Explicit and Implicit Weighting Schemes in Multi-criteria Decision Support Systems: The Case of the National Innovative Housing Quality Program in Italy

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Abstract. While institutionalized and purely contractual public-private partnerships (PPPs) are supposed to be helpful to carry out urban regeneration interventions, many of such projects - especially in Italy - are developed under the framework of negotiation-based PPPs, also known as negotiating partnerships. The structuring process of negotiation-based PPPs extensively uses various valuation approaches and methods, with a remarkable role played by multi-criteria decision support systems. The literature focuses on using valuation approaches and methods in this field, pointing out the potentialities that can be exploited and the limitations that should be addressed. This paper places itself within this debate and tries to address an inherent issue in multi-criteria decision aid (MCDA) techniques. Here we show that there could be a gap between the explicit weighting system used in MCDA analysis and the implicit weighting system actually employed. The issue is discussed using the National Innovative Housing Quality program, lastly adopted in Italy, as a testbed. As a case study, we consider the program proposal defined by the municipality of Treviso, North-eastern Italy. Implicit weights are identified ex-post according to the allocation of funding to the intervention projects. While confirming a difference in comparison to the importance of the criteria identified a priori by the public body that governs the program, we also argue that the gap narrows if assuming that the project options match the criteria according to a nonlinear relationship. The originality and value of this paper lie in addressing a topic that is underestimated in the reference literature. Instead, its thorough consideration might help structure program proposals based on negotiating partnerships that are more effective.

Keywords: Multi-criteria decision support systems · Multi-criteria decision aid · Weights · Weighting system · PINQuA

1 Introduction and Background Literature

The Green Paper on public-private partnerships and Community law on public contracts and concessions, published in 2004 by the European Commission [1], identifies two

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main partnership models involving public and private stakeholders. On the one hand, the so-called institutionalized public-private partnership (PPP) [2, 3] is characterized by establishing a mixed capital company, the equity of which is jointly owned by a public body and a private entity. On the other hand, the purely contractual PPP features an extension of the scope of public sector procurement, beyond the traditional competitive bidding process. It builds on concession agreements meant to assign the design, funding, execution, or exploitation of facilities and related services - not to mention the associated risks [4–7] - to the private partner, depending on the specific model adopted [8, 9]. Both kinds of PPPs are widely used to deliver infrastructure works and, even more often, supply services for the benefit of a local community [10].

PPPs are put forth as suitable frameworks for urban renewal projects in several European countries, signally through the establishment of urban regeneration companies [11–16] as far as institutionalized PPP is concerned, and - even though sometimes subject to criticism [17–20] - employing concessions based on the private finance initiative model [21–24] as regards purely contractual PPP. Nonetheless, in the Italian context, the potentialities of PPPs are exploited much less in urban development or redevelopment projects than in providing local public services [25, 26].

At the same time, similarly to trends observed elsewhere in Europe [27, 28], urban renewal needs have led to the rise of different kinds of partnership transactions. They are subsumed in the expression negotiation-based PPP (or negotiating partnership), which distinctive features are as follows: private ownership of land to be redeveloped or buildings to be regenerated; cooperation between public bodies and private entities based on negotiation rather than competition; negotiations - as well as the subsequent partnership agreements - are ruled by the national or regional town planning legislation [11, 29].

The structuring of the above-mentioned PPP-based regeneration programs makes extensive use of a variety of valuation approaches and methods [30], such as: discounted cash flow analysis and derived models [31–38], multi-objective linear programming [39–43], Multi-criteria decision aid (MCDA) techniques and multi-criteria decision support systems [44–50], and others [51, 52]. In particular, multi-criteria decision support systems are used to rank and identify the intervention proposals suitable to be included in the urban regeneration programs [53, 54], provided the result of the negotiation process is seen as socially acceptable by the public stakeholders - namely, a share of the benefits goes back to the community on the ground [55] - and financially viable by the private ones [56, 57].

Building on the framework above, this study addresses a crucial issue when using MCDA techniques to rank and select the project proposals to be included in PPP-based regeneration programs. Below we show that there could be a gap between the explicit weighting system used in MCDA analysis - namely, the weights of the selection criteria identified a priori by the public body that governs the process - and the implicit weighting system actually employed - that is, the importance of the same criteria that one can infer ex-post according to the allocation of funding to the projects. We also argue that the gap narrows if assuming that the project options match the criteria according to a nonlinear relationship.

The remainder of this paper is organized as follows. Section 2 provides an overview of the National Innovative Housing Quality program, lastly adopted in Italy and referred to by the acronym PINQuA. Section 3 introduces the case study, which is the Innovative

Housing Quality program adopted by the city of Treviso, North-eastern Italy. Section 4 presents and discusses the results of the simulations we performed on the weighting system used in the case study. Section 5 draws the conclusions.

2 Overview of the National Innovative Housing Quality (PINQuA) Program

2.1 Subject Matter and Objective

The National Innovative Housing Quality (PINQuA is the Italian acronym) program is a public-private partnership tool jointly promoted by the Ministry of sustainable infrastructure and mobility and the Ministry for cultural heritage and activities and tourism.

The program aims to pursue urban regeneration, relieve housing distress and other settlement issues, and improve social inclusion, with a specific focus on the suburbs and urban fringe areas. To this end, five areas of intervention are identified as priorities: redevelopment and increase of the outdated public housing heritage as well as of the social housing stock; economic and social regeneration in areas outside the city historical centers; enhancement of accessibility and safety; re-functionalization of abandoned and degraded public spaces and buildings; experimenting with new models of housing services management.

The program has also been identified as one of the operational tools in the National recovery and resilience plan, which is part of the Next Generation EU program, that is to say, the strategy for the modernization of the country in many respects, such as sustainable development and mobility, environment and climate, improvement of the health chain, reform of both public administration and justice system, and promotion of competition.

2.2 Operating Model

Public bodies such as regions, the so-called metropolitan cities (namely, 14 large core cities and their closely related, surrounding towns, which constitute a kind of sub-provinces), and municipalities with more than 60 thousand inhabitants are allowed to submit a program proposal to the Ministry for public co-financing. The proposal must include a technical report, a general plan, as well as technical and economic feasibility projects for the works included.

Approximately, 2.8 billion Euros in public funding have been allocated to implement the Program. Each proposal can obtain maximum public funding of 15 million Euros (though a narrow set of pilot projects are granted up to 100 million Euros), provided it attracts and leverages additional private resources. Additional constraints are as follows: at least a proposal for each region must be approved and financed; 34% of total public funding is destined to proposals located in the southern regions.

The evaluation of the program proposals submitted to the Ministry makes use of a multi-criteria decision support system. Six classes of criteria - environmental impact, social impact, cultural added value, land use improvement, economic viability, and technological advance - each divided into five or six sub-criteria provide the ranking of the

proposals, for the purpose of public funding allocation (see the hierarchical value tree of goals, criteria, and sub-criteria in Fig. 1). Out of 290 applications presented by the entitled public bodies, 159 has been financed. The deadline for completing the works is set for March 31, 2026.

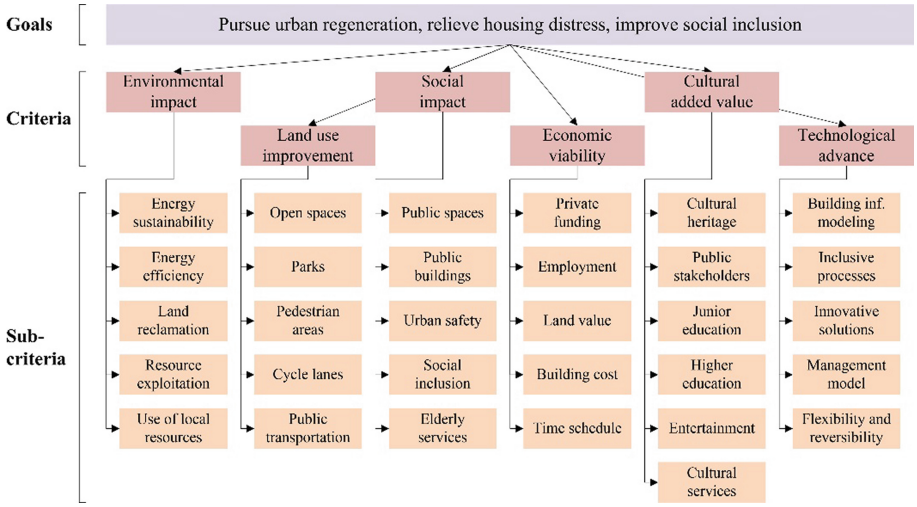


Fig. 1. Hierarchical value tree of goals, criteria, and sub-criteria in the National Innovative Housing Quality (PINQuA) program (source: authors' study and Ministry of Infrastructure).

3 Case Study: The Program Established by the Municipality of Treviso

3.1 Founding Idea of the Program Proposal

The Treviso municipality issued a notice to acquire expressions of interest by other public bodies or private entities in participating in the program proposal. It subsequently approved and submitted to the Ministry the program named after the peripheral district it focuses on: "Treviso San Liberale: the inhabited park."

The program proposal involves projects arranged into four action lines (see Fig. 2). The first action is defined as "City to be re-inhabited", which essentially means the demolition and reconstruction of the outdated public housing stock (see the upper left panel in Fig. 3). Action two - "Acts of cohesion" - provides for the conversion of some properties intended for sale as new facilities serving the public residential area; in addition, it is meant to strengthen the structures and buildings of the public welfare and charity body and the institute for hospitalization and assistance services for the elderly (see the upper right panel in Fig. 3). The third action is hinged upon the notion of a "Network of 15 min on foot", where the network is made by three pedestrian and cycling lanes connecting the parks inside the district and the district itself to the city center (see the lower left panel in Fig. 3). Action four - "Heritage of the'900" - provides for the expansion of

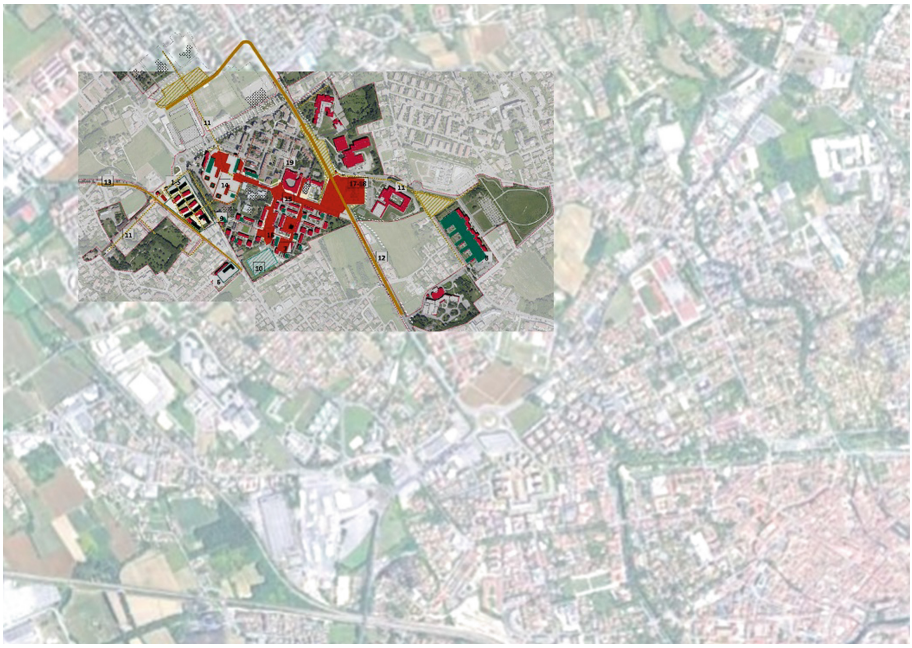


Fig. 2. Layout of the actions included in the program for San Liberale district, North-western of the city center of Treviso (source: authors' study, Municipality of Treviso, Google Earth as the background layer).

existing drainage surfaces and the redesign of the courtyards (see the lower right panel in Fig. 3).

The program proposal is expected to have an overall cost of 55,117,024 Euros. Main financing sources are as follows: 15 million Euros (27.2%) are the public funding provided by the central government; 21.893 million Euros (39.7%) are additional public funding made available by local public bodies, mainly Treviso municipality and the local public housing agency; 1.650 million Euros (3.0%) are expected to be invested by public-private bodies; finally, 16.574 million Euros (30.1%) are the funding attracted though the partnerships with private entities.

3.2 Matching Between Projects and Criteria

The consultancy and design team (see the Acknowledgments section for detail) has built a self-evaluation table where the correspondence between the local projects belonging to the four action lines and the evaluation criteria and sub-criteria defined by the central government to assess program proposals is represented. The self-evaluation table clusters the projects according to three matching levels, which are particularly useful for the purpose of this study since they enable to check for the weighting scheme implicit in the program proposal: none to low is the first matching level, average (or weak) the second, and high (or strong) the third (see Fig. 4).

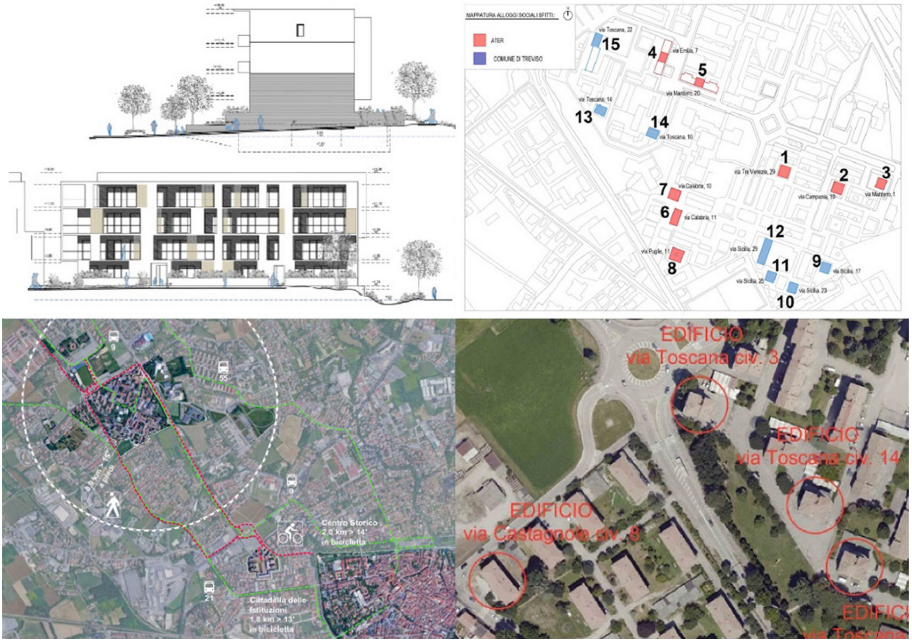


Fig. 3. Actions shaping the program for San Liberale district, North-western of the city center of Treviso (source: Municipality of Treviso).

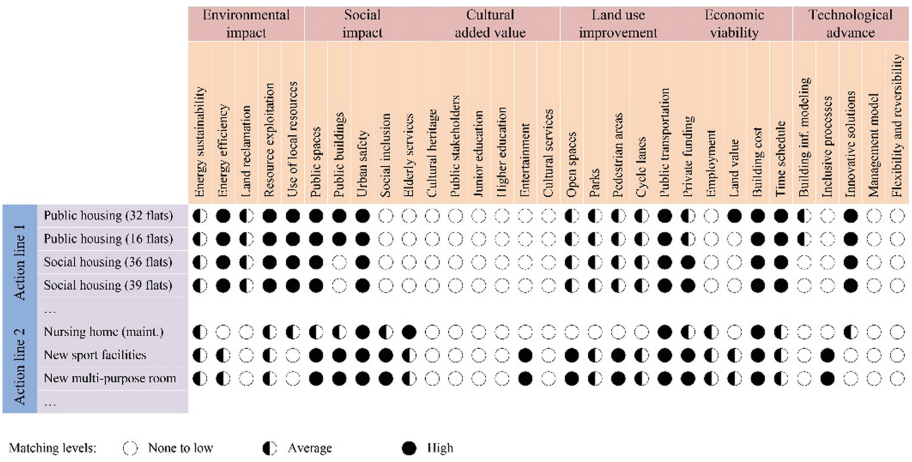


Fig. 4. An excerpt concerning different matching levels between criteria and projects (source: courtesy of architects Paolo Miotto, Mauro Sarti, and Elena Orsanelli, of the architect firm Archpiùdue).

4 Explicit and Implicit Weighting Schemes: Method, Results, and Discussion

4.1 Objective Function

Let us denote by w_i (with $i = 1, \ldots, 6$) the (explicit) weight of each ith criterion, as defined by the Ministry in the call for proposals. More to the point, the weights w_i are as follows: 15% for the environmental criterion, 25% for social impact, 10% for cultural added value, 15% for land use improvement, 25% for financial viability, and finally, a weight of 10% is allocated to the criterion of technological advance.

Let us denote by $\widehat{w}_i$ the (implicit) weight of each ith criterion, as it can be inferred from the allocation of public and private funding to the projects included in the program proposal. The estimated (implicit) weights $\widehat{w}_i$ are calculated as follows:

$$\widehat{w}_i = \sum_{j=1}^{20} c_{\cdot,j} \times m_{i,j} \Big/ \sum_{i=1}^{6} \sum_{j=1}^{20} c_{\cdot,j} \times m_{i,j} \tag{1}$$

In other words, we first multiply the expected cost $c_{\cdot,j}$ of each jth project (with $j = 1, \ldots, 20$, as twenty local projects are included in the program proposal) by the matching level $m_{i,j}$ between the ith criterion and the jth project, then we sum up all the products, and finally, we normalize them to unity. We let $m_{i,j}$ vary, and the objective function to minimize is a simple sum of squared differences, or squared errors, if you will. That is to say, we use a loss function strictly resembling the method of least squares, which is standard in regression analysis:

$$\min_{m_{i,j}} \sum_{i=1}^{6} \left(w_i - \widehat{w}_i\right)^2 \tag{2}$$

4.2 Comparison Between the Explicit and Implicit Weighting Schemes

We first assume that a linear relationship describes the matching levels between projects and criteria. Accordingly, the matching levels $m_{i,j}$ translate into the following values: a none to low matching is given the value 0, 0.5 for an average (or weak) matching, 1 for a high (or strong) matching. That is a basic assumption we make simply to test whether there could be a gap between the explicit and the implicit weights or not. As a matter of fact, we find that the implicit weighting scheme departs from the explicit one (see Fig. 5). As far as the fifth and sixth criteria are concerned, there is no noticeable difference: financial viability is the fifth criterion, 0,25 and 0.22 are its explicit and implicit weights, respectively; technological advance is the sixth criterion, with a relative importance of 0.10 against 0.12.

Nonetheless, the discrepancy is much more apparent when we turn to the other items of the value tree. The implicit weight for the third criterion (cultural added value) is more than half the explicit one, whereas the opposite holds for the first criterion (environmental impact). Similarly, the second criterion (social impact) is underweighted (0.17 versus 0.25), while the fourth (land use improvement) is overweighted instead (0.21 versus 0.15).

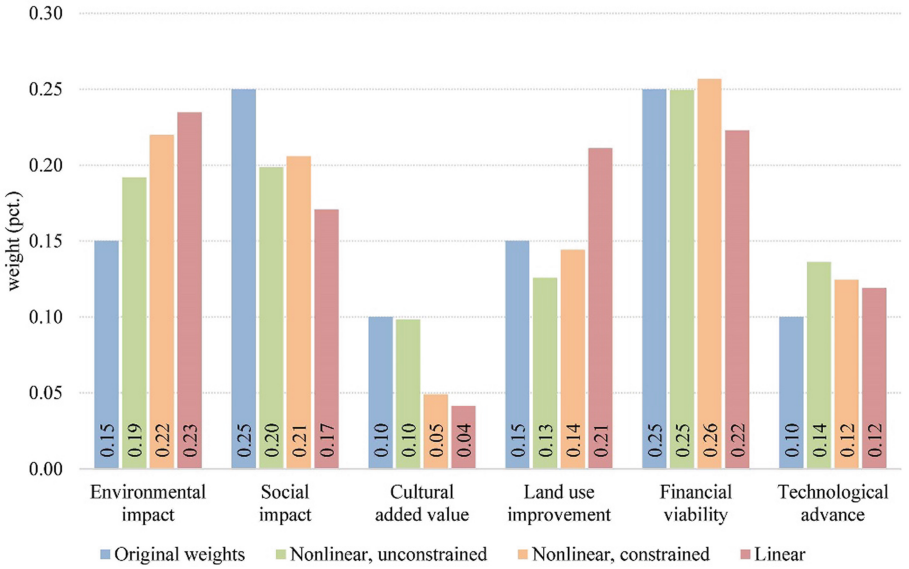


Fig. 5. Comparison between the explicit and implicit weighting schemes, implicit weights inferred according to project costs (source: authors' study).

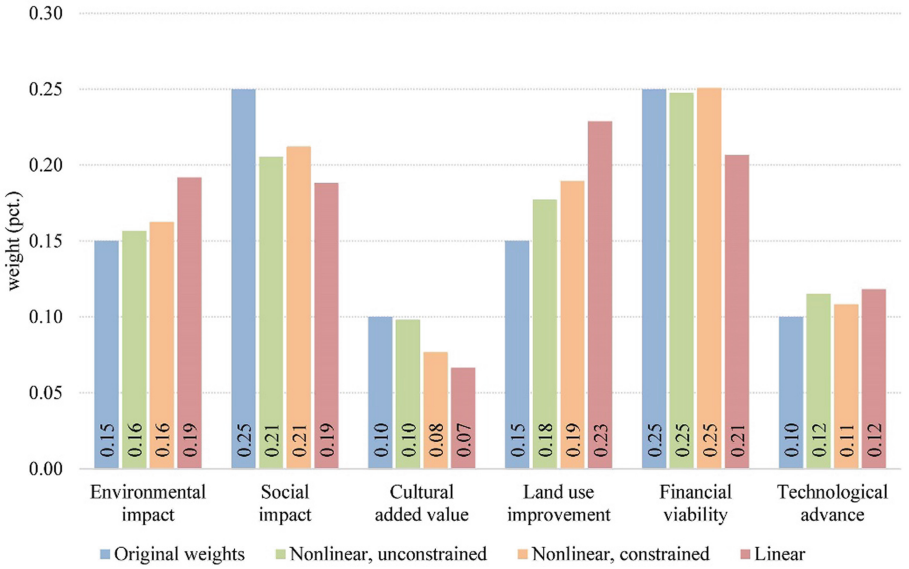


Fig. 6. Comparison between the explicit and implicit weighting schemes, implicit weights inferred regardless of project costs (source: authors' study).

It is worth mentioning that the gap in the weighting schemes might tell much about where local priorities lean towards. In other words, it looks like the program proposal pays

a lot of attention to addressing environmental and land use issues while leaving social and cultural aspects somewhat in the background. Nevertheless, the evidence can be biased. On the one hand, upfront costs are likely to be higher for the projects matching the first and the fourth criteria (environmental impact and land use improvement, respectively). On the other hand, the investment costs are likely to turn out lower for the projects meant to meet the second and the third criteria (social impact and cultural added value, respectively). To control for this potential confounder, we also detect the implicit weights regardless of the project costs (see Fig. 6). The latter results show that the gap between the explicit and implicit weighting schemes narrows, suggesting that the program proposal, though focused on environmental and land use matters, does not disregard other areas of intervention such as the social and cultural ones.

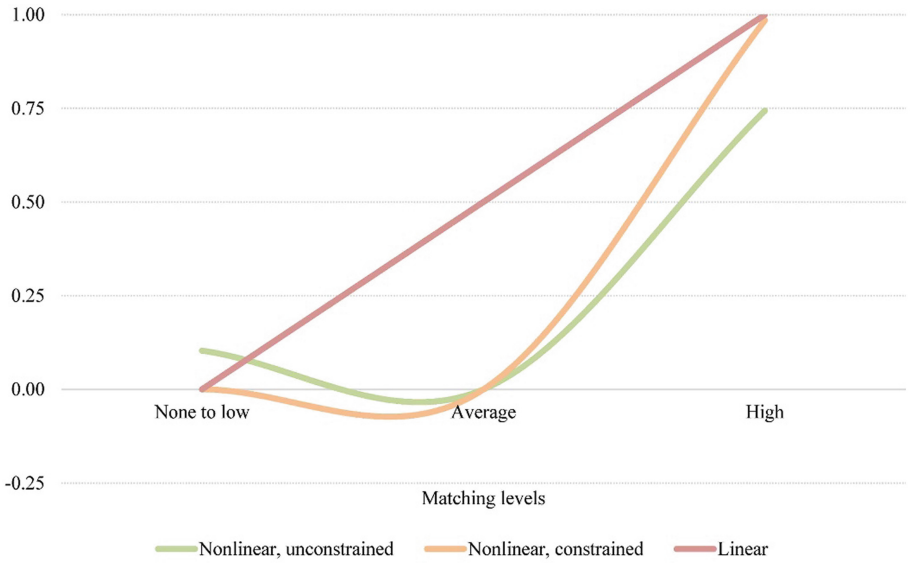


Fig. 7. Comparison between linear and nonlinear functions for the definition of the matching levels between projects and criteria (source: authors' study).

Once we drop the hypothesis that the matching level values are aligned in a straight line, further intriguing results come out of the analysis we perform here. In particular, we test two nonlinear relationships. The first is subject to the constraint that the parameter $m_{i,j}$ must be zero in case of no to low matching between projects and criteria, while the second is unconstrained. The results are not as different as one might expect. To begin with, in comparison to the linear assumption above, both the nonlinear relationships - constrained and unconstrained - provide estimations of the implicit weights $\widehat{w}_i$ closer to the original explicit weights w_i (see Figs. 5 and 6 again). That is particularly evident for the third and fifth criteria: cultural added value and financial viability, respectively. There still are differences, but the gap narrows down to a few percentage points, as can be seen for the first and fourth criteria: environmental impact and land use improvement, respectively.

Another interesting outcome is that the distinction between three matching levels does not make sense anymore once we lessen the constraint of a linear relationship. The high (or strong) matching level is essential to shape an implicit weighting scheme close to the explicit one. Instead, the average matching level is as irrelevant as the none-to-low one (see Fig. 7). This empirical evidence may be symptomatic that the program proposal has been designed by focusing on the actions and interventions that fit the evaluation criteria well, and that could be why the implicit weighting scheme - simply driven by the high matching level - gets close to the explicit one.

5 Conclusions

This paper addresses a crucial issue when using MCDA techniques to rank and select the project proposals to be included in PPP-based regeneration programs. Here we consider one of such PPP-based regeneration tools lastly adopted in Italy, namely, the National Innovative Housing Quality program (PINQuA). Moreover, we analyze the program "Treviso San Liberale: the inhabited park" - proposed by the municipality of Treviso, North-eastern Italy, approved by the Ministry of sustainable infrastructure and mobility - and use it as a testbed. The case study is arranged into four action lines, each of which includes several specific projects to be carried out by the public bodies and private entities involved in the partnership. The local projects are meant to meet the evaluation criteria and sub-criteria defined by the central government to evaluate and rank the program proposals, and those criteria are pre-assigned different weights. Accordingly, we aim to assess whether there is a gap between the explicit and implicit weighting systems used in MCDA analysis or not, where the former is the weighting scheme of the selection criteria identified a priori by the public body that governs the process, while the latter is the weighting scheme one can infer ex-post according to the allocation of funding to the projects.

We find that there could indeed be a gap between explicit and implicit weights. In the case study we analyze, the difference is negligible for four out of six criteria, but it is also noticeable for the remaining two criteria. Nevertheless, this holds only when relaxing the constraint that projects match criteria according to a linear relationship, and the implicit weights are detected regardless of the project costs. Otherwise, the gap between explicit and implicit weights becomes more prominent and worthy of attention under linear constraints. Also, inferring the implicit weights according to project costs leads to strong differences between the explicit and the implicit weighting schemes. Essentially, we find that the allocation of public investments and, most of all, total investments is disproportional in comparison to the weights of the criteria.

The kind of analysis we carry out here addresses a much underestimated topic in the field of multi-criteria decision support systems. Especially, as we point out, the fact that an implicit weighting scheme diverges from a set of weights identified a priori is a warning sign that local priorities may differ - in part, at least - from expectations. The thorough consideration of the issue we highlight might help structure program proposals based on more effective negotiating partnerships.

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