The Individual and Collective Outcomes of Decision-Making

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Abstract — **Solving decision-making problems often depends on the use of methods for multi-criteria evaluation of alternatives. Generally, the challenge relies on the ability to structure long-term goals, while establishing accurate criteria matrices and weights for assessing alternatives. Complexity increases when preference functions become important to define global utilities or determine final rankings. This topic is of high importance for the policy making process, where decisions result from group-thinking and collective processes. Therefore, high levels of subjectivity are associated with the decision process, typically reflected in preferences and options. The application of different software tools or multi-criteria decision-making methods can lead to non-identical outputs. Collective decisions result from aggregation metrics and weighing procedures. This paper discusses the balances of individual and collective decisions, based on the rational choice theory and the shift to behavioural economics. Subsequently, data from decision-making in real practice supports the debate on the use of multi-criteria methods.**

Keywords - Decision-making; Decision theory; Multi-criteria methods; Preferences; Governance; Policy making.

I. INTRODUCTION

Governance arrangements recall a response to direct and hierarchical models. In addition, they show that, among the forms of governance, it is fundamental to deal with the behaviour of the various actors involved in the decision process, either through cooperation, partnerships or networking. Inevitably, new types of management and coordination tools emerge, and changes occur leading to the adaptation of organizational models, and integration of different logics of public service delivery. Public decisions are no longer considered to be totally dependent on hierarchically organized structures and are defined by the interaction of a diverse set of organizations located at different territorial levels [1]. The theory of institutional logics suggests that decisions and outcomes reflect the interaction between individual behaviour and institutional structures; so, individuals and organizations can look for the power, status and economic advantages, as well as their means and ends to respond to their interests, but both are dependent on the institutional logics [2]. Thus, institutions are expected to meet the demands of collective decision-making in increasingly complex circumstances. In this specific context, the need to articulate the multiplicity of agents and interests in the pursuit of common goals is at the basis of the development of decision support strategies. There is a blind will to provide collective results, neglecting the basis and meaning of individual placement and preferences. Decision theories find theoretical and empirical evidence since the seventeenth century, supporting either a rational perspective to explain complex decision-making contexts, or providing complementary research to understand the behavioural mechanisms of individuals and, therefore, deal with the errors and biases of reasoning [3]–[5].

This paper is structured in four sections, besides the Introduction. First, decision-making is framed within the public policy process, focusing on the challenges deriving from governance arrangements. Group decision-making plays a key role as individual decision heuristics, preferences and expectations meet collective purposes and goals. The rational choice theory and the shift to behavioural economics frames this debate. In real (policy) decision-making contexts multi-criteria methods are used to structure and organize priorities among alternatives; thus, a short review is presented. The paper follows with a comparison of individual and collective outcomes by applying different aggregation metrics and Multi-Criteria Decision-Making (MCDM) methods to a real decision-making problem. Finally, conclusions focus on the main findings and further research recommendations.

II. PUBLIC POLICY AND DECISION-MAKING

Governance does not mean the end of politics, but its practice in a context of broader interaction subject to a game of cooperation and conflict across all institutions and actors of government arrangements. Within these arrangements institutions are required to develop a couple of interrelated steps: i) to establish a consensual and strategic vision based on stakeholders' motivations, preferences and expectations; ii) to structure decision processes towards priorities; and iii) to develop effective coordination mechanisms in the integration and regulation of the process [6]. This complexity discloses the notion that decisions reflect the functioning of various decision heuristics, which include decision rules, logical reasoning structures, and value systems [3][4][7]. Thus, decision-making is often associated with high degrees of uncertainty and complexity, resulting from the limited resources, multiple actors with (conflicting) motivations and preferences. Individual or collective choices are made from a set of alternatives, which can change over time or when subject to different evaluation criteria. Gowda and Fox [8] remind other scholars who strived to understand how people's choices operate under conditions of high uncertainty and risk, and conclude that people do have a systematic way to achieve their decisions and choices. During decision-making, certain heuristics or rules of thumb

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are followed, moving away from the typical rational decision process advocated and used by economists (see, for e.g., the works [3][7]). Even though preferences are assumed to be determined by different utilities and probabilities, and one can assume that people choose to maximize expected utilities [9][10], individuals do not always have all the information, or the ability to process, manage and evaluate the consequences of their final options [4]. In addition, other cognitive, normative and motivational elements that delimit and characterize the individual and collective behaviour explain behaviour patterns [3][11].

Group decision-making is a topic of major interest. Roy [12] refers to the comprehensive dimension of decision, as the decision results from the interactions among individuals, entities, communities and the conflicts of their preferences. Regardless the individual perspective of a decision, when placed in the policymaking process, it is shaped by specific information systems, behaviours and organizational structures. There is a challenging effort to balance the relations between actors involved in the decision process, ranging from the alternative definition to the combination of preferences. The perception of alternatives and decision-making depends on a set of sociological and psychological factors, often dealt with communication techniques and strategies. Concepts such as agenda setting, framing and priming mirror this complexity, as they describe how different groups, with different degrees of power, interact and define the political debate and, consequently, contribute to the construction of the political agenda. In what concerns decisions, the problem particularly consists in assessing the option's feasibility, risks and consequences, where setting the wrong priorities may imply inefficient use of available resources and opportunity costs [13]. Indeed, the discussion on the decision-making process within the public policy formation can be multifaceted as you concern, for instances, the organization of all related steps of the decision process; the selection and design of decision techniques and models; the knowledge background, potential bias, interactions and system-thinking of individuals during decision-making moments.

The following section intends to capture two basic elements: i) the actors and their relations during decision processes and ii) the need of decision support tools able to deal with the complexity related with the patterns of behaviour, rules or structures.

III. DECISION THEORY AND METHODS IN PRACTICE

A. *Rational choice and behavioural economics*

Good policy decisions depend on both recognizing the importance of multilevel governance for pursuing micro level goals, by structuring integrated programs grounded in external strategic frameworks, and considering the possible evolution of exogenous factors. These decisions require policy coordination and territorial governance strategies, often using decision support tools. The concept of decision support systems has accommodated multiple perspectives, suggesting the combination of generic and technical principals to respond to the decision design of governance arrangements involving a diversity of social actors and sectorial perspectives. Empirical and theoretical findings are set on the readings of the research of [14]–[19]. As these studies show, decision problems are context-dependent and there is no universal choice pattern to apply. Besides subjective and asymmetric information issues, choices and preferences are subject to great uncertainty and inaccuracy, for which the cognitive characteristics of individuals and the social, institutional and economic structures play a key role.

Moreover, to explain such diversity and complexity, since the 17th century, decision theory has covered rigorous mathematical and quantitative assumptions, defending its rational foundation, and supported other approaches focused on the cognitive basis of human behaviour, analysing the meaning of heuristics and bias [4][7][14][20]–[23]. We believe that the complex equilibrium between individual and group decisions requires both descriptive assumptions and rationalist components. The standard view of traditional microeconomic theory explains human behaviour by using rational choice, therefore, following principles such as unbounded rationality and self-interest. At the basis is the assumption of an optimization approach, subject to consistent criterion assessment. Individual preferences and choices, however, seem to be much more complex. Understanding how and why individuals decide in one way or another underpins psychological and socio-cognitive insights. These questions seem to be captured by behavioural economics studies. This balance of socio-cognitive and rational aspects are somehow present in the work of Mathis et al [24], who present individual and social decisions based on key assumptions and theoretical foundations of rational choice and behavioural economics, for which preferences and restrictions are placed in a debate of maximization of individual and social utility. A variety of studies evidence the characteristics of decision makers and encounter several modelling choice mechanisms to deal with heuristic decision rules, (un)predictable behaviour patterns, typical decision routines, preferences (stated and revealed) and self-oriented motivations [3][4][7][25][26]. Research has evolved providing insights on linking cognitive and social psychology to shed light on how individuals and groups deal in decision contexts (interesting reading on this matter are [3][11][27]). Cognitive and behavioural biases are extremely important to understand decision outputs. However, there is no unified approach regarding the link between socio-cognitive aspects and decision-making; though, efforts towards modelling frameworks grounded on multiple economic, behavioural and cognitive theories are identified, as well as attempts on applying theories of situated cognition and social cognition (see [26][28]–[32]).

In this paper, the rational and socio-cognitive decision-making assumptions are narrowly presented, as these require the combination of multiple preferences, choices and decisions and encounter technical challenges for the design of decision strategies and tools (Table I).

A set of key assumptions and analytic dimensions are put through the above-mentioned aspects. This paper discusses the preference formation process while dealing with the

individual-collective shift. This analysis is complex due to multiple drivers, as shown in Table II. Empirically, is assumed the challenge of applying this background to real context decision-making processes where multi-criteria techniques where used.

TABLE I. THEORETICAL GUIDELINES

Analytic dimensions	Rational choice	Behavioural economics
External incentives	… assumed to be unalterable in the short term and incapable of explaining changes	… reaction to external incentives account for changes in preference patterns
Preferences	… result from assessing benefits and costs, accounting for highest gains among alternatives	… thinking structure has its own benefits and drawbacks; so, they are difficult to predict, but can be indirectly determined through individuals' order of preference via observing both behaviour and restriction
Restrictions	… are relatively easy to identify	… are context dependent
Complexity	… reduced, as people are confined to a few individual characteristics … available information is believed to lead to an efficient result	… high, as the assumption of rationality is relativized … acknowledges that information deficit is unable to account for all deviations
Individual or collective explanation capacity	… there is no attempt to understand the individual, but the behaviour of large groups of individuals ("aggregates")	… there is an effort to provide a more realistic perspective on behaviour based on the analysis of the psychological foundations of economics
Social decisions	… efficiency is generally defined as Pareto efficiency or Kaldor-Hicks efficiency	… social, economic and legal conditions influence the a reciprocal conduct; thus, most people do not always act according to their best self-interest

Source: Based on Mathis and Steffen [24].

TABLE II. KEY ASSUMPTIONS AND ANALYTICAL DIMENSIONS

Rational choice	Completeness Transitivity Continuity Substitutability Choice rules Utility functions Arrow's axioms & impossibility theorem
Behavioural economics	Availability Bias Hindsight Bias Anchoring Effect Confirmation Bias Egocentric Bias Loss Aversion Status Quo Preference Endowment Effect Framing Effect
Additional assumptions	Perfect information Choice under uncertainty Limited cognitive ability Type of preferences (stated or revealed) Consistency assumption

B. *Multi-criteria methods*

The following considerations lie on multi-criteria analysis, based on the assumption that it allows preference relations by combining different assessment on quantitative and qualitative criteria. With rational and/or behavioural guidelines, the decision problem focuses on choosing (most appropriate alternative), ranking (differentiating worst and best options) and sorting (from a list of plausible possibilities) [33]. Some methods enable defining admissible decisions while encountering uncertainties about current or future impacts [34]. A common characteristic of multi-criteria decision-making methods is the evaluation of options by comparing several alternatives, based on individual or collective assessments on several, and perhaps conflicting, criteria. The best alternative derives from the aggregation of all evaluations and comparisons. As Sabaei et al. [35] advise, different types of problems suggest the design and application of adequate methods, whose selection should result on expert's judgments or any other technical restraints.

Amongst the most well-cited and common methods used in publications are the AHP (Analytic Hierarchy Process), the ELECTRE (elimination ET choix traduisant la realite), TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), SAW (Simple Additive Weighting), and PROMETHEE (Preference Ranking Organization METHod for Enrichment of Evaluations) [35]–[39]. Generally, these methods include different outranking methods, possibility of combining qualitative and quantitative data, and ability to deal with uncertainty.

IV. ANALYSING INDIVIDUAL AND COLLECTIVE PREFERENCES DURING PUBLIC POLICY FORMULATION

A. *Decision-making in real practice*

This section presents how AHP was used to structure group decision-making during a strategic municipal plan. The AHP, in comparison with other methods, was considered the more prevalent rank order weighting method due to both its theoretical and application simplicity. This method was developed by Saaty [40], which decomposition principle requires the comparison of pairs of various elements that structure the decision process, allowing ranking the various elements, evaluating the relative importance of alternatives and clarifying prioritization.

To derive and synthesize priorities, the criteria followed a hierarchical structure, further evaluated based on pairwise comparisons with a relative scale. Once individual priorities were obtained, the responses of the various participants were combined to build a collective choice pattern. In practical problems, given people's different positions on the same options (criteria, alternatives, etc.), from which strong convictions and contrasting valuations may arise, reciprocal assumption plays an important role for the collective outcome. As theoretically described by Saaty [41], the decisions must be combined so that the reciprocal of the aggregate responses is equal to the inverse synthesis of these responses. In other words, if a/b = c/d, then b/c=d/c. Thus, no category or answer prevails over the set of options. A key debate issue regards to the consistency of the individual answers. During pairwise comparison, inconsistent answers might appear. In extreme cases this inconsistency may lead to rejection of the answers. This happens in situations where

if A> B and B> C, then C≤A; If the answer is A> B, B> C and C> A, then the answer set is inconsistent. In order to solve problems of logical inconsistency, a control value (R^2) was defined, sensitive to random responses, to the mismatches resulting from the scale used and to the subjectivity that this type of exercise involves. The control value was tested and adjusted to real-context circumstances, as the application of the original recommended by Saaty, did not conform to human reasoning and its capacity for information processing. Wolf et al. [42] and Nogueira et al. [43] further explain this application of AHP (which was applied to four strategic plans: 3 municipalities and 1 regional tourism development association). Generally following AHP assumptions', the alternative classification resulted from the combination of scores (detailed matching of alternatives within criteria) and weights (resulting from public processes) – the output is shown in Tables III and IV.

TABLE III. WEIGHTS ASSIGNED TO THE TWO-LEVEL CRITERIA TREE, USING THE AHP

Criteria - Level 1	Weight index	Criteria - Level 2	Weight index
Economy	100	Economy of the future	100
		Infrastructure	97
		Services and other	78
		Labour / workforce	76
Quality of life	100	Basic services (health, education …)	100
		Vulnerable social groups	77
		Employability	76
Social Inclusion	97	Civic participation	100
		Culture	89
		Sport and leisure	80
Natural heritage	92	Environment (protection)	100
		Risks (prevention and mitigation)	99
		Tourism	88
		Local amenities	83
Urban space	82	Accessibility and mobility	100
		Built heritage	75
		Territorial identity	74
		Urban areas	71

TABLE IV. ORIGINAL RANKING AND RELATIVE IMPORTANCE OF ALTERNATIVES

Case-A_Alternatives	Order	Rank
Case-A_A1	90	9
Case-A_A2	92	6
Case-A_A3	96	3
Case-A_A4	94	5
Case-A_A5	89	10
Case-A_A6	95	4
Case-A_A7	92	7
Case-A_A8	100	1
Case-A_A9	97	2
Case-A_A10	90	8

B. *Methods and possible non-identical outcomes*

1) *Preference aggregation*

As reminded by Wang et. al. [44], multi-criteria methods rely on criteria selection, weighting, evaluation, and final aggregation. They suggest three categories of weighting methods i) subjective weighting, ii) objective weighting and iii) combination weighting methods and point several methods based on weighted sum, priority setting, outranking, fuzzy set methodology. Such statement supports the multiple perspectives leading to different outputs, which change what was initially considered a collective decision. Thus, the following are discussed 1. the collective outcomes by assessing to what extent individual weights when using different aggregation metrics deviate from the results; and 2. the priorities when using other multi-criteria methods.

The use of arithmetic or geometric means, for example, changes the results. The interest in this comparison results from the application of the geometric mean in contexts where it is necessary to obtain an aggregation of items classified with different scales. Although it is not an issue of different scales, criteria vary in number of sub-criteria. Additionally, the scores matrix, which classifies the alternatives in each criterion, has different numerical ranges. It is, therefore, debatable an overestimation of an alternative or criterion deriving from the application of the arithmetic mean. Another discussion around the aggregation of preferences refers to the way in which these are initially evaluated: ordinal, pairwise or cardinal choice. Although the data collected (pairwise) was adjusted to transform the final (and normalized) weights into an ordinal choice matrix, such was not conducted. It would remain unjustified whether potential divergences resulted from the method or from the way judgment is structured in one case or another (such validation would be impossible). Instead, the results were compared with those that would occur with the application of the cardinal choice method. Since the most voted can also be the most rejected, how divergent can the results be?

For decision support purposes, a combined reflection of the information that results from the comparison of real results when subjected to calculations of arithmetic and geometric means, as well as cardinal classification, is relevant. The results show that in more general criteria (therefore, more subjective) extreme values seem more accurate, while in-between values require greater attention. In general, sub-criteria concern to specific issues, where preference matrices evidence greater disparity among options. For analytical and decision support purposes considering other coefficients and dispersion indexes are suggested to consolidate the analysis (e.g. Herfindahl-Hirschman index, Theil index localization and specialization coefficients).

2) *Scores, weights and multi-criteria decision methods*

In general, a multi-criteria problem is performed by defining criteria, alternatives and the link between both. The criteria are valued to prioritize alternatives. As previously mentioned, there is a wide range of methods, whose assumptions of normalization and ordering differ. This work contributes to this debate by demonstrating how these methods can influence decisions made in a real context. Despite the need to shape the input data to run the MCDM methods, its homogenization was ensured, reducing possible bias in the conclusions drawn. The selection of SAW, TOPSIS and ELECTRE is due to their similarity regarding the use of matrices of scores and weights, without having to tamper the actual data. Some scale correction procedures were, however, necessary. PROMETHEE rankings were not

calculated due to the inability to match real data to preferences, indifferences and incomparability.

The comparable ranking results (Table V) are consistent with the most and least relevant alternatives. The AHP, SAW and TOPSIS allow to infer relative importance, under different analytical perspectives. The AHP is via the scale used for comparisons; SAW is due to the additive weighting algorithm and TOPSIS for its performance indicator, comparing each alternative with best and worst ideal ones. The ELECTRE does not allow this differentiation and, in this case, it presented transitivity problems (Table VI).

TABLE V. RANKING COMPARISON WITH APPLICATION OF MCDM METHODS

Case-A_Alternatives	Original	AHP	SAW	TOPIS	ELECTRE
Case-A_A1	9	10	10	10	9
Case-A_A2	6	3	6	8	3
Case-A_A3	3	5	8	4	3
Case-A_A4	5	6	3	9	5
Case-A_A5	10	4	5	6	6
Case-A_A6	4	9	2	5	6
Case-A_A7	7	8	1	3	6
Case-A_A8	1	2	4	7	2
Case-A_A9	2	1	9	2	1
Case-A_A10	8	7	7	1	9

TABLE VI. RELATION BETWEEN ALTERNATIVES: INTRANSITIVE CASES

A2 > A5	A2 > A6	A2 > A7				
A3 > A2	A3 > A6	A3 > A7				
A4 > A5	A4 > A7					
A5 > A6						
A6 > A4						
A7 > A6						
A8 > A1	A8 > A2	A8 > A4	A8 > A7			
A9 > A1	A9 > A2	A9 > A4	A9 > A5	A9 > A6	A9 > A7	A9 > A8

V. CONCLUSION

Typically, the conceptual and mathematical background of multi-criteria decision methods is based on examples describing alternatives with objective criteria (e.g. choosing printers or selecting candidates for a job). It is frequently used in the entrepreneurial context, where the type of problems dealt with allows greater objectivity of the input data. The focus is often on maximizing utility functions, reducing costs, optimizing production or processes. Operational research has contributed to the development of decision support systems that fulfil these purposes. Although dealing with and articulating multiple criteria are a concern in these approaches, the policy-making context opens other debates. Groups are put together to define action plans, based on priorities fulfilling strategic development paths. Understanding individual and collective positioning is a key aspect to support and toughen the decisions. The study on MCDM evidences solid knowledge on structuring priorities, but a lack of coverage on the aggregation of responses. As well, the weight assignment process is described in AHP, but in the other MCDM methods it is assumed as an input data (not deriving from the methods' procedures). While focusing on alternatives, few is said about the combination of scores and weights. Thus, efforts were made to comply with the methods' requirements. The simplicity of MCDM methods is an advantage for its application; however, the difficulty of adjusting them to real decision contexts limits their potential. As explained, the complexity of decision in real practice motivated the adjustment of AHP original assumptions.

To conclude, in addition to those presented, testing aggregate differences based on other ways of collecting preferences is not possible, as the original pairwise data is not prepared for this purpose. This work does not emphasis all assumptions and key analytical dimensions theoretically discussed. It focuses on some of the identified problems, such as transitivity and the use of decision support instruments to overcome the rational limited capacity. Moreover, it opens path to discuss the need to adjust the parameters of the models and methods used, as verified in the real context of application of the AHP.

This work provides an analytic framework, extensible to other cases, allowing to compare and assess the sensitivity and robustness of the results and methods. The apparent consistency at the extremes of the priorities (most and less valued alternatives) suggests the need to consider other decision approaches to tune how intermediate values are calculated. Additional testing by reducing alternatives or the number of criteria can change these conclusions. Further research topics go for explaining how decision makers deal with uncertainty and how groups influence individual decisions. The use of foresight techniques supports the discussion about the methods that allow dealing with uncertainty, in a more or less objective manner (projections, estimates or scenario analysis, as suggested by Borges et al. [45] and Marques et al. [46][47]). Finally, research on group-thinking brings an additional layer to the decision theory. The preferences of decision maker's ex-ante and ex-post collective debate can derive. Explaining this shift based on (socio) cognitive indicators is, as well, useful for supporting decision processes.

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