Environmental Monitoring of the Socio-economic Components of the Impact of a Mega Project

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Abstract Mapping the socio-economic and socio-communicative implications of a mega project in Europe becomes the occasion to fill a gap in the Italian national regulations on the accountability and reporting of socio-economic impacts. A monitoring project is translated into a methodological and experimental proposal to send to the Italian Ministry of the Environment.

A multidisciplinary group has adopted an intervention research approach to design and test a new model that can easily be replicated for other mega projects. The multicriteria modelling and decision aiding way of thinking have been used to propose a critical reading of the model and a methodological approach to data acquisition and multicriteria aid in the monitoring process.

The paper describes the experimental protocol and some methodological analyses and improvement proposals gained from the multicriteria modelling experience.

Keywords Social responsibility of mega projects · Accountability of socio–economic impacts · Multicriteria models · Multicriteria decision aiding

1 Introduction

A multidisciplinary research group is currently involved in one of the most contested megaprojects in Europe, the construction of the high-capacity, high-speed rail line between Turin and Lyon, which includes a more than 50 km long tunnel through the Alps between Italy and France. The European Union and the Italian and French national governments have officially approved the project as part of the

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Mediterranean corridor of the Trans-European Transport Network. However, this happened in direct contrast with some of the local administrators and citizens of the Susa valley, in Italy, who created the No TAV ("Treno ad Alta Velocità"—High Speed Railway) movement. The by now 30 years of the No TAV opposition is somewhat less violent and intense than it was 10 years ago, but it is still witnessed, above all in relation to the setting-up of new construction sites (see Corazza et al., 2021, for the history of this megaproject and the No TAV movement).

The company in charge of the project contacted the research group to map the potential social and economic impacts of the transnational railway project on the territories of reference and to develop and test a monitoring framework of the social and economic impacts generated by the construction sites for the entire duration of the project. This framework, created and tested on this occasion, should fill a gap in the Italian national regulations pertaining to the accountability and the reporting of place-based social and economic impacts generated by construction sites.

A project on the monitoring of these impacts, in the short, medium and long terms (with a time span of more than 20 years), at the construction site scale, and at the municipal, valley and regional levels, was therefore translated into a methodological and experimental proposal to send to the Italian Ministry of the Environment, in compliance with the environmental impact assessment logic.

Contact with the stakeholders became difficult in 2020, as a result of the COVID-19 emergency. Therefore, the multidisciplinary research group focused on the analysis framework, an experimental data acquisition and monitoring protocol. At the end of 2020, the first draft of the framework was drawn up and its line of thought and main concepts were presented in a virtual meeting which involved the company, the Piedmont Region and the main official data sources.

The research group includes people with very different backgrounds: from sustainability accounting to those involved in critical management studies, sociologists, economists, physicists, and circular economy specialists. These figures are not consultants for the company, and the aim of their Interventionist Research (Dumay & Baard, 2017; Jönsson, 2010; Lukka & Vinnari, 2017) is to make a contribution that is theoretical and organisational at the same time in order to (at least) provide elements to help solve a problem.

The intervention of the group is basically focussed on the need to provide an assessment of the socio-economic and socio-communicative implications that may arise due to the megaproject, as explained by the need to reinforce the mandatory environmental assessment required by the Italian Ministry of the Environment (together with the Ministry of Infrastructures and Transport that from 2021 composes the Ministry of the Ecological Transition). On the other hand, the problem situation is extremely interesting, because the complete lack of best practices, not in terms of cases, or as common and shared guidelines, leaves vast occasions to design, experiment and test a new model to account for such impacts. The mainstream practice, in the Italian scenario of megaproject development, has traditionally been to produce assessments that are difficult to replicate, or which are not based on evidence that can easily be retrieved or retrieved in a timely manner. These conditions make the validity test of any model particularly difficult or even impossible.

A new figure, with competency in multicriteria modelling, was included in the multidisciplinary group at the end of 2020, to analyse and improve the draft of the framework from a methodological point of view.

The first suggestions were used to improve the document that was sent to the Ministry in March 2021 (Plan of environmental monitoring of the economic and social components. Focus on Ante Operam 2012–2019). Some data were acquired and analysed before March 2021, and a new data acquisition and analysis step was then activated.

The first section of this paper describes the draft of the experimental protocol, a multicriteria critical reading of some components of the draft and the new version of the document sent to the Ministry.

An analysis of the document and of the data acquisition activity is described in the second section, together with a methodological proposal of data analysis and multicriteria aid in the monitoring process. Some considerations on the possible future use of these proposals are synthesised in the conclusions.

2 Environmental Monitoring of the Economic and Social Components

The aims of the multidisciplinary research group include the formulation of a panel of indicators that should be as open as possible and based on evidence, a verifiable and replicable methodology and the release of data in an open way, all of which make the tool dialogic and transparent.

A literature analysis on large or mega construction projects and their social responsibility and impacts, as well as a comprehensive examination of several reports on the Susa valley economy and mountain condition, were used to identify macro-ambits, ambits and indicators. Objectivity, replicability, easy accessibility and consistency with the Ministerial guidelines for the environmental monitoring (Guidelines for the environmental monitoring project of strategic infrastructures and production facilities, 2003) were considered the main principles to orient the definition of the indicators. The presence of public sources of the required data was considered essential to facilitate future analyses and verifications of the reliability of the proposed procedure.

Six macro-ambits were proposed for the Experimental protocol, and the indicators were associated with specific actions, risks or problems, for employees and the population, and they also included context data. The considered macro-ambits are:

1. *Health and safety* of the employees and population, where health is a physical and psychological state (3 ambits and 6 indicators to indicate the actions adopted by the construction company to guarantee health and safety);
2. *Relational capital* established between the company, institutions and people, which includes both any kind of relationship with the territory and actions oriented towards developing the human capital of the valley (6 ambits and

21 indicators concerning both the connection results and the population state, in terms of development and vulnerability);
3. *Sustainability governance*, in terms of integration of the sustainability and governance structure, at the company level (3 ambits and 12 indicators in relation to the sustainable strategies, but also to the implementation of anti-mafia procedures and certifications and communication with the stakeholders);
4. *Economic consequences* on the territory (9 ambits and 28 indicators of the impact on the local economy, but also on the valley demography and the way of life of the people);
5. *Impact on the mobility of the people*, in terms of traffic problems but also improvement in sustainable mobility (3 ambits and 8 indicators);
6. *Promotion of the territory* and preservation of its cultural capital and identity (5 ambits and 10 indicators, which also include the cultural identity of the bi-national company, where different languages and cultures co-exist).

A methodological analysis of the proposed structure and specific indicators was performed to improve the draft.

2.1 Analysis of the Draft

From the multicriteria modelling point of view, the number of macro ambits and ambits (29) seemed too high, but this is a natural consequence of the literature analysis that led to this structure and a long list of indicators being generated. Proposing a panel of indicators as open as possible is one of the aims of the research group, but a revision, oriented towards the different defined or possible uses of these indicators, would improve the structure and facilitate the development of a verifiable and replicable methodology.

Another point is that some aspects appear in more than one macro-ambit: communication with the stakeholders is present in *Sustainability governance,* but it is also an essential element of *Relational capital;* sustainable mobility improvement appears in *Impact on the mobility of the people,* but it should also be considered a positive consequence of the way of life of the people, which appears in *Economic consequences* on the territory.

During the meeting at the end of 2020, the research group, together with the company and the Piedmont Region, underlined that: (a) different activities (surveillance, attention, intervention) are required in the monitoring process and (b) the company has to be facilitated in the choice of actions that have to be avoided, the impacts that have to be minimised, or at least reduced, in the compensation, reactivation or restoration activities, in the proactive actions and in others that generate positive impacts on the territory. Therefore, the panel of indicators should distinguish a set of specific actions or decisions and the indicators should be associated with these situations.

The draft of the framework distinguished three phases of the monitoring process (Ante Operam, before the opening of the construction sites—AO, during the project in relation to the role of the Construction Sites—CS, Post Operam, when the project has been completed, with a time span of more than 20 years—PO) and the indicators were associated with one or more specific phases. The draft also distinguished between quantitative and qualitative indicators, while a new distinction, more oriented towards the aims of the monitoring activities and the actions or decisions that may be needed, seemed useful. Such a distinction should at least be included in the description of each indicator.

The main distinction should be made between context indicators, which are essential to map the territory and document any socio-economic modification, and the others, which are used to identify situations that require specific actions, decisions or revisions of implemented actions. Monitoring the context indicators allows some critical dynamics to be recognised and reported to the decision makers. The ministerial guidelines for the Environmental monitoring project (Guidelines for the environmental monitoring project of strategic infrastructures and production facilities, 2003 and further updates) propose a list of ambits that should be monitored: population, economic activities, labour market, services and infrastructures, socio-cultural aspects and reconstruction of the main events of the historical evolution. Specific trends, taken from the context indicators, should be analysed by means of other indicators, which can be called decisional indicators. They may be distinguished, for instance, into two categories, the first in relation to risks, communication problems or malfunctions that the construction sites can generate, and the second, which analyses the direct or indirect actions that are positive for the people and territory.

The first category of indicators should be monitored to activate management actions of any foreseen or present criticality. The second should be monitored to evaluate the effectiveness of any action, whether completed or under development, in order to modify it, if necessary, to define new actions or to evaluate the impact of an action on PO. The macro-ambits, ambits and indicators of the two categories should be reorganised, and thus four typologies of data could be distinguished from the structure of the data base:

1. Socio-economic data that describe the territorial situation and its dynamics (which are useful to identify circumstances that require a specific intervention)
2. Data on the activities in the construction sites (which are useful to identify circumstances that require a specific intervention)
3. Data on issues and malfunctions that the construction sites can generate on the territory or people (which are monitored for the risk management or control of the consequences)
4. Data on the developments and effects of direct and indirect actions in favour of the territory (which are useful to evaluate the potential or actual impacts of these actions or to define-modify intervention strategies).

Some of these suggestions were used to improve the draft and generate the document that was eventually sent to the Ministry of the Environment in March 2021.

2.2 The Document

Some data were acquired, between December 2020 and March 2021, in relation to the years 2012–2019, which were considered as the period for the analysis before the opening of the construction sites, and the draft was analysed and improved before sending it to the Ministry of the Environment (whose name was changed in February, by the new Government, to Ecological Transition Ministry).

Each indicator was associated with one of four categories (context, sustainability, construction sites and communication) and a distinction was made between the *main* and *secondary* indicators. Thirty-four of the original eighty-four indicators were considered to be of main importance: thirteen indicators in relation to the socio-economic conditions of the thirty-nine municipalities in the Susa valley and the other twenty-one indicators in relation to the possible direct and indirect effects of the construction sites on the local communities.

The document also included a procedure that could be used to interpret the monitoring results as regards the needed actions. A framework was proposed to evaluate the negative impacts, whenever a counterfactual analysis underlined anomalies in the data trends.

Data pertaining to the main indicators of the context and construction sites were acquired, in relation to the 2012–2019 period, at the valley level (and its 39 municipalities) and their analysis was included in the document. However, these are only quantitative data, because it was very difficult to acquire any qualitative indications.

A methodological analysis of the components of the document is proposed in the next section, together with some proposals for future activities.

3 Methodological Analysis

Three elements should be analysed from a methodological point of view. Two are linked to the essence of the reasoning, and the third is more communicative and related to the aim of proposing a dialogic and transparent tool.

The indicators of the communicative aspect and their descriptions are different, and their nature is sometimes clear and transparent, but in other cases the meaning has to be explained more carefully, and paying attention to the structure of the panel could also facilitate the release of data. This aspect is analysed in Sect. 3.1.

The other aspects are partially connected to each other and to the use of the acquired data. An experimental proposal is presented in the document to interpret the

monitoring results. The proposal includes two procedural elements and indicates that their integration should facilitate decision and action.

3.1 The Structure of the Indicators in the Panel

A large number of indicators is often considered a sign of quality and reliability, but this is often not true. In this case, since several indicators were identified for the purpose of creating guidelines for future applications, a distinction between the main and secondary indicators may be useful to reduce the number of indicators and to more easily orient them towards specific monitoring process activities.

However, the nature of this distinction is not so clear. The document specifies that the distinction was made together with the company, when it was the owner of the data, and by means of interviews with the sources of the other data, and it also indicates that secondary indicators could be used in the future. However, it is not clear whether the distinction was made in terms of importance or significance.

An example can help to clarify this remark. There are some indicators in the Education macro ambit that were created in relation to the "Human capital creation by mean of investments in the local population" ambit. Some indicators, such as the number of collaborations activated with technical institutes and the number of participations in courses held by the technical institutes, were considered as secondary indicators. Two different interpretations are thus possible: technical institutes that are consistent with the topics of the mega project are not present in the Susa valley and therefore their involvement is impossible (the indicators are not significant in this specific case), or the data source considered these activities as not being so useful, and such indicators are therefore of a secondary nature, i.e. they are not essential or are unimportant.

In both cases, the secondary indicators can be included in the panel, but the ambiguity that is associated with the nature of the distinction may have influenced the distinction and acquisition processes and can now influence the use of the acquired data.

Four categories are associated with the indicators. Context indicators are useful, above all because these data allow an analysis to be made of the territory and its socio-economic aspects before the construction sites are opened, in a period characterised by an economic crisis in Italy and, above all, before the COVID-19 emergency that has blocked tourism and several activities since March 2020. The document explains that some context indicators are not clearly associated with the existence of the construction sites, but they should be monitored because they facilitate an analysis of the processes that could have generated some changes on the territory.

The principle is clear and the indicators are annotated in detail in the document. However, some indicators are not so clear. Another example is also associated with the mega Education ambit and the "Human capital creation by mean of investments in the local population" ambit. There are some main indicators in this ambit, and two

are context indicators: the number of students in the technical institutes and the number of courses held for professional qualification and/or re-qualification that the Region activates throughout the territory involved in the mega project.

The first indicator can be used to identify the used interpretation of the "secondary indicator" concept in this ambit. At the same time, the indicator description underlines that the context indicator is not a sign of a possible and direct impact of the construction site, and is instead an element of the education dynamics, because there is evidence in the literature that the territory is interested in being involved in the progress that the project will induce. However, the nature of the induced progress is not so clear in this case and should be explained more clearly.

The second indicator presents another ambiguity: are the courses a consequence of the mega project (i.e. an element of the required compensation) or a sign of the phenomenon described in the literature (i.e. some skills acquired in the courses are connected to the project activities and can be used during the project and also at the end in other situations)? The second interpretation is proposed in the description of the indicators, but it is not always true, because a mega project that requires high specialisation for each activity cannot in general accept employees with a low level of qualification.

Instead, the first interpretation is interesting and has a meaning that can be shared with several other indicators. The compensations for damage, malfunctions or problems that the construction sites may produce are monetary, but they can also be compensations in terms of human capital creation, cultural capital promotion or local public mobility improvements in sustainable terms. Monitoring these compensation forms is important, and the associated indicators should be specifically coded in relation to this aspect.

The aim of the panel is to constitute a dialogic and transparent tool, and the context indicators should therefore be proposed separately from the others, in order to facilitate the understanding of their roles in the monitoring. The other indicators (sustainability, construction sites and socio-communicative) are explicitly associated with possible actions that should be implemented or risks that should be controlled. However, it would be easier to understand the indicators if they were proposed separately and related to two macro ambits that are different from the original ones:

Difficulties, that is, problems and malfunctions, negative impacts on the local economy or risks for the population, in terms of safety or a lack of services;

Positive traits, that is, promotion of the human and cultural capital; relationship with the territory; information transparency; sustainability communication and governance; economic returns and innovation.

An introduction to the description of the socio-communicative indicators underlines that the list of indicators is not definitive, a direct cause—and effect relationship is not always possible and these indicators, because of their nature, are not suitable for the application of rigid protocols. The first two concepts, that is, of the not definitive nature of the indicator list and of the difficult identification of a direct cause—and effect relationship between the indicators, could be extended to all the indicators. The concept of not being suitable for the application of rigid protocols

could be associated more with the difficult acquisition of qualitative data in the Susa valley than to the nature of the indicators.

3.2 How to Evaluate the Negative Impact

A framework was proposed in the document to underline the anomalies in the data trends and evaluate the negative impacts. The Experimental protocol comprises both positive and negative impacts. When the data trends underline a positive impact, it is included in the accountability report, while a negative impact requires surveillance, attention and/or intervention activities. The framework introduces four impact components, which are called criteria: Data trend, Impact duration, Spatial scale of the impact and Probability that the impact will repeat itself. Each criterion is associated with an ordinal scale (see Table 1), and a Significance Index (SI), with a value between 1 and 100, is the result of this formula:

$$SI = (Trend + Duration + Spatial\ scale) * Probability$$

The index is used to distinguish three situations:

- SI >75, substantial impact that requires an urgent and direct intervention,
- $30 \leq SI \leq 75$, the impact is only moderate, and an intervention is therefore required, but it is not urgent;
- SI < 30, a mitigation action may be required.

The first and most important point is that the properties of an ordinal scale cannot accept the application of sum and multiplication operations. If the aspects/criteria are significant, a combinatorial approach can facilitate the definition of SI. An example of the procedure steps is synthesised in Tables 2 and 3.

Another point concerns the nature of the criteria. The acquired data trends are data analysis elements that identify an anomaly, and they may suggest the presence of a

Table 1 Adopted scales

Data trend (over at least 3 years)	Impact duration	Spatial scale of the impact	Probability of repetition of the impact
10 Exponential	5 Permanent	5 National	5 Not known
6 Linear	4 Long term (until the end of the project)	4 Regional	4 High
2 Static	3 Medium term (5–10 years)	3 Total valley	3 Medium
0 Insignificant trend	2 Short term (0–5 years)	2 Construction sites and the adjacent municipalities	2 Low
	1 Temporary (days or months)	1 Construction site	1 Improbable

Table 2 The ordinal scale that combines impact duration and probability of repetition

Probability of repetition of the impact Impact duration	Not known	High	Medium	Low	Improbable
Permanent	X	X	X	X	X
LT (end of project)	X	X	X	X	X
MT (5–10 years)	16	16	8	2	1
ST (0–5 years)	12	12	8	2	1
Temporary (days/months)	8	8	4	1	1

Table 3 The ordinal scale that combines impact duration and spatial scale

Spatial scale Impact duration	National	Regional	Total valley	Construction site and adjacent municipalities	Construction site
Permanent	16	14	12	10	7
LT (end of project)	14	12	10	8	4
MT (5–10 years)	12	10	8	6	3
ST (0–5 years)	10	8	6	4	2
Temporary (days or months)	8	6	4	2	1

negative impact, which other elements can then confirm and evaluate in terms of impact strength. The indication "for at least three years of acquisition" as the minimum period of anomaly in the data trends does not seem to be consistent with the fact that an anomaly should be visible in less than 3 years and that the Impact duration may be temporary, and the impact may therefore no longer be evident after 3 years.

When Data trends underline an anomaly, the different functions of the adopted scale express the strength of the anomaly. The proposed formula associates Impact duration and Spatial scale, plus Probability of repetition, to the strength of the anomaly (Data trends) and creates an impact strength index. The use of Data trends as a criterion, and then as an impact component and not as a sign of anomaly, can be risky. The time and spatial dimensions, and the possible repetition of the negative phenomenon may be evaluation aspects/criteria of the negative impact. A formula that synthesises elements of a different nature by means of addition and/or multiplication is in general a risky procedure.

Another point is that the evaluation states of the scales should be analysed in more detail. The Static trend, for instance, can be interpreted as a stable and non-critical anomaly, a stable but critical anomaly or no anomaly is present. A Probability of impact repetition that is Not known is a critical condition, but is no more critical than a High probability. The ordinal scales can be particularly useful, but the definition of each evaluation level should be unambiguous and totally transparent, in order to be (at least sufficiently) objective. In this case, the trend seems objective because it is expressed by an analytical function, but this is not always true, while the definitions

of all the other evaluation states may only be objective if explicitly documented (High probability means..., Medium means... and so on).

3.2.1 Examples of a Combinatorial Approach

Tables 2, 3 and 4 present some examples of ordinal scales that are created explicitly by combining ordinal scales of two or more aspects. The analysts, experts, decision makers and/or any other interested actor should be involved in the analysis.

The example in Table 2 underlines that some combinations are impossible or not significant (X); in this example, this is because a repetition probability is not so informative if the duration states are permanent or until the end of the project. Indeed, the impact repetition after the end of the project is not possible and a permanent impact implies or a control on the possible repetition or a not significant impact worsening. Different combinations can be associated with the same level/state of the scale; in this example, two different impact durations may have different meanings, in relation to a critical repetition or the same meaning in the other situations, and when the probability is Not known, it may be critical and therefore equivalent to High, thus the states of the scale are identical.

In other cases, all the combinations of states may be possible (see Table 3). Some values of the resulting scale may not be linear, to express that, for example, a negative impact outside the construction site is much more important than when it only occurs within the site. In this example, the two aspects/criteria have the same importance (each passage from one state to another is equal outside the site), but one may be more important than the other, and the values can express this condition.

Table 4 The ordinal scale of a criterion that combines the three aspects

Spatial scale Impact duration and repetition prob.	National	Regional	Total valley	Construction site and adjacent municipalities	Construction site
Permanent	56	44	32	20	10
LT (end of project)	46	36	26	16	8
MT (5–10 years) H	38	30	22	14	7
MT (5–10 years) M	33	26	19	12	6
MT (5–10 years) IM/L	28	22	16	10	5
ST (0–5 years) H	28	22	16	10	5
ST (0–5 years) M	23	18	13	8	4
ST (0–5 years) IM/L	18	14	10	6	3
Temporary (D or M) H	18	14	10	6	3
Temporary (D or M) M	13	10	7	4	2
Temporary (D or M) IM/L	8	6	4	2	1

When only two aspects/criteria have to be combined, the procedure is simple and transparent. When there are more than two, a sequence of combinations is possible. In this example, the valid combinations in Table 2 are inserted into Table 4, where the Probability of repetition of the impact, whenever it may be different, is indicated as H (high, which in Table 2 means between 10 and 16), M (medium, between 5 and 9) or IM/L (improbable or low, between 1 and 4). The scale that results from this combination of states goes from 1 to 56. In real applications, the scale should be created and documented together with the involved actors and/or decision makers. The levels and their number may be different and may be changed during a decision process, for instance when an unexpected phenomenon creates new knowledge or new perceptions of a situation.

3.3 How to Facilitate a Counterfactual Analysis

A counterfactual analysis (Ragin & Sonnett, 2005) was proposed in the document to facilitate the data interpretation. Such an analysis requires a comparison of the data trends pertaining to the Susa valley and to a reference area in order to identify anomalies and then apply the Significance Index, which can facilitate decision making. The document proposes the monitoring of each quantitative indicator in the Susa valley (39 municipalities) and in a homogenous valley, which is considered as a reference for the analysis.

The main problem in the counterfactual analysis is the comparability of the two compared phenomena. In this case, the analysed area in the Susa valley is ample and includes municipalities that are very different from each other, in relation to their local economy and the proximity to the construction sites, and therefore in their involvement in the No TAV movement. The reference area is the Chisone valley, which is in the same Region, but is not involved in the construction of the Trans-European Transport Network, and it includes 14 municipalities, one that is located in both of the valleys.

A multicriteria analysis of these two areas was proposed to generate homogenous and comparable sub-sets of municipalities, which could facilitate the counterfactual analysis.

3.3.1 MC Decision Aid Procedures

Two different procedures are currently being analysed by the interdisciplinary group. Both imply the structuring of a multicriteria model that includes some main aspects, which are made operational by means of certain criteria, that is, analytical functions that assign an evaluation to each municipality in relation to a specific scale.

The relative importance (or weight) of each criterion is an important parameter that has to be included in the MC model. Different weight scenarios can be elaborated to express the points of view and preferences of the involved actors or

decision makers. Some procedures facilitate the decision makers in the expression of the weights (see for instance Figueira & Roy, 2002). Moreover, a representation of the structure of the model can facilitate the definition of the weights.

Figure 1 describes how the distribution of the weights (normalised to one) can be defined at the strategic level (Norese & Carbone, 2014) and at the criterion level, where the strategic importance of each aspect is distributed over the criteria, in relation to their different contributions to making the aspect operational.

An MC model includes parameters that have to be defined in relation to the adopted method. In this case, two different analytical approaches can be implemented. Both approaches are possible, and a comparison of their results could facilitate the work.

In the MCDA context, assigning elements (in this case the municipalities) to homogenous groups, classes or categories is a classical decision problem (see Doumpos & Zopounidis, 2002; Zopounidis & Doumpos, 2002). The problem can be distinguished into sorting or nominal problems. When the categories are predefined and ordered, this is a sorting problem, but when no relationship exists between the classes, which are not predefined, this is a nominal classification problem.

ELECTRE Tri is the most frequently used method for sorting problems, while different methods have been proposed in the literature for nominal classification problems (see, for instance, Perny, 1998; Belacel, 2000; Scarelli & Narula, 2000; Norese et al., 2001; De Smet et al., 2012; Fernandez et al., 2010; Costa et al., 2018).

The analysed elements in a sorting problem can be assigned to categories, if they are compared with the components of a reference model, that is, the reference elements that formalise the characteristics of the categories. These elements may be limiting profiles that distinguish and separate the categories, as in ELECTRE Tri B (Roy & Bouyssou, 1993) and ELECTRE Tri-nB (Fernandez et al., 2017), or characteristic actions (which may be called "central actions") for each category, as in ELECTRE Tri-C (Almeida-Dias et al., 2010) and ELECTRE Tri-nC (Almeida-Dias et al., 2012).

The different importance of the criteria is one of the elements that determines the assignment of an element to a category in ELECTRE Tri, by means of fuzzy outranking relations, which are based on the concordance and discordance principles (Roy, 1996). The degrees of credibility of the outranking relations, which result from comparisons of each alternative and the reference actions, i.e. the profiles, are used to assign each alternative to a category, by means of procedures that formally translate decision rules.

The choice of the ELECTRE Tri variants, such as the definition of the weights and the other model parameters, are decisions that can be made and shared in the participative context that generated the model structure and the nature of the criteria, and which validated the evaluations.

The choice of the method for the nominal classification problem is more complicated, but the multicriteria model can be the same for both problems.

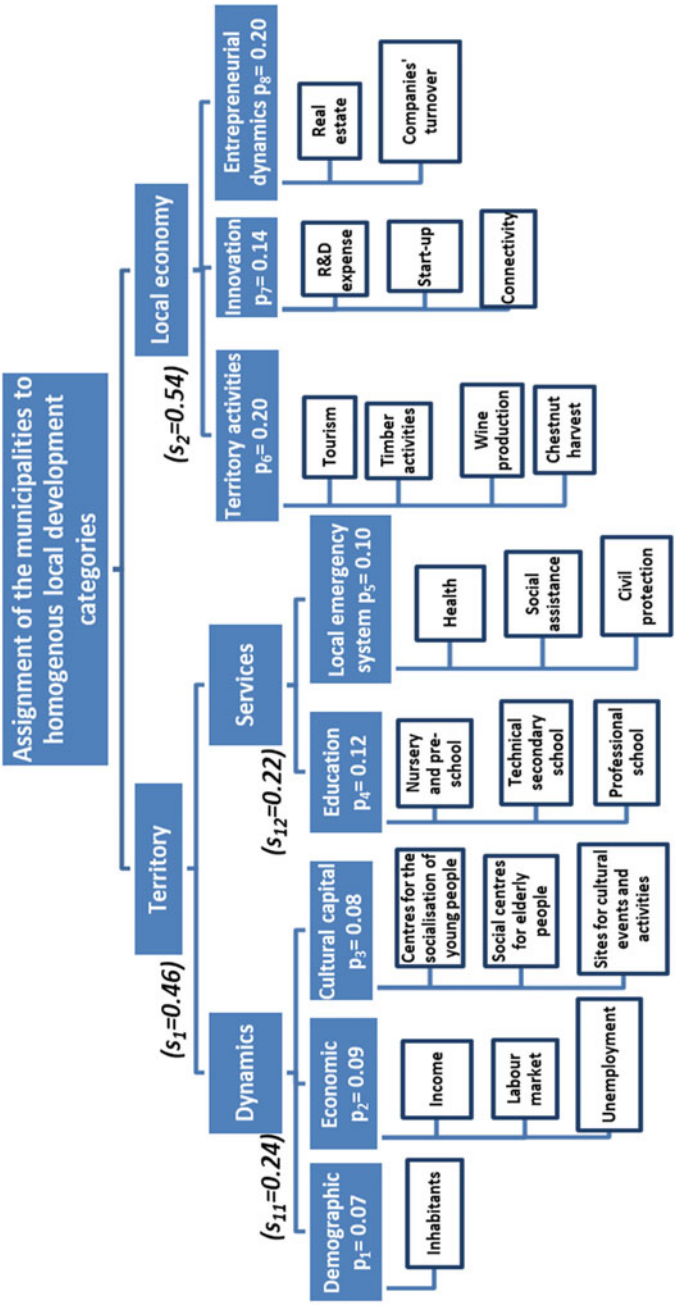

Fig. 1 Structure of the MC model for the application of the ELECTRE Tri method

3.3.2 A Multicriteria Model

The logical structure of an MC model includes the main aspects (or model dimensions) and their analytical formalisation in criteria pertaining to the different related dimensions (Norese, 2016). The model structure is defined in relation to a specific goal (the assignment of the municipalities that present similar characteristics to homogenous local development categories) and includes the main aspects that have to be included. In this case, they are the Dynamics of the territory and its main Services, as shown on the left side of Fig. 1, and the elements that characterise the Local economy, which are shown on the right side.

At this point, the model structure can be oriented to a sorting problem, with the aim of assigning the municipalities to ordered predefined categories. Therefore, the identification of the criteria and their analytical formalisation need an explicit definition of the categories. Such categories may be defined in relation to the economic and territorial organisation of each municipality, which can be Strong and stable (C1), Stable (C2) or with some Weaknesses and instability elements (C3). There are eight possible criteria: demographic dynamics, economic dynamics, cultural capital, education, local emergency system, main activities of the territory, innovation and entrepreneurial dynamics. The main data that can be used to formalise the criteria are listed in Fig. 1 in relation to each criterion.

When the model structure is oriented towards a nominal classification problem, which has the aim of comparing the municipalities and identifying situations of similarity or dissimilarity, the characteristics of each municipality are expressed by attributes. Therefore, a multi-attribute model has to be formalised to be used with a multicriteria nominal classification method. In this case, 22 attributes can be used (see the dark side of Fig. 2).

Both models require the definition of the relative importance of the criteria/attributes. The proposed model structure facilitates the description of this essential concept, which is related to the actors' value system. The values assigned to such parameters have a subjective nature and can only be grasped through communicating with the decision maker(s) in a DA process (Roy & Mousseau, 1996). Some analytical procedures can facilitate this activity (see, for instance, Figueira & Roy, 2002).

The tree structure of the model can facilitate the expression of the strategic importance of each aspect ($s_{i)}$, because a single strategic aspect cannot be much more or much less important than the others. They may have the same strategic importance or even have a different (but not so different) level of importance. The relative importance of the criteria (p_i) can easily be defined, if it is considered a distribution of the importance of a strategic aspect over the associated criteria. An example of how the relative importance of a criterion can be expressed is proposed in Fig. 1.

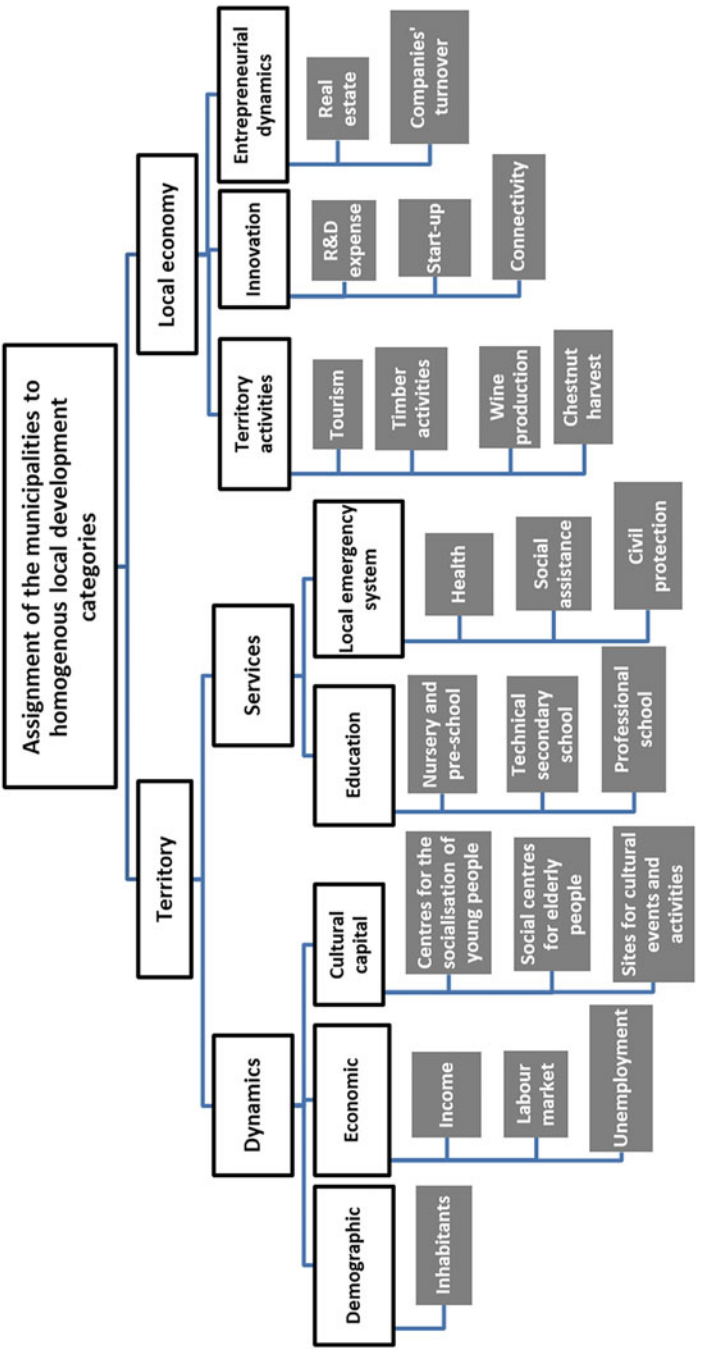

Fig. 2 Structure of the MC model for a nominal classification method

4 Conclusions

The implementation of a monitoring plan for the assessment of impacts on the socio-economic environment generated by a large-scale construction project, or mega-project, is a topic that will become increasingly important in the future. In this chapter, we present the experience of a group of researchers involved in modelling a protocol for the forecasting, control and assessment of the impacts of one of the most important railway corridors in Europe on the socio-economic environment. The protocol includes the study of possible causal links between the construction work and the socio-economic phenomena that have and are taking place in the area under study, for the pre-construction phases (reconstructed through statistical data), during the construction phases and in the post-construction phase. A series of indicators is proposed in the experimental protocol, not only with respect to this study, but also for future occasions of mega-project monitoring. The chapter presents some preliminary reflections on the ongoing pilot study and applications, which may in general be accepted but can sometimes be refused as a result of the monitoring process evolution.

An interesting example pertains to the fact that this mega project requires a high level of specialisation for several activities, but employees can be employed after a well oriented professional preparation. Moreover, some processes are still ongoing to produce these specific qualified figures.

A counterfactual analysis serves to study and compare the dynamics throughout the territories of all those social and economic phenomena that could be influenced or altered by the construction work. This analysis has been proposed in the protocol to specify what kind of manifestation should be considered to predict the severity of a possible impact. The analysis of some socioeconomic phenomena (such as unemployment, the loss of real estate value of buildings, the opening of new companies) has served to understand and describe the trend of societal and economic issues over two territories. A further step will be to conduct a counterfactual analysis on geographical areas that need to be homogeneous in terms of the local development systems. The chapter proposes multicriteria methods and presents two models that will serve to identify different sets of municipalities with similar characteristics in the two territories. The presented models will be tested according to the collected data and the used methods.

In essence, the chapter presents a rather severe criticism of the proposed Significance index and the proposal of a combinatorial procedure to generate the index. It should only be used once it has been ascertained that a certain phenomenon has occurred in a specific area in a totally different way from the rest of the entire valley, or even in municipalities with similar characteristics in another close but different geographical area (in neighbouring geographical areas, such as adjacent valleys).

The proposed reflections on decision aiding are important, because, especially for complex projects that can last 10 years over a vast territory, the management of information complexity is a critical variable for both the political and institutional decision makers. On the other hand, the consideration of different levels of

comparison of phenomena and counterfactual thinking is certainly of interest for the development of megaprojects, especially for the impacts that they can generate in the sustainable development field.

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