosen "oracle".

Now with these new probabilities we can roll back the tree. The first two branches remain the same of the previous example, namely, in the branch "to decline"the policy-maker

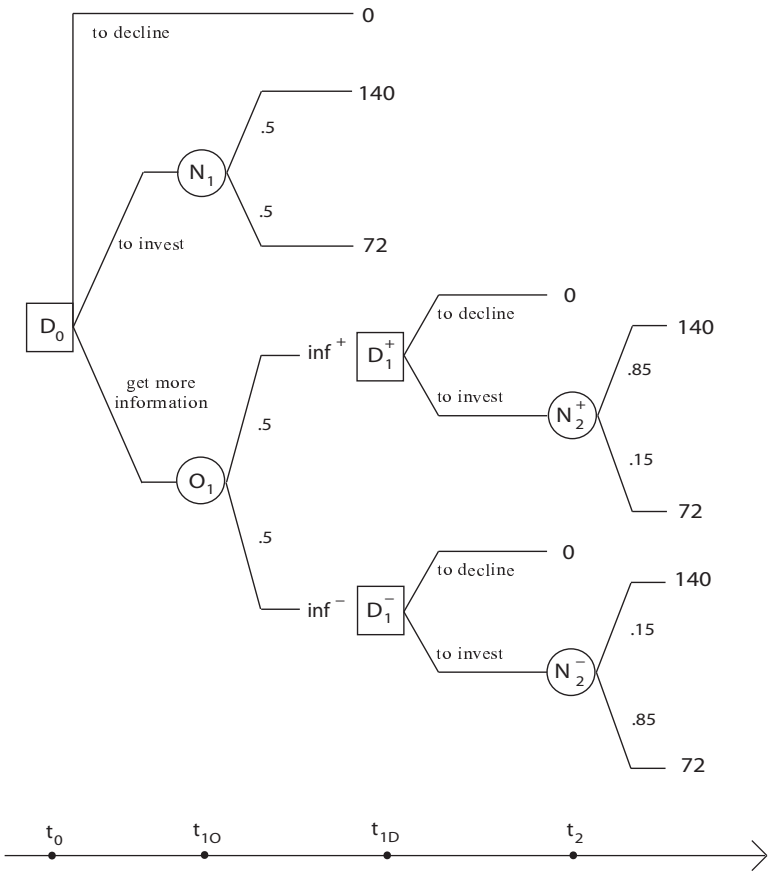


Figure 7.6: Decision tree with perfect information

decide to do nothing, so he has a certain outcome of 0, and in the second branch "to invest" we have $N_1 = 0$.

Otherwise, the branch "get more information" is changed and we have:

$$N_2^+ = \frac{0.85 * Max[140; 0] + 0.15 * Max[72; 0]}{(1 + 0.095)} = 116.89 \tag{7.17}$$

$$N_2^- = \frac{0.15 * Max[140; 0] + 0.85 * Max[72; 0]}{(1 + 0.095)} = 55.89 \tag{7.18}$$

$$D_1^+ = Max[0; 116.89 - 102] = Max[0; 14.89] = 14.89 \tag{7.19}$$

$$D_1^- = Max[0; 55.89 - 102] = Max[0; -46.11] = 0 \tag{7.20}$$

$$O_1 = \frac{0.5 * 14.89 + 0.5 * 0}{(1 + 0.095)} = 6.79 \tag{7.21}$$

and the final decision is:

$$D_0 = max[0; -0.94; 6.79] = 6.79 \tag{7.22}$$

While the value of information is:

$$Inf = O_1 - 0 = 6.79 \tag{7.23}$$

In this case, as might be expected, the value of information is less than in the previous example. This because here the "oracle" is not perfect, so also its information will be imperfect and therefore with less value.

7.3 If it were a Real Options

Now, in this section, we present the above "generic numerical example" how it would be solved if it were a real option, namely, if the market was complete and if for the policy-maker the market represents a good proxy of his preferences. In practice, in this example there is a twin security for the investment, that allows us some simplifications, in order to know the correct discount rate, that in this case is the risk free interest rate. Then, using this we will able to find the neutral risk probabilities.

Using the same data, we have: - $I = 100$ Investment;
- $I^* = 102$ Investment at time 1;

- $C^+ = 140$ positive consequence;
- $C^- = 72$ negative consequence;
- $rf = 2\%$ risk free interest rate;
- $k = 6\%$ discount rate.

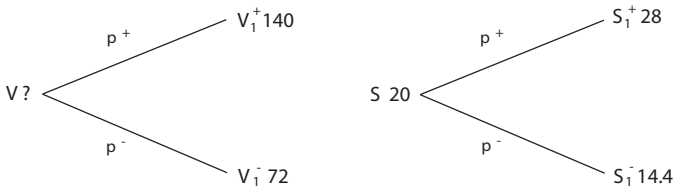


Figure 7.7: Binomial lattice for project and twin security

At this point, following the traditional practice (explained at chapter 5) let S the listed stock price of an identical project. The twin security is assumed to have a value of 28 in a positive state and 14.4 in a negative state (figure 6.7). The gross value of the completed project should not be confused with the value of the (possibly complex) opportunity to implement the project. The value of the opportunity to start the implementation, E will then move in a manner that is perfectly correlated with the movements in S_1^+ or S_1^-. Thus, we must construct a portfolio consisting of n shares of the twin security S partially financed by borrowings the amount B at the rate rf. This portfolio can be chosen such that it will exactly replicate the opportunity to build a new project, independently of whether the project does positive (S_1^+) or negative (S_1^-):

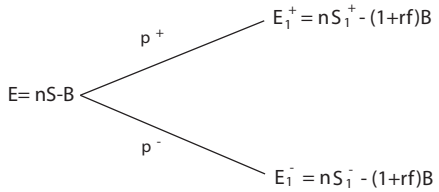


Figure 7.8: Binomial lattice for opportunity

Now this portfolio can be specified, then the project opportunity, E, must have the same value as the equivalent portfolio. Taking the conditions of equal payoffs as two equations n and B are:

$$n = \frac{E_1^+ - E_1^-}{S_1^+ - S_1^-}$$

$$B = \frac{E_1^+ S_1^- - E_1^- S_1^+}{(S_1^+ - S_1^-(1 + rf)}$$

In other words, the policy-maker can replicate the payoff to the new project opportunity

by:

- purchasing n shares of the twin security, and
- financing this purchase in part by borrowing an amount B at the risk free interest rate rf.

Now we can find:

$$E = \frac{p^+ E_1^+ + p^- E_1^-}{(1+rf)}$$

$$p^+ = \frac{(1+rf)S - S_1^-}{S_1^+ - S_1^-}$$

Thus, since $p^- = (1-p^+)$ we have all terms to solve our example. Let us substituting the numerical value in order to find the risk neutral probabilities and the value of the project without option, namely implemented today:

$$p^+ = \frac{(1+0.02)20 - 14.4}{(28-14.4)} = \frac{20.4 - 14.4}{13.6} = 0.44117647$$

$$p^- = 1 - p^+ = 0.558823529$$

and

$$V = \frac{p^+ V_1^+ + p^- V_1^-}{(1+rf)} = 100$$

Thus, in this case implementing the project today the value is $V - I = 100 - 100 = 0$, exactly like in our tree, when there are no postponements.

Now, let us calculate the value of the project with option to wait, namely implemented tomorrow. In this case we have that:

$$E_1^+ = Max[\frac{V_1^+}{(1+rf)} - I*; 0] = Max[137.25 - 102; 0] = 35.25$$

$$E_1^- = Max[\frac{V_1^-}{(1+rf)} - I*; 0] = Max[70.58 - 102; 0] = 0$$

Again, using the risk neutral probabilities we find that:

$$E = \frac{p^+ E_1^+ + p^- E_1^-}{(1+rf)} = \frac{0.44 * 35.25 + 0.56 * 0}{1.02} = 15.2$$

Also using the ROT, the project has a value of 0 if taken today, but also in this case the project should not be rejected, because the opportunity to implement the project in a year has positive value of 15.2. Thus, the value of the option to defer is:

$$OptionPremiun = ExpandedNPV - StaticNPV = 15.2 - 0 = 15.2$$

Concluding these set of examples, we can say that using the ROT we have to make different hypotheses, but above all we must find a twin security that replicate perfectly our project (or policy). In fact, only using that we can make the necessary simplification in order to assume the use of the risk free interest rate, and thus we are able to find probabilities and the option value. If this way of thinking and operating is possible in economic and private context, in public policy context this is not possible (in most cases).

Anyway, the two tools may lead to the same results when there are special conditions, namely, the policy-maker subjective discount rate is equal to the risk free interest rate and the prior probabilities are equal to the neutral probabilities.

7.4 Differences Between the Model and the Available Tools

In the previous section we have shown our model first in general and then applied to two simple examples. Now, that the model and its features should be clear, we will try in the current section to explain because our modified decision tree is different from DT, ROT and CBA, and because it is more appropriate to the public policy context.

7.4.1 Difference from CBA

The first difference between our model and CBA is the flexibility. In fact, using the decision tree and some ROT ideas we structure the problem and the alternatives in a very different way than the CBA. With the CBA, in fact, we not consider needs and ability to change some already taken decision. CBA does not consider the decisions as collections of other decisions, but as single decision "yes or not", and it considers each policy "now or never". Otherwise for us it is very important to understand and emphasize the degree of flexibility that a decision of this type (that is to implement a policy) involves; for us decisions are always a stream. In fact for example, policy-maker can extend the time of policy implementation or increase/cut the available resources during the policy implementation and not before, so CBA does not consider all these possibilities.

Concluding CBA does not consider as the information can change value and perspective at the policy, and it does not capture information value that produce flexibility.

7.4.2 Difference from classical DT

Why the decision tree presented above is different from the classic decision tree presented in chapter 4? The main differences between these two tree are two the following ones: the interpretation and use of time, and the structuring of the problem with costs and benefits. The reasons for these differences must be find into the specific nature of public policies, in fact, when we talk about them it is important to understand that policies have a

real dimension. This means to recognize that one policy is made up of concrete variables such as the *space* on which they affect, as the *time* that they involve and the *resources* that they mobilize. Whether for the first variable "the space" we can not do anything (directly with our model) for the other two we can do something.

Time

Recognizing that one policy is structured over time (design, implementation, evaluation and monitoring) and that its consequences have effects over time (usually in the long term) is very important in order to build a tool able to help the policy-maker to choose the best alternative. This consideration requires us to conceive time as a very important variable of our model, that is measurable in weeks, months and years, and from which we can not overlook.

However, the classical decision tree does not explicitly recognizes and incorporates the time variable. Time in DT is seen simply as a series of subsequent decisions and states of nature. To be more clear, in a decision tree time is just a sequence of decision forks (square) and chance nodes (circle). Time in DT view lacks of concreteness and for this reason in DT there are no ways to accounting this variable, and how it changes preferences, perspectives and consequences. DT and classical decision tree are designed in a general way in order to deal with each case of decision that then need to be modified for specific context. We believe that public policy decision is a very special context where traditional types of tools and analysis should be revised and adapted.

Therefore, in order to adapt the decision tree at our context, in our model we have introduced a *concrete time*, which influenced:

- the problem structuring;
- the decision-maker's preference;
- the problem data.

Introducing concrete time, also following the ROT ideas, we can use time in order to generate alternatives. What we means by saying this, it is that choosing a different time horizon is like choosing a different action (policy). In public policies this variable is so much relevant that alone can transform or generate an alternative. To be more clear, coming back to our model and observing the tree, excluding the alternative to do nothing (branch "to decline"), we have two alternatives, but the only difference between them is the implementation time. Nevertheless, we consider them as two alternatives, and not as one that may be implemented in different period of time.

We believe that this point is very important especially if related with the theory of Keeney [142] Value-Focused Thinking (chapter 4).

Cost and Benefit

The second aspect that makes our model different from the classic decision tree is the presence of monetized costs and benefits. In fact, usually in DT, and so in decision tree, are used utilities, or general values, but hardly costs and benefits. This because it is common thought believing that DT field and economic field are two different worlds, and it is better to keep them separate. We do not believe that this attitude is correct, especially in public context. As we said above public policies are made of concrete variables and one of these is: the resources. The resource aspect is very important and we can not afford to neglect.

7.4.3 Difference from ROT

What is different from our model and the binomial lattice in ROT (chapter 5)? And what are the differences between our model and the models presented at the beginning of this chapter, where ROT and DT are used together? The difference are in **goals**, **hypothesis** and **methodology**.

Goals

First of all, although to build our model is strongly inspired by the ROT, and has ideas and concepts that coming from the ROT, the model and ROT have different goals. We do not assess the value option (chapter 5), but the information value (chapter 4). Options and value that may look the same, in reality are two different things. Moreover, we are justified to say that they have different goals because for the economic field is central the market, for DT is central the decision-maker and his subjectivity.

Hypothesis

One of the most significant difference between the model and the ROT is given by the hypothesis. In our model we have wrote among the hypothesis that:

- the market is not a perfect mirror of society and policy-maker preferences;
- capital markets are not complete with respect to all public investments.

The first of theses hypothesis underlines for us the inability to use the market as information source of preference. This means that we have to find preferences directly from the policy-maker, and this is the reason for which we decided to use value functions in our model. The second of these hypothesis means that we can not use the capital market to find price or other data about public policy investments. In fact, it is highly unlikely that all economic agents can exchange public goods directly or indirectly with any other agent, this when the public goods market exists, because usually public good market does not exist.

However, the most important thing, that these two hypothesis said us, is that we can not apply ROT, since its approach:

> *assumes that a portfolio of traded investments can be constructed to replicate the returns of the option in question, and therefore that the option can valued based on standard no-arbitrage arguments.*[36]

> *is based on the construction of a replicating portfolio that consists of holding both the option and its underlying asset, the latter must be traded in the market.[...] where the underlying asset, i.e. the project, is not traded, it is usually assumed that the payoff of the project can be spanned by existing traded assets. Such assumptions of market completeness allow for what is called risk-neutral valuation, i.e. the payoff from the option to be discounted at the risk-free rate. However, if none of these conditions are met, then real options valuation can be used if we assume that the decision maker is risk neutral.* [176]

Methodology

The third difference between ROT and our model is due to their methodology. To be more clear, the classical ROT approach is built around the idea of a replicating portfolio (twin security). Brennan and Schwartz [41] have wrote:

> *"the cash flows from the project can then be replicated by a self financing portfolio of riskless bills and futures contracts"*;

or as Trigeorgis [287] have made explicit with an example, where he wrote:

> *"Let S be the price of oil, or generally of a twin security that is traded in the financial markets and has the same risk characteristics as (i.e., is perfectly correlated with) the real project under consideration (such as the stock price of a similar un levered oil company)"*

All this means that the two approaches are very different in their methodology, since we do not use a replicating portfolio, and especially we do not believe at the existence of a twin security traded in the financial market that could have the same risk characteristics of a public policy. In fact, the belief in the existence of a twin security means accepting a number of simplifications, which lead to having a risk-neutral rate, already defined, that allows us to find the risk neutral probabilities (different from our prior probability). Moreover, these simplifications eliminate the a posteriori probabilities, which become always 1 or 0 being the twin security like a perfect oracle.

Concluding, the two tools have an opposite perspective, which results in a different approach to the two key uncertainties (implementation outcome, money worth). Decision

tree time, fixing the prior probabilities, declares to know the uncertainty about the implementation outcome, choosing as unknown element the subjective discount rate. Otherwise, in ROT, the known uncertainty is the money worth, that is the risk free rate, thus choosing as unknown element the prior probabilities.

7.5 Conclusion

In the first part of this thesis we highlighted as the current available tools for the evaluation of public policies and more in general to support the policy-making decision process are inadequate. Finally, in this chapter we presented our ideas to overcame such situation. Thus, we presented a "new model", namely a temporal decision tree, in which we collected and combined all the positive characteristics of: CBA, DT, and ROT.

We presented our model using a simple explanatory example. In this way we show at first how the policy-makers can use the new information coming over time, or better how they can use information to manage policy decisions an improve the policies value. In this example we imagine that such information are always true, and thus also the forecast will be always true. Although, this example was enough to illustrate the basic principles of the model and of our idea, believing to have always a perfect forecasts was to hardly credible for us. Thus, in the second example we overcame this limit and we suppose that forecasts are only partially true. We have called the source of information "oracle", thus we said that in the first case the oracle is perfect, while in the second it is imperfect. When it is imperfect also its information are imperfect, and thus the future states of the nature will be forecast using the conditional probabilities, conditioned by the oracle credibility.

Despite this difference the model proposed is the same. That is, a common decision tree to which we added:

- the economic concept of cost and benefit;
- time;
- policy-makers preferences.

in this way the model considers all the public policy characteristics, and it answers at the policy-makers needs both in terms of legitimacy and in terms of flexibility.

CHAPTER 8

Conclusion and Perspective

8.1 Introduction

Policy is power. Usually, the term "policy"is used talking about a set of actions, which have some direct or indirect reference to the conquest or the exercise of sovereign power in a community of people on a territory [32]. For this reason from it is always viewed with respect, but also with suspicion. People change with power, and through that they could not pursue more the common good for which they were elected. Because of this in the history there were several instruments of power control, especially in the last 100 years, and never are in the European policies management.

Our research stared from the European policies management and more especially in European founds distribution, and their mechanisms of choice and control. Thus, studying these processes, procedures and tools we understood that whereas under some aspects public policies can be compared and assimilated to private investments, under other aspects their are unique. In fact, public policies are ultimately investment decisions, but which are based on a different philosophy, with different goals and motivations. Moreover, policy decisions should be subject to different constraints and expectations.

For all these reasons transparent process, proof, evidence and tools in order to support and justify choice and policy-making decisions are very important, but most important is the rationality. A shared rationality is the basis on which to build a transparent policy process, on which to collect proof and evidence, and thus to convince everyone that we made the best possible choice. Our modern society are characterized by a continuous search for rationalization of actions [110]. The rationality that we talked about, and to which we referred in this thesis, it is not an objective entity that exist apart from the stakeholders. We talked about a kind of rationality that exists because these stakeholders exist, it is build with and for that stakeholder through the interaction with their environment.

As a result the processes and tools to support the policy-maker can not ignore such rationality, but instead they must be found on such rationality.

This thesis, on these premises, attempted to develop before a conceptual framework and then a a model of policy-making aiding process and policies evaluation. In order to do this we have at the beginning studied and so presented some tools and theories used in policy field as:

→ *Cost-Benefit Analysis(CBA)*

→ *Decision Theory (DT)*

→ *The Real Option Theory (ROT)*

Then, trying to overcame their limits and weaknesses, but combining and enhancing their strengths, we developed our ideas, and so the model.

8.2 The Questions

We started this thesis with the following questions:

→ How to build public policies?

→ What kind of decision support?

→ What kind of model?

Following these questions, we investigated first the pubic policies field. What characteristics must have a "good policy", and before of this what is a "good policy". We explained that for us a "good policy" is: the result of a transparent and informed policy-making process. We have not discussed in this research about moral value of policies, or about their main goals, or about ethical requirements, because we believe that such issues are and must remain a strictly political issues, and not technical. Said that, this work focused on the research of how build such policy-making process, moreover, we not explain just the features of this, but we propose also an our own model to evaluate alternative policies.

Now that we arrive at the conclusion of this thesis, we can answer at these questions in a concise and comprehensive way.

How to build public policies?
Given the characteristics needed at one policy to be accepted, efficient and effective (chapter 2), we believe in order to build such pubic policy it is necessary follows a decision aiding process. This process, with its four principal steps or artifacts (chapter 4):

- representation of the problem situation;
- problem formulation;
- evaluation model;
- final recommendation.

will be able to lead the policy-maker or the policy-makers, first to understand his (their) real problem, without prejudice or constraints. Second he (they) with the analyst will formalize the problem and the possible solutions, namely the alternatives. Third, with an evaluation model, previously defined, the analyst evaluates the alternatives and with the results of such

evaluation he will be able to give at the policy-maker some informed recommendations. Thus, with these recommendations he can support his choice with evidences.

We believe that using this process the policy-maker will be able to make decision more effective and efficient, but he will mainly reduce his discretionary without affect subjectivity and flexibility of the context. In this way, under some aspects, it will be possible to compare different policies, or better it will be possible to compare their artifacts, and thus the policy-makers actions, choices and ability to react under certain constraints and conditions. Moreover, using the decision aiding process it will be easier to build good practice and to share information.

What kind of decision support?

Talking about kind of decision support we talk about rational decision aiding approach. At the beginning of this thesis (chapter 1) we presented four rational approaches, with their features and their difference:

- normative approach;
- descriptive approach;
- prescriptive approach;
- constructive approach.

During our researches and explanations we discussed many times about what kind of approach and so rationality could be the most appropriate in public policies context. Now we can argue that to use just one approach is difficult and not correct in public policies context. In fact, we demonstrated that the best thing in this case is to use simultaneously both the normative and the constructive approach.

The normative approach provides a general model to analyse and see the situation, that exist a priori. This model based on economic considerations and on the policy-makers ought to decide is very important in order to have a legitimate model. However, at the same time the constructive approach is fundamental in order to provide effectiveness and efficiency. In fact, each situations is unique in public policies, and the policy-makers must have the ability to adapt and shape the model to the specific needs of the situation. Namely, it is important that the model retains a certain degree of flexibility and subjectivity.

What kind of model?

Concluding this section, we can say that in order to help the policy-makers we need a model having the above characteristics. First, the model must be able to joint both the rational approaches, namely normative and constructive. Second, it must be designed in order to work in a decision aiding process, that means that each chosen tool should be connected to the

various steps of the process. We can say that the model should be recognize and build with the policy-makers in order to legitimize its results, and thus the derived recommendations, therefore, it must be easy to explain and to understand. A model too difficult to understand could be seen as a black box in the hands of technicians, who are able to move politicians and thus overcame the legitimate policy-making power. Moreover, the model must be designed in order to consider the time as a very important decision factor. To forget time would be forget the many alternatives which it can offer.

8.3 Our Model

Our model (chapter 7) is an example of what we wrote above, because we tried to build a model with all these features.

- The model is able to joint normative and constructive approach, in fact, it is build both from the real options theory and from a decision tree analysis. In this way, it is based both on economic theory concepts and on decision theory concepts, many of which concern the policy-makers subjectivity. For these reasons it is recognized as rational, logic and thus legitimate.
- The model is designed to work in a decision aiding process. Although, it is mainly an evaluation model, it is strictly connected with the other steps of the process. The representation of the problem situation and the problem formulation can be modified by the model in an iterative process, changing the tree structure can produce both new alternatives and change some of the existing. Moreover, thinking with the model structure can lead to a change in the representation of the problem situation, and thus at the whole problem and decision aiding process.
- The model is easy to explain and understand because: first the tree structure is decided with the policy-maker himself, second the subdivision in cost and benefit is commonly accepted, third the other data used in the tree are found from the interaction between policy-maker preference and market information, and fourth the mathematic used is simple.
- The model considers the time as very important since the tree is built as function of the policy time-frame.

8.4 Limits and Perspective of the Research

We achieve our objectives and goals, namely understanding the specific features of the public policies, understanding problems, constraints and opportunity derived from the evidence-based policy-making, but also studying the strengths and weakness of the current

evaluation tools (CBA, DT and ROT) in connection with policies features, policy-making process, EBPM and legitimacy. Moreover, using this knowledge we built an evaluation model, which tries to combine all these information in order to help the policy-makers and to support their decisions.

Despite all that our research, and especially the model are limited. Some topics deserve further study as for example the interaction between DT e ROT, the bayesian learning, preference elicitation and discounting rate. In fact, we are fully aware that all these arguments have not been studied fully, but for time and space, the study of these was stopped at a not much more than the initial level. However, we believe that our approach is correct, and we hope that these topics can be deepened in further research.

Other aspects that we not fully developed in this thesis are the decision aiding process steps. In fact we explain as this process can be useful in policy-making, but we only dealt with the evaluation model, the other three steps have not been studied and investigated, but only introduced. However, we retain that that could be a very interesting research.

Moreover, we believe than another interesting field of research which was only introduced by our work is that of public policies. We believe that researches and studies about tools and model used in such field must be strengthened, because there is a lack of specific studies between policy-making and decision aiding. In fact, we believe that in a political situation like the European, where mechanisms of decision and control are farther away from the territories and the population, the necessity of processes, tools and models for aiding the policy-making, is increasing.

APPENDIX A

EU: Cohesion Policy and evaluation tools

A.1 Preface

European Regional Policy in the lasts years increased his relevance in public debate. The highest concentration of resources in Cohesion and Structural funds brought a great attention both on allocation methods and on funds management. A recent European report says: *"EU cohesion policy is the object of conflicting views at all levels of debate - political, economic and institutional"* it is necessary to reform and *" modernise its budget, tackling the new challenges and breaking away from bureaucratic inertia and the just retour logic that hitherto have prevented change."* [16]
About useful reform, several changes and heterogeneous proposal were are made. In this context it is important to have a change in methodological process and tools. Since, without a straightforward and coherent decision process, supported by appropriate tools, any theoretical and philosophical new approach are vain.

To show our idea we explain before: what the European Cohesion Policy is, its goals and its tools. Then we explain our point of view about this and we propose our alternative solution.

A.2 European Cohesion Policy

A.2.1 Brief History

We start with a brief description Regional Policy and Cohesion Policy birth and to do this we follow the line drawn by [16]).

The founding fathers of the European Economic Community (EEC, later the European Union) had mixed feelings about the creation of a Community regional policy. In the preamble to the Treaty of Rome, they declared themselves *"anxious to strengthen the unity of their economies and to ensure their harmonious development by reducing the difference existing among the various regional and the backwardness of the less-favoured regions"*. However, while their spatial awareness is clear from several Treaty statements, the founders did not provide a firm basis for establishing an autonomous Community regional policy. This happened for two main reasons. First, there was a general and overoptimistic, feeling that integration in itself would contribute to reducing regional disparities through the promotion of inter-regional trade. Secondly, the experience with domestic regional policy in a number of countries as France, Italy and Germany was relatively recent and it was not felt necessary to duplicate or interfere with this. But it should not really true, and soon several factors fuelled a growing demand for a Community regional policy. Despite Commission efforts and a series of resolution by the European Parliament (Resolution Van Campen in 1959; Resolution Motte in 1960; Resolution Birkelbach in 1964), no action was taken by the Council. The conditions for the creation of a Community regional development policy

came in the late 1960s and early 1970s, generated by the plan to deepen the internal market and to launch an Economic and Monetary Union.

As the Werner Report [306]said, *"the realization of global economic equilibrium may be dangerously threatened by difference of structure. Cooperation between the partners in the Community in the matter of structural and regional policies will help to surmount these difficulties, just as it will make it possible to eliminate the distortions of competition. The solution of the big problems in this field will be facilitated by financial measures of compensation. In an economic and monetary union, structural and regional policies will not be exclusively a matter for national budgets"*. The first enlargement of the Community in 1972 created a focus for change when both Ireland and the UK supported a new Community policy instrument that could also reduce their net financial contribution to the Community. The Heads of State formally agreed at the Paris Council summit of 1972 to *"give top priority to correcting the structural and regional imbalances in the Community which could hinder the achievement of the Economic and Monetary Union.... [and]... ask the Community Institutions to set up a Regional Development Fund... "*. [55]

However EU regional policy came about, its motivation went far beyond that of a mere compensatory tool for correcting the effects of market integration. The Treaty commitment to reducing Community regional disparities was regarded as *"a human and moral requirement of the first importance"*. To this end, the Report by Commissioner George Thomson adopted in 1973 initiated the legislative process for the creation of the Regional Development Fund, making two key lasting points:

> *"no Community could maintain itself nor have a meaning for the people which belong to it so long as some have very different standards of living and have cause to doubt the common will of all to help each Member State to better the condition of its people ... The long history and diversity of the European people, the historical and cultural values which are the moral wealth of each region, make the maintenance of establishment in each region of the groundwork of an up-to-date economy a matter of capital importance". "The purpose of a Community regional policy is to give areas suffering from regional imbalances the means to correct them and enable them to put themselves on a footing of more equal competitiveness. If this can be achieved, then it will be possible for the various factors of production of the community to be more fully utilised and the human resources and under-used social capital and infrastructure to be more fully employed"*.

The new policy and its visibility was clearly seen as a necessary way of not just guaranteeing the sustainability of the integration process but, much more importantly, of ensuring the sustainability of the Community itself, particularly given the long history and diversity

of the European people. Moreover, the two distinct, though complementary, goals of the new policy, efficiency and equity, were very clearly identified. European citizens demanded a Community effort, on the one hand, to give all regions (or places) the opportunity to fully utilise their potential and achieve competitiveness (efficiency), on the other, to pursue more similar standards of living for all individuals in each region (equity). The role of the Community level of government in the new policy was not actually very relevant. The old social fund and the new regional fund, collectively called "Structural Funds", were kept separate, the first being to support people to gain new skills, the second to provide infrastructure. Their overall size was rather small (5%of the total Community Budget). They were to be distributed on the basis of national quotas to finance projects, with no clear-cut strategy agreed between the Commission and Member States and the latter having the final say on project approval.

The things change under the 1979 and 1984 reforms that reflecting an attempt to improve the effectiveness of policy and to develop an "integrated approach", under which EU measures and national policies could converge. Together with the abandonment of the quota system for allocating resources to them (replaced with a system of indicative ranges), Member States were requested to submit regional development programmes that allowed the Commission to identify and discuss common Community priorities. And was also introduced the ex-post assessment with the publication of periodic Commission reports on regional development trends. In the size of the regional funds rose to around 13% of the Community Budget by 1985. At the same time, a "higher degree of convergence" [54] between countries and regions came to summarise the policy objectives, aimed at capturing at once the equity and the efficiency dimensions.

For the Cohesion Policy the starting point was the Single European Act (SEA) [56], which dedicated a Treaty title to *"Economic and Social Cohesion"*. This treaty start to says "In order to promote its overall harmonious development, the Community shall develop and pursue its actions leading to the strengthening of its economic and social cohesion. In particular the Community shall aim at reducing disparities between the various regions and the backwardness of the least-favoured regions. The Community shall support the achievement of these objectives by the action it takes through the Structural Funds (European Agricultural Guidance and Guarantee Fund, Guidance Section, European Social Fund, European Regional Development Fund), the European Investment Bank and the other existing financial instruments. The European Regional Development Fund is intended to help redress the principal regional imbalances in the Community through participating in the development and structural adjustment of regions whose development is lagging behind and in the conversion of declining industrial regions.

The Treaty revision at Maastricht in 1992 gave added priority to *"strengthening . . . cohesion"* by including it in article 2 as one of the means for achieving the Union's goals, on a par with

the establishment of economic and monetary union". This was accompanied by the creation in the Treaty of a Cohesion Fund for countries that were lagging behind in economic terms, aimed at improving their environmental and transport infrastructure. Successive increases in the resources allocated to cohesion meant that it exceeded 32% of the EU Budget in 1993. These developments were followed by a substantial change in the way policy was governed. Community objectives and priorities were defined as the reference framework for resource allocation. Member States for the most part were required to formulate programmes in line with this and obtain Commission approval for their implementation. The change from annual to multiannual budgeting underpinned this new strategic approach, which increasingly reflected the idea that economic and social development was not so much to do with building infrastructure and giving subsidies to firms but more to do with encouraging the provision of extensive bundles of integrated services. The Commission invested human resources in designing and developing this framework.

This strategic development was helped in the social sphere by the adoption of a European Employment Strategy (1994), which became a point of reference for designing programmes. The importance of involving local actors in development policy if it is to be successful was reflected in the introduction of a "partnership principle" under which regional and local authorities were to be involved in programme formulation and implementation. A Committee of the Regions was created, emphasising the growing role of the regional level of government in all Member States, while an "additionality principle" was also introduced to ensure that Community-funded expenditure did not simply replace nationally-funded expenditure. At the same time, the share of resources allocated to initiatives directly managed by the Commission grew to 15% of total funding in the years 1989-93 (reduced to 10% in 1994-99).

The reform was pushed by concerns about the different effects on regions of technological change and the Community's policy of market integration and liberalisation (see [72]. As stated in the Padoa-Schioppa Report [215], *"there are serious risks of aggravated regional imbalance in the course of market liberalisation ... and adequate accompanying measures are required to speed adjustment in structurally weak regions and countries ... reforms and development of community structural funds are needed for this purpose"*. It was also prompted by the accession of Spain and Portugal in 1986, which substantially widened regional disparities across the Community.

Since then, the architecture of cohesion policy has been revised as a result of a continuous search for a balance between conditionality and subsidiarity. The enlargement of the Union to 27 very diverse countries has provided further arguments for a policy aimed at enabling all people, independently of where they live, to benefit from the opportunities

created by the Union. The financial success of monetary union and the euro and the more recent international financial crisis have highlighted once again the unavoidability of the EU having development objectives. The relevance of spatial awareness has been emphasised by the explicit introduction in the Nice Treaty of the territorial dimension of cohesion policy alongside the economic and social dimensions. Nevertheless, no significant progress has been made in giving cohesion policy stronger conceptual foundations or in rejuvenating the cultural and political compromise that occurred at the end of the 1980s. The progress of the theoretical debate has not adequately found its way into the rather close cohesion policy community. "Efficiency and equity" have been highlighted as policy objectives, combined as they have been from the start. The design of an overall "development" strategy, the Lisbon Agenda, in 2000 provided a potential opportunity for cohesion policy to be rethought. But, lacking a shared concept of the policy around which to rebuild a strong political compromise, and with several Member States focusing on the financial features of the policy, the linkage with "Lisbon" failed to be used as a way of focusing cohesion policy on a limited number of priorities and on areas of intervention where its original place-based approach could be most effective.

In this situation, the consensus on the value added by the Cohesion Policy approach has been progressively eroding over the years. The misconception that cohesion policy is either an equalisation fund for countries or regions or a source of finance for EU sectoral policies has gained ground. Conflicting and incoherent views have emerged and there is a need to re-establish common ground for debate and as said Barca [16]*" understanding the economic rationale for place-based policies is an essential starting-point for this"*.

A.2.2 The evolution of governance: 1988-2009

1989-93 and 1994-99

The 1988 reform led to a radical change in the balance of decision-making authority in the governance of cohesion policy, providing the Commission with much stronger leverage and influence. In the programme periods 1989-93 and 1994-99, considerable emphasis was placed on the programme design stage, where the Commission was able to exercise a powerful role in influencing programme priorities, measures and the balance of funding. Several important conditionalities on the use of funds were introduced: stricter regulatory provisions on programme content, requiring quantified objectives; an evaluation of environmental impact; more detailed financial tables and specific information to allow additionality to be verified; increased emphasis on compatibility with other Community policies, most notably in the areas of State aid, public procurement, gender equality and the environment; and strengthened evaluation obligations. Lastly, as a member of Monitoring Committees with veto power, the Commission services were given the opportunity of an important over-

sight and a decision-making role in the implementation of programmes. Outside the mainstream programmes, the role of the Commission was also reinforced through the increased importance given to Community Initiatives, where it had greater scope for proposing priorities for targeted EU support and stronger managerial responsibilities (prominent examples include Interreg for cross-border cooperation, RECHAR for the conversion of coal-mining areas, URBAN for urban development, and LEADER for rural development).

2000-2006

During the mid to late 1990s the power of the Commission was increasingly perceived as excessive. The approach was criticised for being too top-down, with insufficient flexibility for the Member States and Regions to adapt the policy requirements to different local contexts. At the same time, national and regional authorities (the latter strengthened by decentralisation trends across the EU), had gained experience in preparing development strategies, and were less ready to accept the Commission's role. In response to these pressures, the regulatory framework adopted in 1999 led to a new balance in the respective roles of the Commission and the Member States. On the one hand, the Commission's discretion was curtailed by decentralising responsibility for programme content and management to Member States and Regions. The Commission's role in the Monitoring Committees receded to that of an observer, and its role in the programming phase took a step back. On the other hand, in return for this loss of discretion, and with the idea of better supervising the effectiveness of expenditure, new requirements were introduced. So the obligations for monitoring and reporting became more prescriptive; a formal distinction was introduced between ex-ante, interim and ex-post evaluations, eroding the unitary nature of the evaluation process; a "performance reserve" was introduced where the performance was supposed to be captured by fully-defined and rigid targets and their achievement was rewarded. Finally, stronger audit and control requirements were introduced and applied with increasing rigour throughout the latter half of the 2000-2006 period.

2007-2013

It soon became clear during the 2000-2006 programme period that the shift away from discretion to more automatic rules had not achieved the desired results. The conditionalities were very often considered by Member States as a "compliance exercise", and they failed to give the Commission substantial information or an opportunity chance to exert adequate influence on performance. The performance reserve, in most cases, placed emphasis on financial absorption rather than on other dimensions of performance (i.e. effectiveness or management), and the difficulty of determining meaningful targets in advance was very often tackled by setting them at unchallenging levels. At the same time, programme authorities found themselves burdened with a very complex web of procedural tasks with high regulatory uncertainty. This reinforced existing doubts on the effectiveness of cohesion pol-

icy. Amid increasing criticisms and growing proposals to restrict the policy to disparities among countries, a widespread conviction arose that a strategic turn was needed in which the Commission could step back from some of the procedural issues and play again a more substantial role regarding the content of policy.

It can be anticipated that the changes to the Regulation produced by the long 2003-2006 negotiation, while representing a step in the right direction, especially in introducing a National Strategic Reference Framework for each Member State, have fallen short of expectations. Having been substantially weakened by Member States pressure, they have not provided the Commission with the opportunity or the information adequately to press Member States and Regions on matters of substance and results. The potentially interesting decision to earmark expenditure for Lisbon-related priorities offers such room for manoeuvre that it was treated as yet another compliance exercise. While some procedural requirements were loosened, others have been strengthened or newly introduced. A strengthening of audit and control obligations has also taken place.

A.2.3 Historical objectives and goals

Objectives and goals at the foundation and institution of European Cohesion Policy was clear: build an *"harmonious development by reducing the difference existing among the various regional and the backwardness of the less-favoured regions"* with efficiency and equity.

After this brief historical introduction about Regional Policy, we want already outline the key ideas and values that underline the policy. At the foundation and institution of the European Cohesion Policy the main objective was clear:

Efficiency is about realising the full utilisation of the every region's potential. The achievement of fully capacity or potential meaning the value of output that, given the resource, would be achieved if all the economic and institutional opportunities were exploited and every possible secondary effect was at work [35]. In this way we encompasses both static and dynamic aspects. Full capacity means, accordingly, the private and public's action result which either increases the capacity the utilisation of current capacity at a given point in time (static aspect) or expands capacity itself over time (dynamic aspect).

Opening a small window on the dynamic aspect, that will be a key aspect in our thesis, we want just underline that on time-span taken into account in the dynamic perspective, the hardest thing is assess what the potential is and which effect some actions have on it. Thus, the more likely it becomes that a trade-off arises between a short-term increase in capacity utilisation and a long-term sustainable rise in the potential. This trade-off is relevant in

terms of public action, since the two objectives generally have different distributive effects and are thus supported by different groups of individuals. And the irreversible effects often produced by either one or the other choice can make the use of compensatory mechanisms hard or impossible [3]. Another think very important for us that we want introduce now is the importance of the decision-makers' preference and the stakeholders' preference. Indeed, whenever we speak about decision process we must understand for who this process will work and for who the chosen actions should be efficient. North [203] says *"institutions are not necessarily or even usually created to be socially efficient; rather they, or at least the formal rules, are created to serve the interests of those with bargaining power to create new rules"* and Barca [16] says *"the political power to choose economic institutions depends on the political institutions in place and the de facto distribution of power, which in turn depends on the distribution of resources. Elites which hold political power might not choose to put in place more efficient institutions if this is likely to reduce their share of resources."*

Equity is about ensuring equal opportunities for individuals without considering where they live. One of the objectives of governments is achieving an equitable distribution of well-being. There is also increasing agreement that development is about both efficiency and equity, and that public action, at whatever stage of development of an economy, should address social problems. In Europe, pressure has mounted for greater attention to be given to social issues at EU level. A concern is that high and rising inequality, and increasing fear of globalisation, could jeopardise economic integration (market-compensating motivation). Another is that national welfare systems are increasingly constrained by EU budgetary rules (political-economy motivation). A third is that the EU's existence is based on the expectation that citizens should enjoy equal rights (federal motivation). The failure to reduce inequality in several European countries, and its rise in others, are signs of the extent of the problem [16].

There is widespread agreement that no single dimension can capture a person's well-being and thus the inequality's degree. A life worth living, including the opportunity both to achieve what an individual considers relevant and to widen her or his set of options, embraces labour skills, health, education, housing, security, income, working conditions, self-respect, a role in decision-making and so on. Income is a relevant component of these dimensions but it does not reflect them all, as empirical data confirm [86]. Income is one factor in achieving well-being, though it cannot achieve many aspects of well-being and, accordingly, cannot be seen as an end in itself. Sen's capability approach (1985) makes clear that the capacity of any individual to convert a given amount of any *"commodity, including money, into achievements that are relevant for their life depends on a combination of (social and physical) circumstances and on access to other commodities often produced by policy"*. Indeed, several dimensions of well-being strongly depend on public institutions

performing essential tasks and provide public goods and services.

Sometimes, in Regional Policies, these two goals were considered as different aspects that, in order to achieve, must to belong to the same policy action. But in most cases this thought is left alone in the theory. In fact, in practice, when the policy-maker choose an action, this action was built in order to achieve just one of two goals.

We believe that when it happens something went wrong. Since, when alternatives actions are built and then selected by the policy-maker, these actions to be effective must contain the features that are important for the policy maker. To obtain this, we think it is necessary to use an appropriate process to create alternatives and afterwards an appropriate decision process in order to choose the best one. Thus, our research wants to suggest a new process to create and to select alternatives in European policy context.

A.2.4 Cohesion Policy in practice

We try to present now briefly what really is the Cohesion Policy in the last programming periods 2007-2013. Which are the resources, the goals and what king of governance is adopted. to do this we follow the line drawn by Barca [16].

The framework for the period 2009-2013 is the result of several changes which have taken place since the 1988 reform as shown above.

a) TIMING

Resource, goals and governance for the cohesion policy for the seven year period 2009-2013 were set by three separate decision policy that were made at different times between December 2005 and October 2006:

- Resource and their allocation to Member State Resources and their allocation to Member States and Regions, after a de facto negotiation with the Commission started in 2003, were first agreed by the Heads of State at the European Council summit of December 2005, and then finalised by an Inter-Institutional Agreement between the European Parliament, the Council and the Commission (2006/C 139/01) on May 2006.
- Governance was agreed in July 2006 through a set of Regulations by the European Parliament and the Council, on Commission's proposal (Regulations 1080 and 1081, and Council Regulation 1083).
- Goals were set in October 2006 when the Council adopted the Community Strategic Guidelines, a document that the Commission had drawn up by moving from an original draft prepared in July 2005.

b) AMOUNT

The overall amount of expenditure allocated to cohesion policy for seven years is 346 billion euro (308 billion at 2004 prices, which was the basis for the negotiations), accounting for 35.7 percent of the EU budget. The budget is divided into three distinct funds. The two "Structural Funds" are: the European Regional Development Fund (ERDF, or Regional fund) which have the 58 percent of the total; and the European Social Fund (ESF, or Social fund) has the 22 percent. The "Cohesion Fund" accounts for the remaining 20 per cent. These percentage are the result of Member States' choice and their negotiation with the Commission. In the Commission, the responsibility for the ERDF and Cohesion Fund is entrusted to the Directorate for Regional Policy (DG REGIO), which also has an overall responsibility for cohesion policy, while the responsibility for the ESF is entrusted to the Directorate for Employment, Social Affairs and Equal Opportunity (DG EMPL).

c) TERRITORIAL ALLOCATION

Resources are allocated to three types of eligible territory, using as a geographic unit of reference either jurisdictional Regions or nation-states:

1. the lagging Regions and the lagging countries, named "convergence" in order to underline the existence of a development gap to be reduced;
2. the other (non-lagging) Regions, named "regional competitiveness and employment";
3. all areas entitled to run interventions of territorial cooperation.

Lagging Regions and countries have been assigned the majority of resources: 81.6 per cent (see table II.1). Lagging Regions (61.6% of the total funds) qualified for the assistance when their GDP per capita in the years 2000-2002 was below the threshold of 75 per cent of the EU25 average: this criterion led to the selection of 84 Regions (in 18 Member States), with a total population of around 154 million (or 31 percent of the EU27 population). A further 13 EU15 Regions (accounting for 3.4 per cent of the total EU population) were eligible as transitional "phasing-out Regions", in recognition of the "statistical effect" (on the threshold) of enlargement. Lagging countries (20% of the total funds, corresponding to the whole of the Cohesion Fund) qualified for EU support when they had a GNI per capita in the years 2001-2003 below 90 percent of the EU25 average. They included all of the new Member States, Portugal and Greece (plus Spain on a transitional basis), with a total population of around 166 million euro. The major part of the remaining resources (15.9 per cent of the total) has been assigned to the non-lagging Regions, a greater intensity of assistance being provided for those "phasing-in Regions" which in the previous programming

period qualified as "lagging" but which exceeded the eligibility threshold because of their own growth. The third component of the cohesion policy budget (2.5%) is assigned to European territorial cooperation. The main beneficiaries (two thirds of the amount) are all the "level 3" NUTS territorial units that are considered to be entitled to cross-border projects: those along internal and certain external land borders and along maritime borders separated by a maximum of 150 km (and including overall almost 40% of the EU27 population). The other beneficiaries under this part of the budget, for trans-national and inter-regional cooperation are all areas of the EU.

For each eligible territory, the distribution of resources across Regions and countries followed some general criteria. For a lagging Region, the per-capita allocation was inversely related to the per capita GDP of the Region and the per capita GNI of the country of which it is part, while the region's unemployment rate had only a very small influence (about 3%). A series of ad hoc provisions also had to be introduced during the negotiations in order to take care of specific national interests.

The resulting overall distribution among Member States is presented in Table II.2, while Map II.3 shows an estimate of the final "aid intensity" for each Region of the EU and Map II.4 shows the corresponding gaps in per capita GDP across Regions.

d) AUTHORITIES ALLOCATION

The territorial allocation of resources says nothing about the authority that manages those resources, which might well be the central State. It only establishes that the beneficiaries have to be citizens of that Region. By looking at the decisions actually undertaken by the Member States on the management of resources allocated to Regions, it appears that only 36.9% of these resources are managed by the Regional authorities, the rest being managed by the central government. Taking account of the resources allocated to the national level through the Cohesion Fund, the administrative Regions are now managing only 30.5% of the whole cohesion policy budget (excluding territorial cooperation) (see Table II.5).

e) INTERVENTION TYPE

The cohesion policy budget can finance a broad range of expenditure, under the different typologies, or "priorities", in which the development strategy is categorised. The Regulation explicitly excludes only: interest on debt, recoverable value added tax, decommissioning of nuclear power plants, purchase of land for an amount exceeding 10% of the total eligible expenditure for the operation concerned (and, for the social Fund, purchase of furniture, equipment, vehicles, infrastructure).

The 16 expenditure categories currently in use are presented in Table II.5, where the distribution of tasks between the ESF and ERDF is also reported.

Table II.1: Allocation of the cohesion policy budget for 2007-2013 and eligibility criteria (2004 prices)

Territorial allocation		Criteria for Regions' and States' Eligibility	Criteria for allocating resources among Regions and States	Eligible population	Financial resources		Annual euro per capita
				Millions	%	Billion euro	
Lagging Regions and Countries	Countries	GNI p.c. below 90% of GNI p.c. of EU25	Surface, population and GNI	166.0	20.0	61.6	53.0
	Regions	GDP p.c. below 75% of GDP p.c. of EU25	For groups of eligible Regions of each MS: GDP per capita, population, unemployment rate and GNI of the Region's country[1]	153.7	57.5	177.1	164.6
	Phasing out Regions	GDP p.c. below 75% of GDP p.c. of EU15 (and not selected by the previous criterium)	Linear reduction from the 2006 level, unemployment rate[2]	16.4	4.1	12.5	109.1
	Total	-	-	206.4[3]	81.6	251.2	173.9
Non-lagging Regions	Phasing in Regions	Not included in the previous categories but eligible as lagging Region in 2000-2006	Linear reduction from the 2006 level, unemployment rate	19.0	3.4	10.4	78.1
	Regions	All Regions different from the other categories	For groups of eligible Regions of each MS: suggested distribution[4]	295.3	12.5	38.7	18.7
	Total	-	-	314.3	15.9	49.1	22.3
Territorial Cooperation	Cross-border	NUTS 3 areas along all internal and certain external land borders and along maritime borders separated by a maximum of 150 km.	Share of population of eligible NUTS 3 Regions	190.0	2.5	7.7	2.3
	Transnational	All areas	Share of national population	484.4			
Total	-	-	-	484.4	100.0	308.0	90.9

Source: DG Regio.

(1) The rather complex criteria are such that the weights of the three variables "correcting" the population are approximately as follows: 85% regional GDP, 12% GNI, and 3% to unemployment.

(2) The allocation for the statistical phasing out region in 2007 corresponds to 80% of their per capita aid intensity level in 2006 and a linear reduction to reach the national average per capita aid intensity level for the Regional competitiveness objective in 2013 (i.e. between EUR 18 and EUR 25 per capita). To the allocation thus obtained is added, if applicable, a premium of EUR 600 per unemployed person exceeding the number that would be unemployed if the unemployment rate of the EU convergence Regions applied (see point 6(a) of Annex II to Council regulation 1083/2006).

(3) It includes 166 millions of people in lagging countries, 31,2 millions in lagging Regions not included in lagging countries and 9,2 millions in phasing-out Regions not included in lagging countries.

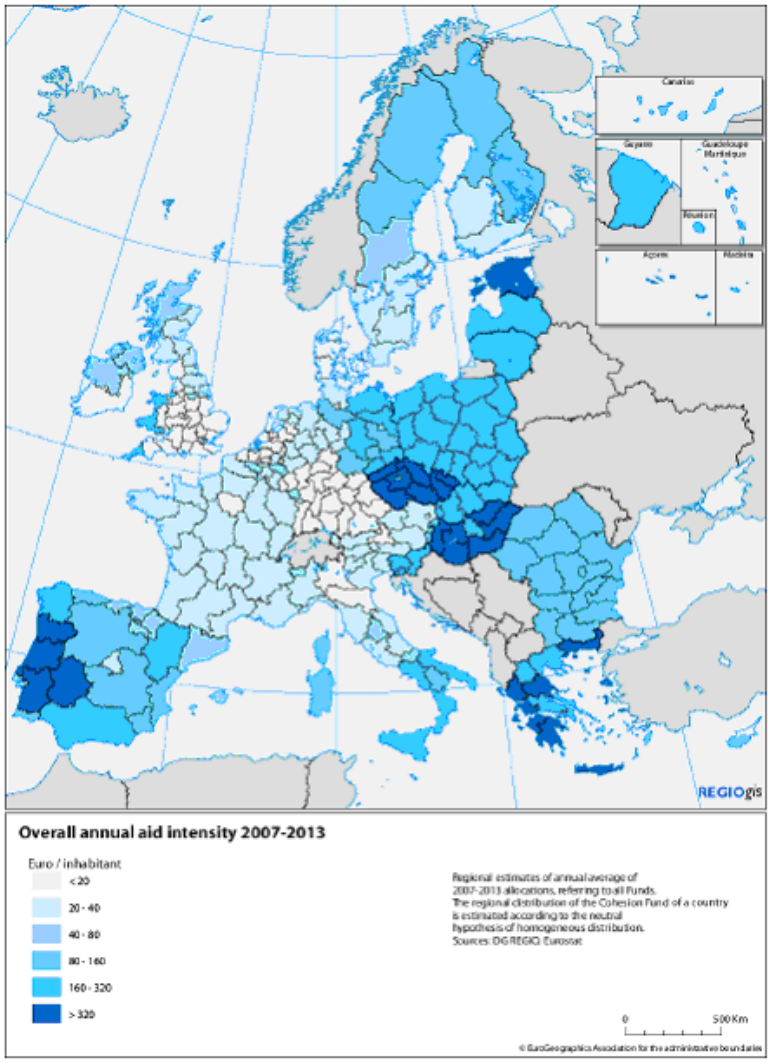
(4) For the distribution of the resources within any group a formula was suggested by the Commission: weighted average of population, unemployed people at NUTS 3, number of jobs needed to reach an employment rate of 70%, number of employed people with low educational level, population density.

Table II.2 - Allocation of cohesion policy budget to Member States for 2007-2013 (million euro, 2004 prices)

Member States	Lagging Regions and States		Non-lagging Regions	Territorial Cooperation	Total
	Countries	Regions			
Austria	-	159	914	228	1 301
Belgium	-	579	1 268	173	2 020
Bulgaria	2 015	3 873	-	159	6 047
Cyprus	193	-	363	24	580
Czech Republic	7 830	15 149	373	346	23 698
Denmark	-	-	453	92	545
Estonia	1 019	1 992	-	47	3 058
Finland	-	-	1 426	107	1 533
France	-	2 838	9 123	775	12 736
Germany	-	14 323	8 370	756	23 449
Greece	3 289	14 158	584	186	18 217
Hungary	7 589	12 654	1 865	343	22 451
Ireland	-	-	681	134	815
Italy	-	19 255	5 640	752	25 647
Latvia	1 363	2 647	-	80	4 090
Lithuania	2 034	3 965	-	97	6 096
Luxembourg	-	-	45	13	58
Malta	252	495	-	14	761
Netherlands	-	-	1 477	220	1 697
Poland	19 562	39 486	-	650	59 698
Portugal	2 722	15 494	843	88	19 147
Romania	5 769	11 143	-	404	17 316
Slovakia	3 433	6 230	399	202	10 264
Slovenia	1 239	2 407	-	93	3 739
Spain	3 250	20 161	7 628	497	31 536
Sweden	-	-	1 446	236	1 682
United Kingdom	-	2 594	6 232	642	9 468
Not allocated	-	-	-	392	392
Total	61 558	189 604	49 127	7 750	308 041

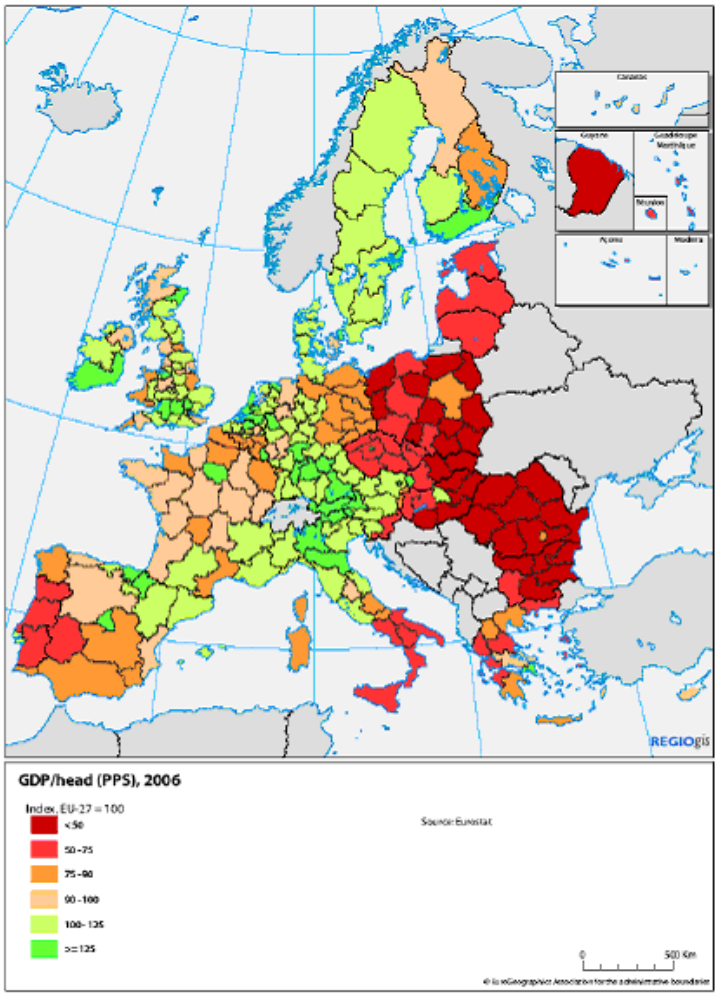
Source: Fourth progress report on economic and social cohesion, COM (2006)281, Brussels,Annex, p.12.

Map II.3: Overall annual aid intensity 2007-2013



Source: Eurostat

Map II.4: Disparities in GDP per capita among NUTS 2 Regions in 2006



Source: Eurostat

Table II.5: Share of resources managed by regional and national authorities in (%)

Managing authorities	Lagging countries	Regions			Total
		Lagging	Non-lagging	Total	
National	100.0	69.4	31.5	63.1	69.5
Regional	-	30.6	68.5	36.9	30.5
Total	100.0	100.0	100.0	100.0	100.0

Source: DG REGIO

The Cohesion Fund, targeted on the lagging countries, has a more limited scope of action defined by the Treaty: transport, energy and environment. In the current period, Member States and Regions were also asked to "earmark" resources for those expenditure categories that are considered to fit mostly the EU's Lisbon agenda. These are equivalent to nine of the 16 categories. Lagging Regions were required to concentrate 60 percent of expenditure on those categories, with the requirement increased to 75 percent in other Regions. Earmarking was voluntary for the Regions of the so-called EU12 newer Member States.

Table II.8 - Categories of policy interventions and scope of the specific Funds(*): 2007-2013

Categories	Regional Fund	Social Fund	Cohesion Fund
Research and technological development (R&TD) and innovation(1)	X		
Support to firms' investments	X		
Information Society	X		
Transport	X		X
Energy	X		X
Environmental protection and risk prevention	X		X
Tourism	X		
Culture	X		
Urban and rural regeneration	X		
Adaptability of workers and firms, enterprises and entrepreneurs		X	
Access to employment and active and preventive labour market measures		X	
Social inclusion of less-favoured persons(2)		X	
Human capital (education, life-long training, high-level studies in R&TD)		X	
Social infrastructure(3)	X		
Partnership and networking		X	
Institutional capacity at national, regional and local level		X	
Reduction of additional costs of outermost Regions	X		
Technical assistance	X	X	X

Source: DG REGIO

(*) The flexibility of the eligibility criteria of each Fund is such that both of regional and the social ones do also finance a few interventions falling in the categories which are not marked in the table.

(1) R&TD activities, technology transfers, assistance to R&TD, advanced support services to firms, assistance to SMS for environmentally-friendly products, support to firms' investments directly linked to research and innovation.

(2) Integration and re-entry into employment for disadvantaged people.

(3) It also includes: education, health, childcare, housing.

f) GENERAL CONDITION

The funding provided by the EU must be matched by national financing. Matched funding does not need to be provided at the level of single projects or intervention, but rather at the level of all the expenditure made in any given category of each Operational Programme. This system of co-financing promotes coherence between cohesion policy and national policies and it extends the amount of expenditure on which EU cohesion policy rules have an influence beyond the limits of the EU budget. Since co-financing does not apply to single projects, it does not reduce the moral

hazard of national authorities in choosing projects for EU financing.

Together with this co-financing principle and with the coherence principle (earmarking of expenditure to support the Lisbon strategy), five other general pre-requisites are established as "principles of assistance" (regulation 1083/2006, articles 9-17):

- Additionality: dating back to the origins of the Regional fund, the aim of this principle is to ensure that Community expenditure does not merely substitute for planned national expenditure. In 2007-2013, its verification has been restricted to lagging Regions and a new sanctioning mechanism for non-compliance has been introduced, which could allow the Commission to withhold a percentage of the Member States' funding allocation at the stage of ex-post verification of additionality.
- Complementarity, sustainable development and gender equality: the implementation of cohesion policy must complement national actions and other EU policies, must take into account, and actively promote, sustainable development and gender equality/non discrimination in the planning and implementation of assistance.
- Partnership: Member States are required to organise the design and implementation of EU funded regional development programmes in partnership with "competent regional, local, urban" authorities, with economic and social partners, and with "appropriate bodies representing civil society, environmental partners, non-governmental organisations, and bodies responsible for promoting equality between men and women".
- Shared management: the implementation of cohesion policy operates through a mode of shared management, whereby tasks are delegated to Member States but which are required to cooperate with the Commission to ensure sound financial management.
- Proportionality: newly introduced for the 2007-13 period, this principle stipulates that the financial and administrative resources employed by the Member States and Commission should be proportional to the total amount of expenditure of a programme in relation to indicators, evaluation, management, control and reporting.

g) RESPONSIBILITY

Responsibilities for programming and "contracts" among the Commission and States/Regions
Member States are responsible for implementation, but they must comply with the previous principles and with the commitments that are agreed ex-ante in "contracts" with the Commission. The Commission is responsible for this contracting process,

for ensuring the compliance of contracts with the regulations, as well as for offering advice, technical support and guidance.

The contracting process works as follows. First, on the basis of Commission proposals, the Council adopts a set of Community Strategic Guidelines which specify an indicative framework for intervention linked to the Integrated Guidelines for Growth and Jobs. Then, by building on these guidelines (with which "consistency" is required by the Regulation), every Member State prepares "in dialogue with the Commission" a National Strategic Reference Framework which sets out the strategy for the use of the funds in that country. The Framework is required to contain the following information:

1. the analysis of existing weaknesses and potentials;
2. an outline of the strategy, including its priorities, and its justification;
3. a description of how it will contribute to the EU priorities;
4. a list of the specific "operational programmes" through which the strategy would be implemented;
5. the indicative allocation of funds among the programmes; only for lagging Regions,
6. information on the Additionality commitment;
7. on the actions planned for improving administrative efficiency.

The Commission is given the power formally to approve points 4-5-6-7, while it takes note of the other points.

Finally, each authority of the Member States to which the National Framework has assigned a role for managing a programme, draws up an Operational Programme (separately for the Social and Regional funds). About 430 Operational Programmes exist in the current programming period. Each Programme is required to contain: a socio-economic analysis; a strategy with priority axes (justified on the basis of the previous two strategic documents) and quantified targets; an indicative breakdown of categories of expenditure; a financing plan; and implementing provisions for a monitoring and evaluation system; and an indicative list of major projects. The Commission is given the power to "appraise" the propose operational programmes "to determine whether it contributes to the goals and priorities of the National Strategic Reference Framework and the Community Strategic Guidelines", and to approve the Programme or ask the Member States to revise it.

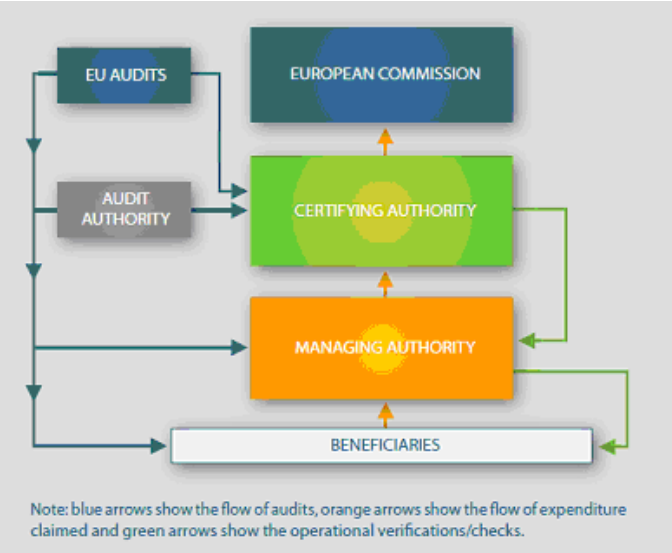
It must be noted that no information or commitment is required, either in the National Framework or in the Operational Programmes, on the institutional requisites which must be satisfied in each sector where interventions take place in order to spend resources effectively, the institutional focus is limited to the requisite for financial implementation and administrative efficiency by the authorities managing the funds, or on the chain of events (the "theory of change") through which the planned expenditure should bring about results. Quantification of targets is required only in the Operational Programmes.

Significant difference are present between lagging Regions and countries and non-lagging Regions for the allocation. In the first group, about 45% of resources is assigned to transport, environmental and energy infrastructures, while this share goes down to about 15% for the second group. The main differences concern transport infrastructure, which represent more than one quarter of all the expenditure of lagging Regions and countries (less than 5% in the other group). Human capital receives about 8% in both groups. In Regions with a GDP per capita lower than 50% of the EU average, the share of infrastructure goes up to 52%, with human capital falling to less than 5%. Interventions related to research and innovation receive 13% of the funds in the lagging Regions and countries and about 22 per cent in the non-lagging Regions. Generic subsidies for business investment (not connected to innovation or environment) are down to about 4% in both groups. Pro-active and preventive labour market measures, access to employment (and self-employment) and adaptability of workers and entrepreneurs absorb 8% of funds in the first group and about 26% in the second. Social services (mostly education and health) and measures aimed at social inclusion in the labour market account for about 7% in the first group, and over 10% (mostly aimed at the labour market) in the second.

h) MANAGEMENT AND CONTROL

Once the programmes have been approved, Member States have the responsibility for management. The responsibilities for programme management, audit and control are assigned to three key bodies:

- a Managing Authority with overall responsibility for the main programme-level management and implementation tasks (some of which can be delegated to a technical secretariat or intermediary body);
- a Certifying Authority, responsible for certifying statements of expenditure and payments applications;
- an Audit Authority.



Project generation, appraisal and selection are the responsibility of the Managing Authority, providing that they are in line with programme objectives. Also, a Monitoring Committee, created by the Member State for each programme, is required to approve project selection criteria within six months of programme approval. An exception concerns major projects, which require prior approval by the Commission.

The financial management of programmes is undertaken on the basis of commitments and payments. Financial commitments are made by the Commission on an annual basis, in line with the agreed profile of spending under the EU budget and, at Member State level, the aggregation of approved or planned expenditure. Payments to Member States are made by the Commission at three stages:

- a first interim payment, conditional on receipt of assurance on management and control systems;
- interim payments, three to five times a year on the basis of certified expenditure incurred;
- and the final payment of the balance, once the programme closure requirements have been fulfilled and the necessary documentation has been sent to the Commission.

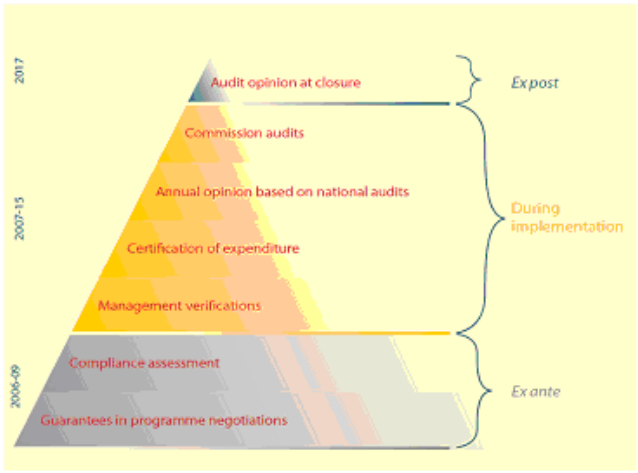
Finally, coming to control, the overall system is intended to ensure that the expenditure reimbursed from the EU budget meets all the required national and Community conditions (relating to public procurement, State aids, environment, eligibility) and demonstrate a low error rate. The control system has several levels.

- One is the control system of the Member States themselves, which aims to prevent, detect and correct irregularities.
- A second level is the Commission's supervision, which aims to ensure that Member State control systems are established, operate as required and mitigate the risk of control failures, with provisions for financial corrections to be made when irregularities are detected.
- A third level involves controls by the European Court of Auditors.

In the current period, as a result of successive tightening and adjustments of controls, Member States are required to certify, for each Programme, the compliance of its management and control system: the Commission's approval is needed before interim payments can start. An annual audit opinion on the effectiveness of the system must also be issued by Member States.

i) MONITORING, EVALUATION, DEADLINES AND SANCTION

Monitoring is linked to the financial and physical targets set in the operational programmes. Progress in achieving these targets is reported by the Managing Authority to the Commission through an Annual Implementation Report, which must be examined and approved by a Monitoring Committee, whose composition is fully up to the Member States to decide and where a representative of the Commission might take part. A review meeting is also held annually between the Commission and Member State authorities to examine, for the whole country, programme implementation progress and results over the previous year. Evaluation focuses on the overall programme and is segmented in three distinct phases: " ex-ante, " on-going, " ex-post.



The first two stages are primarily the responsibility of Member State authorities, although the Commission offers support through the publication of guidance documents, networking activities and participation in evaluation steering groups, while

ex-post evaluation is formally required to be undertaken by the Commission. The scope of ex-ante evaluation is broad, covering the appraisal of needs, goals, expected results, quantified targets, strategic coherence, lessons from the previous period, as well as the quality of the procedures for implementation, monitoring, evaluation and financial management. The "on-going" evaluation is left to Member State choice, in connection with changes in the external environment, difficulties revealed by the monitoring system, and proposals for programme modification.

The only compulsory incentive mechanism used by cohesion policy is the automatic decommitment rule which requires committed funding to be spent within two years (three years for the EU10, Greece, Portugal, Romania and Bulgaria, but only for 2007-10 commitments) or be lost to the programme: the so called n+2 system. Member States are allowed to set aside, at the start of the programme period, a "national performance reserve" equal to three percent of programme allocations, whose allocation is linked to the achievement of performance goals and targets. Most Member States have not set up a performance reserve.

The suspension of payments is foreseen only for "serious deficiencies" in the managing and control system, for "serious breaches" of the control procedure, for "serious irregularities". No discretional tool is given to the Commission, other than moral suasion, if no or inadequate move seems to be made in the direction of the announced results. The pressure to produce results is left to possible mechanisms operating at country level, or to the possibility of public debate taking place at EU level on the basis of Member States' reporting.

j) REPORTING

With the aim of enhancing accountability and transparency, Member States are required to elaborate two Strategic reports in 2009 and 2011 for all Programmes, analysing their "contribution" to cohesion policy objectives, tasks of the Regional and Social Funds, priorities set out in the Community Guidelines, and the Lisbon goals (beyond this reference to these very general goals, no mention is made in the Regulation of comparing results to objectives or targets). A summary of the Member State strategic reports will be prepared by the Commission in 2010 and 2013 and will be subject to examination and debate by the Council, the European Parliament, the Economic and Social Committee and the Committee of Regions.

Finally, the annual implementation Reports prepared by Member States for the National Reform Programmes of the Lisbon strategy must include a concise section

analysing the contribution of each cohesion policy Programme, beginning in 2007. An annual progress report summarising the Member State reports is submitted by the Commission to the Spring European Council from 2008 onwards.

A.2.5 Major project and CBA

Project selection and ex-ante evaluation within the Cohesion policy framework is normally the sole responsibility of the national authorities. Without that any requirement process or tool that aiding the decision-maker to choose or that giving same evidence at his choice decision. However for major projects (with a total investment cost of more than EUR 50 million, or 25 for environmental projects and 10 million in the case of IPA projects(Article 157(2) Regulation 718/2007), the European Community requires the following information (Article 39 Regulation 1083/2006):

1. information on the body to be responsible for implementation;
2. information on the nature of the investment and a description of it, its financial volume and location;
3. the results of the feasibility studies;
4. a timetable for implementing the project and, where the implementation period for the operation concerned is expected to be longer than the programming period, the phases for which Community co-financing is requested during the 2007-2013 programming period;
5. a Cost-Benefit Analysis (CBA), including a risk assessment and the foreseeable impact on the sector concerned and on the socioeconomic situation of the Member State and/or the region and, when possible, of the other regions of the Community;
6. an analysis of the environmental impact;
7. a justification for the public contribution;
8. the financing plan showing the total planned financial resources and the planned contribution from the Funds, the EIB, the EIF and all other sources of Community financing, including the indicative annual plan of the financial contribution from the ERDF or the Cohesion Fund.

So the Member States to submit, among others, CBA and then takes a specific co-financing decision (Article 40 Reg. 1083/2006). The CBA is the only quantitative aid and evidence expected in the regulation, to justify and support same action or project.

In addition to relying on the governments of the Member States to acquire this information and ex-ante project evaluation, the regulations state that *"The Commission shall carry out and ex post evaluation for each objective in close cooperation with the Member States and managing authorities. Ex post evaluation shall cover all operational programmes under each objective and examine the extent to which resources were used, the effectiveness and efficiency of Fund programming and the socioeconomic impact."* Hence, there is a clear provision for ex-ante and ex-post evaluation in the regulations, but there is, however, no clear link between the investment co-financing decision and such evaluations (except when fraud is discovered in rather extreme situations).

In fig. 1 we shows how the evaluation and grant decision framework currently works for major investment projects (2007-2013).

First , the applicant should show to the EC that, after a suitable CBA, the economic net present value (ENPV) is expected to be positive: if negative, the project will be immediately rejected.

Second , in the case of revenue generating projects, the financial profitability is assessed in order to establish whether the project actually needs a grant and to what extent this applies.

Third , under the so-called "funding-gap method", the EU grant co-finance the portion of the investment cost which is not covered by the future net revenues.

The funding gap-rate R is simply:

$$R = (DIC - DNR)/DIC$$

where DIC is the net present value (NPV) of investment costs, DNR is the NPV of net revenue, (i.e., the difference between discounted revenues and discounted operating costs plus the discounted residual value). Then, the Decision Amount (DA, *"the amount to which the co-financing rate for the priority axis applies"*, Art. 41.2) is:

$$DA = EC * R$$

where EC is the eligible cost.

The (maximum) EU grant is given by:

$$EUgrant = DA * MaxCRpa$$

where CRpa is the maximum co-funding rate fixed for the priority axis in the Commission's decision adopting the operational programme. In principle, projects expecting a positive financial net present value (FNPV) have no funding gap and thus do not generally receive a grant from the SF (special rules apply to productive investments under state

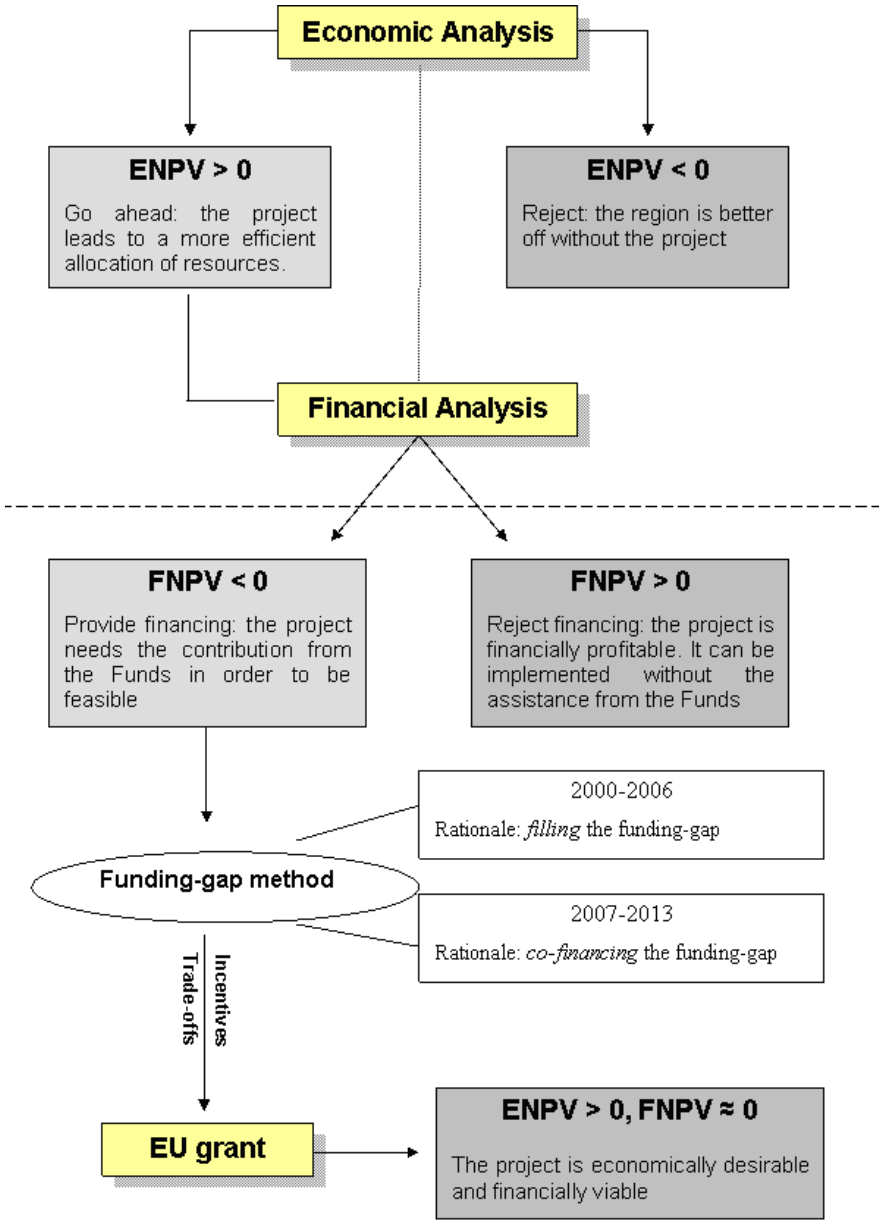


Figure A.1: The allocation of Funds to the projects: CBA and the funding-gap method.

aid regimes). The rationale of the 'funding-gap' approach is to determine the project's self-financing ratio so as to grant to the investor not less and no more than what is actually needed to implement a socially beneficial, but financially loss-making, project. The problem with this approach is obvious: the applicant has a clear incentive to exaggerate expected costs and to underestimate revenues, in order to maximize the EU grant.

A.2.6 Problems and weaknesses

In the above presentation emerged some problems and weaknesses about European Cohesion Policy, that here we will explain more in details.

The first problem is actions' effectiveness and how to calculate its impact. Estimate the success or the failure of European support is not easy because often region/programme-specific due to the factors such the quality of strategic planning, the policy and institutional context, and administrative capacity. Thus, beyond of specific suggestions the analysis shown divergent and in some cases inconsistent results. Another problem is the starting point of convergence analysis, that is the average GDP per capita or to productivity. The general opinion is that the convergence is not a good measure of development, and that the GDP per capita refers only one dimension of well-being, that cannot be taken as a summary measure of all the others. Thus, any analysis made from this starting point is unsatisfactory in order to understand the effectiveness of implemented actions. This limit is even greater since in practice the convergence is generally measured with reference to administrative regions, which have little to do with the regions or places relevant from the point of view of development[16, 207, 191, 242].

A weakness that can affect the understanding the effectiveness of one policy is the lack of data. Despite in the last decades was done a great effort in investment and human resource to export the evaluation approach and culture, there are not good and enough data in order to make a useful analysis. First of all this situation makes us think about the real application of funds. Then with this lack of data is impossible to understand if an intervention works well, what works and what does not. The survey of ex-post evaluations confirms what the absence of any EU-wide database available to the public on indicators and targets was already signalling: the quality of the indicators is doubtful and so is the meaningfulness of the targets [16, 207, 191].

Another weakness concern the deficits in strategic planning and policy conception. Despite the Commission's guide lines and the meetings to check consistency and coherence in programming National Strategic Reference Framework (NSRF) or Operational Programs are generic and vague. In this situation, the administrators have not a straightforward strategic planning to follow when they chose or implement an action and the concept of plan and also the synergies between actions are totally lose [16].

One more weakness is represented by the lack of incentive in pursuing European ob-

jective. At the start of a programming period, each member state's financial allocation is determined on the basis of relative socio-economic conditions and on macroeconomic criteria. Subsequently, there are no measures in order to check that the administrators' objectives are European objectives. Administrators might follow different objectives. One of these different objectives might be maximising the financial allocation for the next programming period. This is due to the fact that the initial allocation is made with reference to the relative prosperity, thus for instance, administrators might be tempted to spend the money recklessly in order to remain in the Convergence objective without risking having its funds reduced in the future [174].

The problems and the weaknesses presented, even without enter in technical or philosophical issues that are, otherwise, present in current debate, give at the European Cohesion Policy little coherence and credibility. The funds allocation and the choice of actions lack of a straightforward process to follow in order to achieve the objectives. Without formal process every action and situation became arbitrary and difficult to analyse. We think that formal process is necessary to give some procedural rules more useful. We do not want stiffen the bureaucratic situation or take off autonomy, we want structured the decision-making process in order to give coherence, transparency, efficiency and flexibility at the actions and decisions adopted. The need of this change is not something new. In Sapir Report([242]), when the first seven-years program had not yet finished, he underline as the European Policy and its instruments were complex and fragmented, and he suggested to find new methods for governance and decision-making. He said that to reform European Cohesion Policy would make little sense if we leaving untouched the procedures and process through which the policy are designed, decided and implemented.

A.2.7 Policy decision process

At the end of this presentation about European Policy and especially European Cohesion Policy we want to describe in a schematic way the process used in order to allocate European funds. In this scheme we show the links between different levels of government (European Commission, States, Regions), the tools used and also the government products.

From this scheme we can see as funds distribution has a vertical movement, or in other words from a higher level of government to a lower one. We can see also that these allocations are made at the higher level using the GDP criterion and then using national and regional priorities. Despite the contrasting opinion on the pertinence of the GDP criterion,in this context, it might be possible to recognise GDP criterion as straightforward and transparent. On the contrary some problems of clarity and transparency arise when the allocation criterion becomes national or regional priority. In fact, these priorities are usually supported by some preliminary socio-economical analysis and by the nation or region

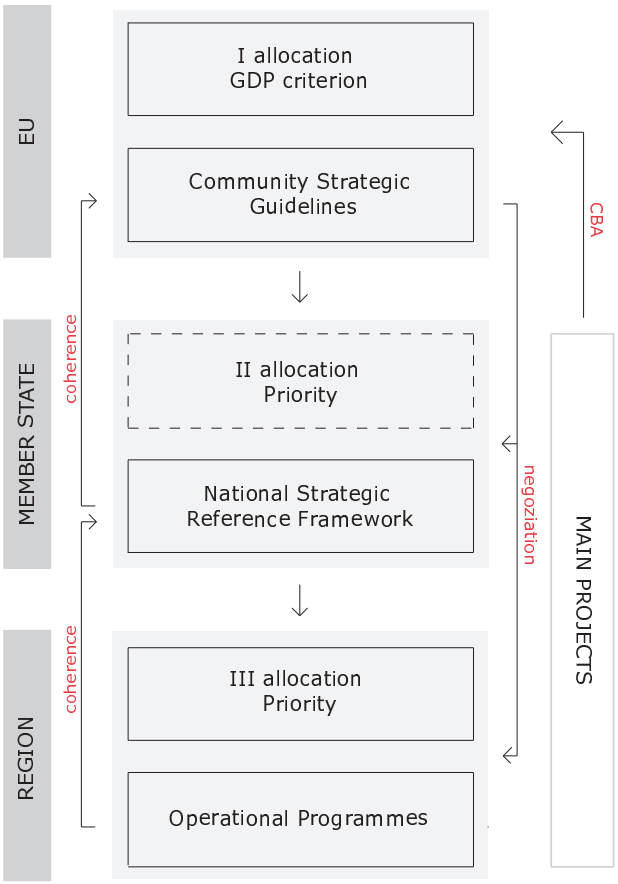


Figure A.2: Policy decision process.

retaining power. The only instrument that the commission has in order to check the funds allocation is a coherence test. But this coherence test is performed on the National Strategic Reference Framework (NSRF) and on the Operational Programmes, which doesn't include real projects but just some generic declaration. Thus, it is easy to understand that Nation and Region do not have some real regulations to allocate funds and to choose projects. The only exceptions to this process are the main projects. Main projects must be contained (although in a generic form) within NSFR and Operational Programs they need to pass the coherence test. Moreover, these projects need a dedicated CBA in order to be approved by the Commission. In this way the Commission has two type of control, one of coherence on the objectives and another one on the projects' economic perspective.

In the light of that, before showing what main projects are, we want to underline some issues related to the aforementioned process. First, we think that performing just a coherence test on a preliminary programs, on the one hand gives flexibility to the administrators but on the other hand makes it impossible to have any kind of real control. In the current situation, the Commission doesn't have tools to ensure that administrators pursue the right objectives. The negotiation enables the Commission to assess that national or regional plans are in tune with the Community Strategic Guidelines related to economic and social cohesion as a whole [174]. The second issue is, from our side, the use of CBA. We ignore the broader issues about using CBA (that will be discussed in the next chapter), despite the fact CBA can be a useful tool to understand the economic situation of projects, however, in this context it is inadequate. The according to its nature CBA gives no managerial flexibility to the administrator, that should be able to adjust their forecasts when a new information arrives. Thus, using CBA in Cohesion policy that involves a seven-years programming period, becomes something far from reality. In this way CBA is just a more or less good exercise according to which the administrators justify their choices on questionable assumptions, but that actually cannot assure to the Commission some economic security. Moreover, the most relevant thing to us is that CBA is a tool that does not allow a decision-making process according to the Operational Program.

In order to give a more suitable answer to this matters we think it might be necessary to establish a new policy process. Thus, in our work we propose to change the coherence test and negotiation into a participated process, in order to create a useful NSRF and Operational Program. Where possible, it is advisable to find a real link with the Community Strategic Guidelines and this would mainly build a set of projects and alternatives for regions' development. Furthermore, in relation to this process we suggest to change CBA with Real Options Analysis (ROA). ROA is a tool that can give more flexibility to the administrator and to all the structures above it; made as a decision tree, it allows to think and to build alternative projects and programs.

A.3 Conclusion

In this section we presented the European Cohesion Policy. We briefly told about its born, its evolution and its growing relevance in the last years. We tried to explain its procedures and processes, starteing from the funds amount and their territorial allocation to the policy government, its control and evaluation systems. Then to conclude we explained the Major Projects mechanism and the existent problems and weaknesses.

We shall say that the European Cohesion Policy includes a wide variety of policy instruments and decision-making power, ranging from microeconomic regulations to macroeconomic and redistributive instruments at the different European levels. However in order to achieve the objectives to have instruments and power are not enough, but it is required a higher degree of coherence across policies and in the decision-making process. From this concept were born our remarks and therefore our work, that we starting to shown in the last part of this presentation. We shown a scheme of the current European decision-making process and we explain our motivations and intentions.

The nature of the governance system in which the Funds operate tends to create potential information asymmetries. Notwithstanding on-the-spot checks and ex-post evaluations, the Commission cannot fully observe whether the projects selected by the administrators during the implementation of programmes are actually meant to contribute to the goals of the European Cohesion policy. In this moment no strong evidence exists to support the Cohesion Policy's investments and governance. Our proposal was to reform this situation with a revisited decision aiding process and an evaluation model built considering policy features and goals.

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