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How to assess stakeholders' influence in project management? A proposal based on the Analytic Network Process

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Abstract

In this paper we present a methodology to measure stakeholders' influences within a project from the point of view of the Project Manager. It is a novel proposal for the definition of "influence" among stakeholders based on a multiperspective approach.

The concept of influence is broken down into criteria, evaluating different aspects that together define an index which measures the influence of each stakeholder with respect to the rest of the project team. This index is calculated with the Analytic Network Process.

The methodology has been applied to a maintenance project for the Spanish National Railway Infrastructure company. Results show that the most influential stakeholders are the Contractor and the Signaling systems provider accounting for 40% of the total influence.

These results have helped the Project Manager to be aware of the two most influential stakeholders and set the guidelines for the stakeholder management in the future.

Keywords: Stakeholder management; Stakeholder influence; Project management; Analytic Network Process

1. Introduction

The International Project Management Association (IPMA) defines project management success as "*the appreciation by the various interested parties of the project outcomes*", the interested parties[1] being "*people or groups who are interested in the performance and/or success of the project, or who are constrained by the project*" (IPMA, 2006). The Project Management Institute (PMI) defines stakeholder "*as an individual, group, or organization who may affect, be affected by, or perceived itself to be affected by a decision, activity or outcome of a project. Stakeholders may be actively involved in the project or have interests that may be positively or negatively affected by the performance or completion of the project*" (PMI, 2013). ISO 21500:2012 suggests the relevance of a detailed analysis of stakeholders and their impact on the project.

These two important project management associations in the world recognize that it is essential that project managers pay close attention to stakeholders. Beringer et al. (2013) say that both research and practice suggest that stakeholders play a crucial role in the successful management of projects. The ability to understand the often hidden power and influence of various stakeholders is a critical skill for successful project managers (Bourne and Walker, 2005). In fact, stakeholder management is one of the ten knowledge areas recognized by PMI. One of the questions of this area is "*how the stakeholders are able to influence the project management*". According to Aaltonen and Kujala (2010) this question has not properly been

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[1] Instead of using the term "interested parties" the term "stakeholder" is the most commonly used in the literature (in fact, IPMA considers both words as synonyms). For this reason, in this work, we will use the word "stakeholder".

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addressed in the literature. Answering this question is not an easy task because there are different points of view to define the concept of "influence the project management" and different strategies stakeholders can use to influence the project (Aaltonen et al., 2008).

In this paper we want to shed some light to this particular issue and propose a new method to measure the influence that stakeholders exert on project management. The aim is to provide an individual influence index for each stakeholder analyzing the concept of influence from a multiperspective point of view based on Multicriteria Decision Aid (MCDA) techniques.

MCDA describes a number of formal approaches which seek to take explicit account of multiple criteria in helping individuals or groups explore decisions that matter (Belton and Stewart, 2002). MCDA concepts and methods have been largely studied in the Operational Research literature (Figueira et al., 2005; Ishizaka and Nemery, 2013). Most of the MCDA techniques work well under the assumption of judgmental independence of criteria. However, this assumption is not always realistic, particularly when analyzing the influence relationships among stakeholders. From all the MCDA techniques the Analytic Network Process (Saaty, 2001) has been chosen because it is the only one that takes into account the interdependency of all the elements of the network, that is, the way that they influence each other.

As far as we know, ANP has never been applied to analyze the influence between stakeholders. This is not an easy task because the stakeholder network can be modeled in different ways. The main problem that we now have to face is how to define the concept "influence" in a specific stakeholders' network.

Therefore, the main questions that we try to answer in this work are 'from the point of view of the Project Manager: i) Which is the individual influence of each stakeholder on the project and ii) how can we measure it?'

The rest of the paper is organized as follows: Section 2 presents a literature review in the field of stakeholders' management; Section 3 describes the ANP stakeholder analysis; Section 4 presents its application to a case study and finally Section 5 draws some conclusions of our work.

2. Literature review

Identifying project success factors and the different perceptions of these factors by stakeholders has been extensively studied in the Project Management literature and remains a matter of debate (Davis, 2014). Yang et al. (2011) suggest that stakeholder involvement is important to project outcomes. Aaltonen and Sivonen (2009) argue that stakeholder related conflicts and incidents are among the most significant unforeseen risks in projects implemented in challenging environments.

The stakeholder theory is becoming an important approach in project management (Littau et al., 2010). These authors place the birth of the stakeholder theory after the publication of the book "Strategic management: A stakeholder approach" (Freeman, 1984). Since then, interest in analyzing how stakeholders (individuals, groups or organizations) influence management and decision-making processes has grown significantly, as it is shown in the literature, (Freeman et al., 2010; Bryson, 2004) as well as in more specific areas, for example, policy and health care management (Brugha and Varvasovszky, 2000), environmental management (Reed et al., 2009) or project management (Yang et al., 2011; Davis, 2014; Mok et al., 2015).

According to PMI (2013) Project Stakeholder Management includes the processes required (i) to identify stakeholders, (ii) to analyze stakeholders' expectations and their impact on the project, and (iii) to develop strategies for effectively engaging stakeholders in project decisions and execution. The process of identifying stakeholders is closely related to the analysis of their influence and potential impact on project success. Some of the works in the literature which study this particular process analyze the relationship of the stakeholders to the success of the project (Achterkamp and Vos, 2008), the types of strategies stakeholders have attempted to increase their salience and affect project outcomes (Aaltonen et al., 2008), or the strategies of response to the demands and pressures of the stakeholders (Aaltonen and Sivonen, 2009).

Other works have proposed tools for identifying and managing stakeholders. According to Bourne and Weaver (2010) there are three basic approaches used to help and visualize, map and understand stakeholders: customer relationship management (CRM), techniques for listing and mapping stakeholders and their influence, and social networks. CRM is used in business management and requires a large amount of data on large groups of stakeholders (usually customer segments). It uses techniques based on data mining and does not apply in project management.

Techniques for listing and mapping stakeholders are very simple and intuitive to use and therefore they are widely used in project management (PMI, 2013). One of the most well-known models for stakeholders' identification and prioritization in business management (steps (i) and (ii)) is the theory of stakeholder identification and salience proposed by Mitchell et al. (1997). These authors suggested to classify stakeholders in terms of three attributes: power to influence the firm, legitimacy of the stakeholder's relationship with the firm and the urgency of the stakeholder's claim on the firm. Based on these three attributes Mitchell et al. (1997) tried to explain how managers prioritize stakeholder relationships. Based on this model they also proposed some techniques that used the graphical representation of the types of stakeholders through pairwise matrices that combine the following dimensions: power, support, influence, interest, and attitude. Examples of practical use of power/interest matrices can be found in Gardner et al. (1986) or Olander and Landin (2005). A more complete review of these techniques can be found in Bourne and Weaver (2010) and Reed and Curzon (2015).

The above-mentioned techniques are based on the qualitative analysis of the dimensions cited. In an attempt to perform a quantitative analysis, Bourne and Walker (2005) proposed the *vested interest-impact index* (ViII) that assesses the potential impact of each stakeholder interest on project execution. This

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index takes into account two parameters: vested interest level (probability of impact) and influence impact level (level of impact). Olander (2007) suggested to complete the analysis by adding two concepts: the attribute value based on the stakeholder classes (A) proposed by Mitchell et al. (1997) and the position value (Pos) based on the levels of stakeholder position proposed by McElroy and Mills (2000) (cited by Olander, 2007). With these four concepts Olander developed a Stakeholder Impact Index (SII) as a function of A, Pos and ViIl. Nevertheless, this index needs further development, since it does not give a way of measuring and evaluating the attributes of power, legitimacy and urgency of each stakeholder (Olander and Landin, 2008).

Bourne and Weaver (2010) proposed a methodology, named Stakeholder Circle, that might be useful for managing relationships among stakeholders (Yang et al., 2011), but according to Yang (2014), the model needs a deeper analysis of the underlying structure of those relationships that can be done through the Social Network Analysis (SNA). Other authors have also proposed the use of SNA to calculate individual influence and trust for each actor (Wu and Chiclana, 2014). However, when there are different types of relationships among actors, different networks have to be constructed and different SNA analysis have to be carried out, one for each type of relation analyzed, which ends up in very complex analysis structures.

Yang (2014) also performed a review of the stakeholder analysis techniques mentioned above and applied them to two case studies. This author concludes that none of the methods is perfect.

2.1. Background of AHP and ANP

The Analytic Hierarchy Process (AHP) and the Analytic Network Process (ANP) are theories of relative measurement of intangible criteria (Saaty, 2005a; Saaty and Sagir, 2009), proposed by Saaty (1980, 2001). The method measures the preferences of the decision maker using accurate and reliable relative scales that do not have a zero or a unit. Saaty proposes the use of ratio scales to rate the decision maker's preferences, known as Saaty's 1 to 9 Fundamental Scale (see Table 1).

Table 1
Saaty's fundamental scale.

Intensity of importance	Definition
1	Equal importance/preference
2	Weak
3	Moderate importance/preference
4	Moderate plus
5	Strong importance/preference
6	Strong plus
7	Very strong or demonstrated importance/preference
8	Very, very strong
9	Extreme importance/preference

The main steps to solve a multicriteria decision-making problem using AHP are the following (Aragonés-Beltrán et al., 2014):

1) The decision-making problem is structured as a hierarchy and is broken down into several levels. The top level of the hierarchy is the main goal of the decision problem. The lower levels are the tangible and/or intangible criteria and subcriteria that contribute to the goal. The bottom level is formed by the alternatives to evaluate in terms of the criteria.
2) The criteria weights are obtained.
   2.1) The n criteria in the same level are compared using Saaty's 1-to-9 scale. For each level a pairwise comparison matrix A is obtained based on the decision maker's judgements a_{ij}.

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \dots & a_{2n} \\ \vdots & & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix}, \text{where } a_{ji} = 1/a_{ij} \quad i, j = 1, \ldots, n \tag{1}$$

   2.2) The Consistency Ratio (CR) of matrix A is used to check judgment inconsistencies. CR = CI / RI, where $CI = \frac{\lambda_{max}-n}{n-1}$ and λ_{max} is the maximal eigenvalue of A.

   The Random Index (RI) is an experimental value which depends on n (Saaty, 1980). If CR is less than a threshold value then the matrix can be considered as having an acceptable consistency, and the derived priorities from the comparison matrix are meaningful. In Saaty (1994) the following threshold values are proposed: 0.05, 0.08 and 0.1 for n = 3, n = 4 and n ≥ 5 respectively. If CR exceeds the threshold value, then the judgments in matrix A should be reviewed.

   2.3) The local priorities vector $P = (p_1, p_2, \ldots p_i, \ldots, p_n)$ is obtained from the pairwise comparison matrix A. To derive the priorities Saaty suggested to calculate the principal right eigenvector of the pairwise matrix A (Eq. (1)). These priorities are local priorities because they are the priorities of elements in the same level of the hierarchy.
   2.4) The local priorities are synthesized across all criteria in order to determine the global priority of all criteria, g_i, i = 1, …, n^H, where n^H is the number of criteria and subcriteria in the hierarchy, multiplying its local priority by the global priority of the element. The local and global priority of the main goal is 1. The sum of the global priorities of all bottom-level criteria is 1.
3) The assessment of alternatives for each criterion is obtained. There are several ways of obtaining a value depending on the nature and number of alternatives. If the number of alternatives is small, Saaty proposes the use of pairwise comparisons, like the procedure used for criteria prioritization, obtaining a matrix A for each

lower level criterion, and calculating the priorities of the alternatives for each criterion. If the number of alternatives is large (greater than 9) Ratings are generally used (Saaty, 2006).

4) The decision matrix is built using the priorities of the bottom-level criteria and alternatives.
5) The alternative priorities and criteria priorities are aggregated using a MCDM method. The weighted sum model is the most widely used approach in AHP.

The Analytic Network Process (ANP) is a method proposed by Saaty (2001). This method is a generalization of AHP.

ANP represents a decision-making problem as a network of criteria and alternatives (all called elements), grouped into clusters. All the elements in the network can be related in any possible way, i.e. a network can incorporate feedback and interdependence relationships within and between clusters. This provides a more accurate model of complex settings. The influence of the elements in the network on other elements in that network can be represented in a supermatrix. According to Saaty (2001), the ANP model comprises the following steps:

1. Identifying the components and network elements and their relationships. This step can be divided into three basic tasks:
   i. Identifying the network elements (decision criteria and alternatives).
   ii. Grouping the elements based on some common feature.
   iii. Analyzing the relationships between network elements.
2. Calculating the priorities between elements of the same cluster. The purpose of this step is to determine which element is more influential and to what extent among the elements of a cluster. This is done by paired comparisons and calculating the eigenvector associated with the main eigenvalue. As a result of this step the *unweighted supermatrix* is obtained.
3. Calculating the priorities between clusters. This is done using pairwise comparison matrices between clusters. A pairwise comparison matrix between clusters associated with a network group is a matrix whose rows and columns are formed by all network clusters that have some influence on a given cluster.
4. Weighting of the unweighted supermatrix blocks using the priorities of each cluster, so that the resulting supermatrix, *weighted supermatrix*, is column-stochastic.
5. Getting the *limit supermatrix*. The limit supermatrix is obtained by raising the weighted supermatrix to successive powers until their inputs converge. In this matrix, the elements of each column represent the final weightings of the different elements considered.

The design of the network in a decision problem is a key factor to find an appropriate solution, although there are no clear directions in the literature on how to design the network (Saaty and Shih, 2009). Network design is usually the first and one of the most important steps of the method. It forces the decision maker and his/her team to conduct a thorough analysis of the problem.

Mathematical foundations of AHP and ANP can be found in Saaty (1994, 2005b, 2008). A review of the main developments in the AHP and ANP can be found in Al-Harbi (2001), Vaidya and Kumar (2006), Ishizaka and Labib (2011), and Sipahi and Timor (2010).

In this paper, we propose the use of ANP to quantify the relative influence of stakeholders on a project, from the perspective of the Project Manager. In our model, the concept of influence of stakeholders is broken down into criteria or viewpoints, evaluating different aspects that together define an index measuring the influence of each stakeholder. We conducted an analogy in which the project stakeholders are the alternatives in the decision model and the criteria are the concepts which define different aspects of the concept "influence". ANP allows the analysis of all interdependencies among the elements of the model (criteria and stakeholders). With this model the Project Manager and his team can conduct a detailed reflection about which stakeholders have more influence on the project and the way these stakeholders exert this influence.

3. ANP-based stakeholder analysis

Fig. 1 presents our proposal for the stakeholders' analysis. The different steps will be described in the following paragraphs.

In this section only the general steps of the model are described, that is, those that could be applied to any case study.

3.1. Selection of stakeholders

The key stakeholders have to be identified. This will be done by asking the Project Manager (PM henceforth) of the project that we are going to analyze. He/she has an overview of the entire project.

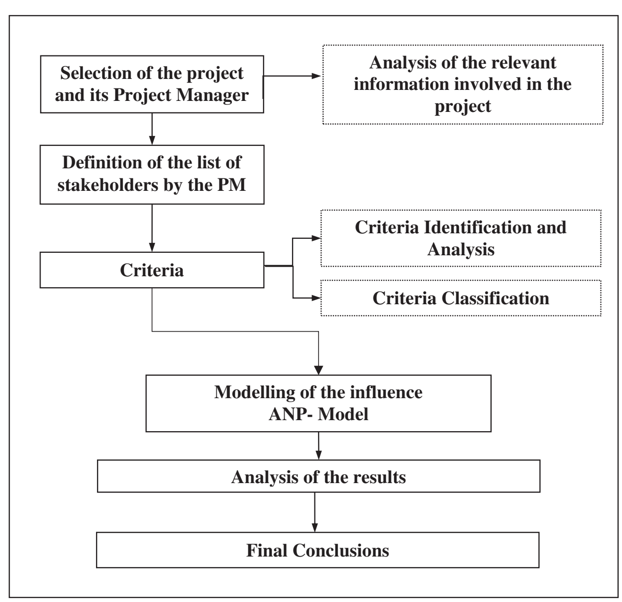

Fig. 1. Proposed model to assess the influence of stakeholders.

Only in case the PM thinks there might be more stakeholders that he/she might not identify, a snowball procedure based on the information given by the key stakeholders to further identify more people should be carried out (Hage et al., 2010).

3.2. Criteria to measure the influence

The stakeholder literature provides some approaches of how to deal with the definition of *influence*. The following approaches have been found in the recent literature, all of which carry out thorough literature reviews of previous outstanding related papers.

- Beritelli and Laesser (2011) analyze how power is perceived by different individuals and stakeholder groups in an actor's network. They assume that influence reputation is a good indicator for power and identified four variables to measure this concept: (i) hierarchy, reflecting vertical power, which refers to the hierarchical position of the stakeholder in the given network, (ii) knowledge, which includes intelligence, skills and experience, (iii) process power, which gives information about their position in a specific process, and finally (iv) assets, composed of every resource (i.e. money, land).
- Hage et al. (2010) suggest to select and prioritize stakeholders according to the following criteria: (i) Scientific or other knowledge, (ii) stake or interest, (iii) values, (iv) representativeness and (v) communication and social skills.
- Gomes et al. (2010) provide a model for summarizing stakeholder influence, based on three theories: (i) Resource Dependency, (ii) Social Network Perspective and (iii) Institutional Approach.
- Aaltonen et al. (2013) and Aaltonen et al. (2008) introduce a rather dynamic approach for measuring influence, based on identifying strategies of the project's stakeholders: (i) direct withholding, (ii) indirect withholding, (iii) coalition building, (iv) resource building, (v) conflict escalation, and (vi) credibility building.

Based on the former approaches we propose our model to measure the influences of stakeholders based on twelve criteria grouped into four clusters: *Cluster Knowledge* is composed of elements that give information about stakeholders' intangible skills when it comes to skills or knowledge that they acquired, *Cluster Social Skills* represents intangible values closely related to social interactions of an actor, *Cluster Assets* covers all the properties an actor possesses that have monetary value, and *Cluster External* is composed of elements that allow external dependence.

The criteria have the following meaning:

Cluster: Knowledge

K1: *Expert knowledge*. Refers to Knowledge that one stakeholder specifically possesses e.g. through further trainings. This criterion does not refer to the knowledge that one stakeholder possesses through his profession (Beritelli and Laesser, 2011; Hage et al., 2010).

K2: *Professional competence*. Refers to Knowledge that was gained through the education and execution of the stakeholder's profession (Beritelli and Laesser, 2011; Hage et al., 2010).

K3: *Experience*. Refers to situations, circumstances and events one stakeholder has experienced in the past (Beritelli and Laesser, 2011).

Cluster: Social Skills

S1: *Representativeness*. Refers to the ability of one stakeholder to represent himself within the network through social competences (Hage et al., 2010; Gomes et al., 2010; Aaltonen et al., 2013).

S2: *Affiliating with others*. Refers to the ability of one stakeholder to build coalitions within the network through social competences (Gomes et al., 2010; Aaltonen et al., 2013).

S3: *Manipulating others*. Refers to the ability of one stakeholder to reach individual goals by managing other actors of the network to their advantage e.g. through leadership competences (Gomes et al., 2010; Aaltonen et al., 2013).

Cluster: Assets

A1: *Financial security*. Refers to the liquidity or financial stability of one stakeholder (Beritelli and Laesser, 2011).

A2: *Providing resources*. Refers to the willingness and capability of one stakeholder to provide the project with resources (Beritelli and Laesser, 2011; Gomes et al., 2010; Aaltonen et al., 2013).

A3: *Providing financials*. Refers to the willingness and capability of one stakeholder to provide the project with financials (Beritelli and Laesser, 2011; Gomes et al., 2010; Aaltonen et al., 2013).

Cluster: External

E1: *Dependency to external factors*. Refers to the degree that one stakeholder is dependent to any factor that does not lie within the network of the project e.g. politics or regulatory bodies (Gomes et al., 2010).

E2: *Public image*. Refers to the image one stakeholder has outside of the network e.g. through media (Gomes et al., 2010).

E3: *Hierarchical position*. Refers to the power one stakeholder possesses through his/her hierarchical position (Beritelli and Laesser, 2011).

Fig. 2 illustrates the final criteria that will have to be used in the ANP model of the proposed model. We have aggregated the *Cluster Stakeholders* that would be the individuals to be analyzed.

To demonstrate the applicability of our ANP model in the following sections we will particularize it from a case study.

4. Application to a case study

The model has been applied to a real case study consisting of a project that has to be developed by the Spanish National Railway Infrastructure company (ADIF, Administrador de Infraestructuras Ferroviarias). It is a project of maintenance

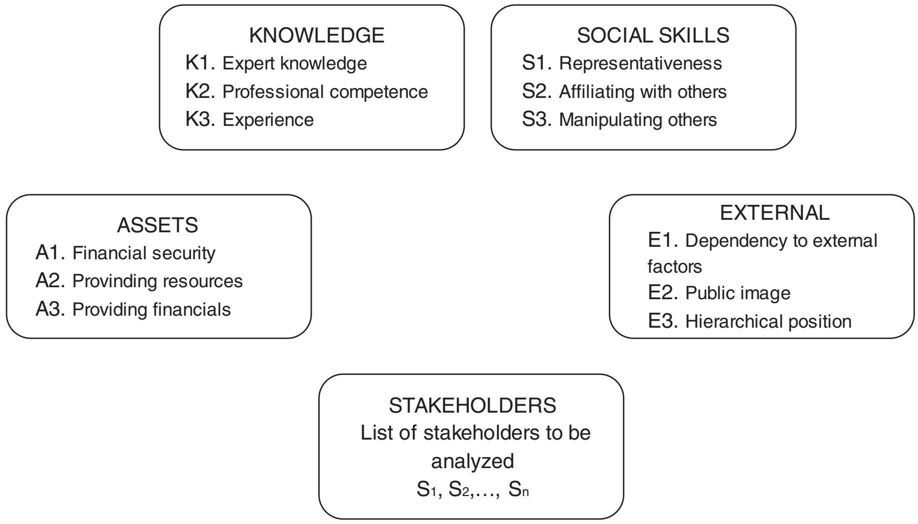

Fig. 2. Clusters and criteria used for evaluating stakeholders' influence in the ANP model.

and improvement that has to be implemented over the whole Spanish conventional railway network (non-high speed). It involves the replacement of a particular type of electrical resistors in the system's signaling service. The resistors to replace were installed between the 60s and 80s of the 20th century and have to be removed because these systems may release asbestos particles. There are over 2500 resistors distributed over the network that have to be replaced.

In this case study the PM is an engineer of the systems department. He is responsible for the daily operation of the facilities and assigns personnel to carry out the work.

The project consists of the following phases:

– Identification and location of all resistors to replace.
– Provision of new resistors.
– Design a work plan for the replacement of the old resistors.
– Replacement of resistors.

4.1. Identification of stakeholders

The PM has identified 8 stakeholders grouped into 2 clusters, internal and external.

Internal stakeholders

– ST I1. *Chief/Manager of the Human Resources Department*. He is the project sponsor. Since the resistors may release asbestos particles, he wants them to be removed as soon as possible. He does not want ADIF employees to work with such a health risk.
– ST I2. *Systems department engineer*. Promotor and director of the work. Responsible for the installations and facilities of the overall railway network. He is the PM of the project analyzed in this case study and one of the authors of this paper.
– ST I3. *Unions*. They want the project to be developed as soon as possible and under conditions of maximum safety.
– ST I4. *Maintenance department engineer*. He is responsible for the maintenance and daily operation of the facilities. He assigns personnel to carry out the work.
– ST I5. *Railway safety administrator*. He ensures compliance of legislation regarding safety management. He will not allow changes in the operation of the signaling systems that could reduce the safety of railway operation.

External stakeholders

– ST E1. *Contractor*. He executes the project, is in charge of the resistor substitution work, under the supervision of railway company personnel. He must meet the conditions stipulated in the contract and execution modes approved by the coordinator of health and safety and railway safety department.
– ST E2. *Signaling systems provider*. Supplier of the new resistors and technical specifications for the replacement process. He designed the original system and the new and safer resistors. He is responsible for developing the maintenance user's manual for replacing the resistors when required.
– ST E3. *Health and safety coordinator*. He gives advice to the railway safety administrator and is responsible for the legislation compliance. This service is provided by an external subcontractor.

4.2. Modeling the influence assessment with the ANP model

In this step, we will have to carry out all the steps proposed by the ANP method (see Section 2.1) in order to calculate the final influence index.

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Table 2
Dependence matrix of all elements of the network.

	K1	K2	K3	S1	S2	S3	A1	A2	A3	E1	E2	E3	St1	St2	…	Stn
K1	0	1	0	1	1	1	1	1	1	0	1	1	1	1		1
K2	1	0	0	1	1	1	1	1	1	0	1	1	1	1		1
K3	1	1	0	1	1	1	1	1	1	0	1	1	1	1		1
S1	0	0	0	0	1	1	0	0	0	0	1	1	1	1		1
S2	0	1	0	1	0	1	0	0	0	0	1	1	1	1		1
S3	0	1	0	1	1	0	0	0	0	0	1	1	1	1		1
A1	0	1	0	0	0	0	0	1	1	0	1	1	1	1		1
A2	0	1	0	0	1	1	1	0	1	0	0	0	1	1		1
A3	0	1	0	0	1	1	1	1	0	0	0	0	1	1		1
E1	0	0	0	0	0	0	0	0	0	0	1	0	1	1		1
E2	0	0	0	1	1	1	0	0	0	1	0	0	1	1		1
E3	0	0	0	1	1	1	0	0	0	0	1	0	1	1		1
St1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1
St2	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1
…																1
Stn	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1

4.2.1. Identifying the components and network elements and their relationships

The criteria have been fixed and grouped in the general model and accepted by the PM and all stakeholders have been identified so that the model considers all required elements.

In this step the dependencies between criteria and stakeholders and also between stakeholders have to be analyzed for this particular project, which will be done by the research team together with the PM.

For this purpose, a zero-one dependence matrix has to be used whose elements take either the value 0 or 1, depending on whether the PM thinks that one element has a dependence on the other or not. Thus, 1 in position $r_{i,j}$ in the matrix means that the element in row i has some influence on the element of column j. The rows and columns of the matrix are formed by all the elements of the network, namely the criteria and the stakeholders (Saaty, 2001). This information has to be obtained by asking the PM. For example, according to our knowledge and experience, the criterion *K2 Professional competence* (in the columns) depends on the criteria K1, K3, S2, S3, A1, A2, and A3 (in the row) and all the stakeholders. As it can be seen, the matrix includes the dependencies among the stakeholders of the project and between stakeholders and criteria. Table 2 illustrates the resulting matrix.

The stakeholders identified by the PM and the dependences among criteria were used to build the ANP network of our case study (see Fig. 3).

4.2.2. Determining the weights of the criteria and stakeholders of the model

A questionnaire was designed in order to assess to what extent each element has some influence on other elements to which it is related. For that purpose, the PM has to answer all the pairwise questions required by the ANP model. A sample of the questionnaire is shown in Table 3.

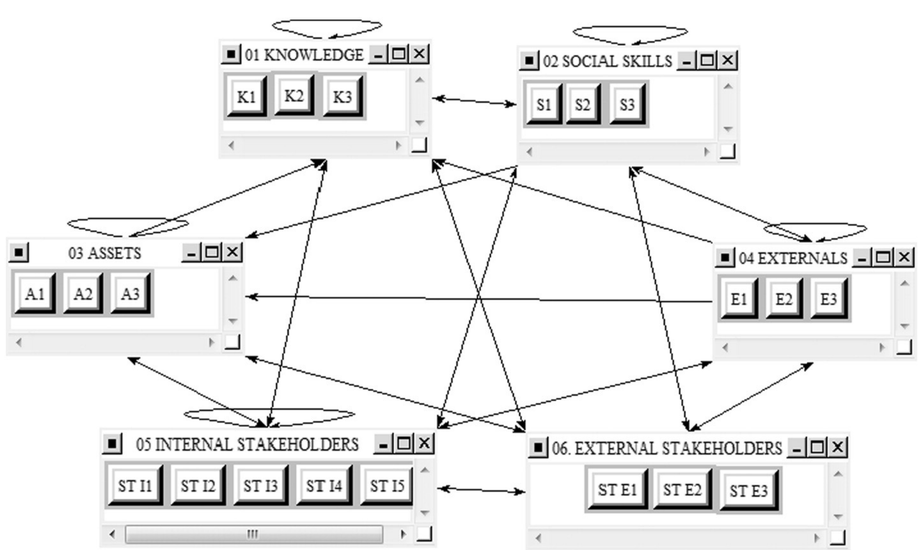

Fig. 3. ANP influence model in Superdecisions©.

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Table 3
Example of the questionnaire about prioritization of elements.

Compare the following elements in the cluster "*Social Skills*" according to their influence upon the element *K2. Professional competence* in the cluster "*Knowledge*":

S2 Affiliating with others
S3 Manipulating others

Which has a greater influence?	☐ *S1*	☒ *S3*

How much greater?	☐ *Equal*	☐	☒ *Moderate*	☐	☐ *Strong*	☐	☐ *Very strong*	☐	☐ *Extreme*

The response shown in this example indicates that according to the PM's opinion, the element *S3 Manipulating others* is moderately more influential on the element *K2. Professional competence* than *S2 Affiliating with others*.

All this data has to be processed with the software Superdecisions© which allows us to obtain the individual results as well as the inconsistency index of each expert.

4.2.3. Calculating the priorities between elements of the same cluster

The purpose of this step is to determine which element is more influential and to what extent among the elements of a cluster. This is done by paired comparisons and calculating the eigenvector associated with the main eigenvalue. As a result of this step the *unweighted supermatrix* was obtained (Table 4).

4.2.4. Getting the weighted supermatrix

In a network model different elements from different clusters have influences on one element and the corresponding unweighted matrix is non-stochastic by columns. Thus, according to Saaty (2001), all clusters that exert any kind of influence upon each cluster have to be prioritized using the corresponding cluster pairwise comparison matrices. The value corresponding to the priority associated with a certain cluster weights the priorities of the elements of the cluster on which it acts (in the corresponding unweighted supermatrix), and thus the weighted supermatrix can be generated (Table 5).

4.2.5. Getting the limit supermatrix

The limit supermatrix is obtained by raising the weighted supermatrix to successive powers until their inputs converge. In this matrix, the elements of each column represent the final weights of the different elements of the model. For all the elements within the matrix a dimensionless value between 0 and 1 is obtained. For the alternatives (stakeholders) this value (once normalized) shows the influence of each stakeholder in relation with the other stakeholders and will be named the *Influence Index*.

5. Analysis of results

Since all the columns of this last matrix have the same values, only the resulting values of one column are shown due to space constraints (Table 6).

Table 5 shows the priorities among stakeholders. The "limit matrix column" shows the influence that each stakeholder has in relation to the whole network. The "normalized by clusters" column shows the relative influence (priorities) among internal stakeholders (see Fig. 4) and the relative influence (priorities) among external stakeholders (see Fig. 5). The "normalized column" shows the influence (priorities) that each stakeholder has in relation to the rest of the stakeholders (see Fig. 6). In Figs. 4 and 5 it can be seen that the most influential stakeholders among the internal stakeholders are ST I2 "*Systems Department*" and ST I1 "*Human Resources*". The most influential stakeholders among the external stakeholders is ST E2 "*Signaling system provider*". When considering all the stakeholders together, Fig. 6 shows that the most influential

Table 4
Results of the unweighted supermatrix.

	K1	K2	K3	S1	S2	S3	A1	A2	A3	E1	E2	E3	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6	ST 7	ST 8
K1	0.000	0.167	0.000	0.113	0.109	0.114	0.143	0.105	0.200	0.000	0.208	0.113	0.091	0.731	0.143	0.105	0.659	0.067	0.091	0.258
K2	0.750	0.000	0.000	0.179	0.345	0.405	0.429	0.258	0.200	0.000	0.131	0.179	0.455	0.081	0.429	0.637	0.156	0.467	0.455	0.105
K3	0.250	0.833	0.000	0.709	0.547	0.481	0.429	0.637	0.600	0.000	0.661	0.709	0.455	0.188	0.429	0.258	0.185	0.467	0.455	0.637
S1	0.000	0.000	0.000	0.000	0.167	0.250	0.000	0.000	0.000	0.000	0.594	0.179	0.600	0.600	0.361	0.179	0.333	0.528	0.258	0.143
S2	0.000	0.000	0.000	0.750	0.000	0.750	0.000	0.000	0.000	0.000	0.249	0.709	0.200	0.200	0.574	0.709	0.333	0.333	0.637	0.714
S3	0.000	1.000	0.000	0.250	0.833	0.000	0.000	0.000	0.000	0.000	0.157	0.113	0.200	0.200	0.065	0.113	0.333	0.140	0.105	0.143
A1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.167	0.833	0.000	1.000	0.714	0.091	0.111	0.249	0.157	0.600	0.157	0.223	0.084
A2	0.000	0.000	0.000	0.000	0.167	0.167	0.250	0.000	0.167	0.000	0.000	0.143	0.455	0.778	0.594	0.594	0.200	0.594	0.070	0.705
A3	0.000	0.000	0.000	0.000	0.833	0.833	0.750	0.833	0.000	0.000	0.000	0.143	0.455	0.111	0.157	0.249	0.200	0.249	0.707	0.211
E1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.167	0.000	0.714	0.143	0.272	0.200	0.778	0.731	0.655	0.773
E2	0.000	0.000	0.000	0.167	0.125	0.167	0.000	0.000	0.000	1.000	0.000	1.000	0.143	0.143	0.661	0.200	0.111	0.188	0.290	0.139
E3	0.000	0.000	0.000	0.833	0.875	0.833	0.000	0.000	0.000	0.000	0.833	0.000	0.143	0.714	0.067	0.600	0.111	0.081	0.055	0.088
ST 1	0.430	0.074	0.061	0.396	0.305	0.212	0.550	0.101	0.451	0.206	0.045	0.557	0.649	0.051	0.287	0.080	0.000	0.000	0.000	0.709
ST 2	0.071	0.445	0.458	0.071	0.114	0.096	0.157	0.374	0.134	0.048	0.120	0.106	0.000	0.655	0.000	0.150	0.139	0.709	0.249	0.113
ST 3	0.335	0.029	0.039	0.303	0.056	0.440	0.050	0.038	0.049	0.581	0.526	0.038	0.279	0.000	0.557	0.037	0.000	0.000	0.000	0.000
ST 4	0.127	0.311	0.325	0.045	0.303	0.161	0.085	0.406	0.278	0.054	0.068	0.231	0.072	0.167	0.117	0.465	0.088	0.179	0.157	0.179
ST 5	0.038	0.141	0.117	0.185	0.221	0.091	0.157	0.082	0.089	0.110	0.241	0.068	0.000	0.127	0.039	0.267	0.773	0.113	0.594	0.000
ST 6	0.072	0.188	0.229	0.088	0.258	0.179	0.333	0.659	0.600	0.143	0.119	0.200	0.000	0.000	0.000	0.113	0.000	0.528	0.100	0.352
ST 7	0.279	0.731	0.696	0.773	0.637	0.709	0.333	0.185	0.200	0.429	0.747	0.600	0.000	0.900	0.000	0.709	1.000	0.333	0.900	0.089
ST 8	0.649	0.081	0.075	0.139	0.105	0.113	0.333	0.156	0.200	0.429	0.134	0.200	1.000	0.100	1.000	0.179	0.000	0.140	0.000	0.559

Table 5
Results of the weighted supermatrix.

	K1	K2	K3	S1	S2	S3	A1	A2	A3	E1	E2	E3	ST 1	ST 2	ST 3	ST 4	ST 5	ST 6	ST 7	ST 8
K1	0.000	0.090	0.000	0.021	0.014	0.015	0.011	0.008	0.016	0.000	0.049	0.027	0.005	0.042	0.008	0.006	0.038	0.003	0.004	0.011
K2	0.608	0.000	0.000	0.033	0.045	0.053	0.033	0.020	0.016	0.000	0.031	0.042	0.026	0.005	0.024	0.036	0.009	0.019	0.019	0.004
K3	0.203	0.452	0.000	0.132	0.071	0.062	0.033	0.050	0.047	0.000	0.156	0.167	0.026	0.011	0.024	0.015	0.011	0.019	0.019	0.026
S1	0.000	0.000	0.000	0.000	0.069	0.103	0.000	0.000	0.000	0.000	0.122	0.037	0.079	0.079	0.047	0.023	0.044	0.037	0.018	0.010
S2	0.000	0.000	0.000	0.443	0.000	0.309	0.000	0.000	0.000	0.000	0.051	0.145	0.026	0.026	0.075	0.093	0.044	0.023	0.044	0.050
S3	0.000	0.331	0.000	0.148	0.343	0.000	0.000	0.000	0.000	0.000	0.032	0.023	0.026	0.026	0.009	0.015	0.044	0.010	0.007	0.010
A1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.087	0.435	0.000	0.117	0.083	0.044	0.053	0.120	0.075	0.288	0.071	0.100	0.038
A2	0.000	0.000	0.000	0.000	0.050	0.050	0.131	0.000	0.087	0.000	0.000	0.017	0.218	0.374	0.285	0.285	0.096	0.267	0.032	0.318
A3	0.000	0.000	0.000	0.000	0.252	0.252	0.392	0.435	0.000	0.000	0.000	0.017	0.218	0.053	0.075	0.120	0.096	0.112	0.319	0.095
E1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.063	0.000	0.101	0.020	0.038	0.028	0.110	0.058	0.052	0.061
E2	0.000	0.000	0.000	0.009	0.005	0.006	0.000	0.000	0.000	0.859	0.000	0.380	0.020	0.020	0.093	0.028	0.016	0.015	0.023	0.011
E3	0.000	0.000	0.000	0.044	0.032	0.031	0.000	0.000	0.000	0.000	0.317	0.000	0.020	0.101	0.009	0.085	0.016	0.006	0.004	0.007
ST 1	0.043	0.005	0.032	0.034	0.018	0.013	0.110	0.020	0.090	0.018	0.002	0.021	0.106	0.008	0.047	0.013	0.000	0.000	0.000	0.093
ST 2	0.007	0.030	0.243	0.006	0.007	0.006	0.031	0.075	0.027	0.004	0.005	0.004	0.000	0.107	0.000	0.025	0.023	0.093	0.033	0.015
ST 3	0.033	0.002	0.021	0.026	0.003	0.026	0.010	0.008	0.010	0.049	0.020	0.001	0.046	0.000	0.091	0.006	0.000	0.000	0.000	0.000
ST 4	0.013	0.021	0.172	0.004	0.018	0.010	0.017	0.081	0.056	0.005	0.003	0.009	0.012	0.027	0.019	0.076	0.014	0.024	0.021	0.024
ST 5	0.004	0.009	0.062	0.016	0.013	0.005	0.031	0.016	0.018	0.009	0.009	0.003	0.000	0.021	0.006	0.044	0.126	0.015	0.078	0.000
ST 6	0.006	0.011	0.108	0.007	0.015	0.011	0.067	0.132	0.120	0.008	0.003	0.005	0.000	0.000	0.000	0.003	0.000	0.120	0.023	0.080
ST 7	0.025	0.044	0.328	0.066	0.038	0.042	0.067	0.037	0.040	0.024	0.019	0.015	0.000	0.024	0.000	0.019	0.027	0.076	0.205	0.020
ST 8	0.058	0.005	0.036	0.012	0.006	0.007	0.067	0.031	0.040	0.024	0.003	0.005	0.027	0.003	0.027	0.005	0.000	0.032	0.000	0.128

Table 6
Final priorities of stakeholders.

		Limit matrix	Normalized by cluster	Normalized
05 Internal stakeholders	ST I1. Human resources	0.044	0.258	0.134
	ST I2. Systems dept.	0.047	0.276	0.143
	ST I3. Unions	0.012	0.071	0.037
	ST I4. Maintenance dept.	0.041	0.241	0.125
	ST I5. Railway safety adm.	0.026	0.154	0.080
06 External stakeholders	ST E1. Contractor	0.061	0.387	0.186
	ST E2. Signaling system prov.	0.067	0.424	0.204
	ST E3. Health and safety coord.	0.030	0.189	0.091

stakeholders are ST E2 and ST E1. After them we can find a group of three stakeholders, ST I2, ST I1 and ST I4. The least influential is ST I3 "*Unions*". These results make sense from the point of view of the Project Manager of this kind of projects because if the main provider or the contractor has problems (for example, delays or cost overruns), the project will have problems too. It is also logical that the following most influential stakeholders are *Systems Department* and *Human Resources Department*, as the former is the organization in which the Project Manager is integrated and the latter is the project sponsor.

Table 7 shows the criteria priorities. The limit matrix column shows the influence of each criterion in the whole network (including stakeholders). The *normalized-by-cluster* matrix column shows the relative priorities among criteria in the

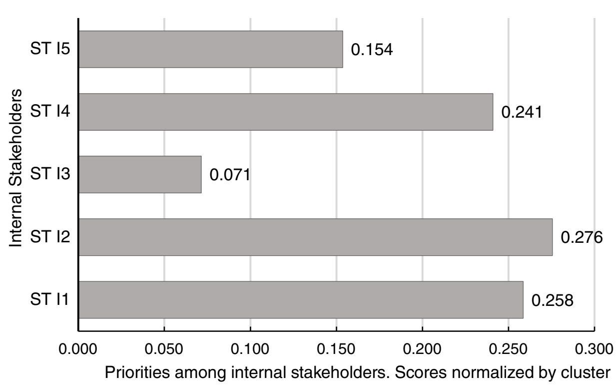

Fig. 4. Priorities among internal stakeholders.

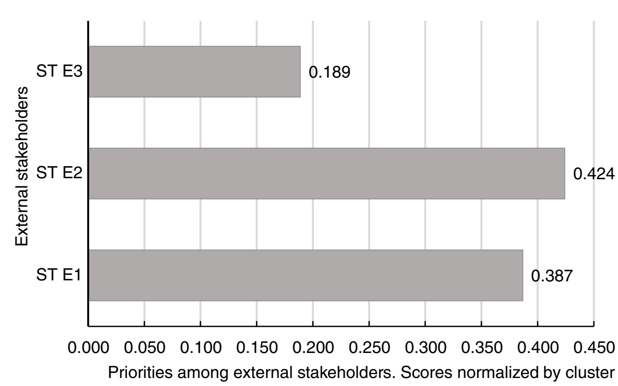

Fig. 5. Priorities among external stakeholders.

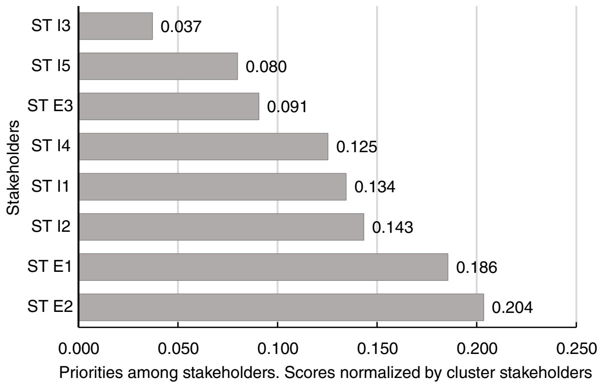

Fig. 6. Priorities among stakeholders.

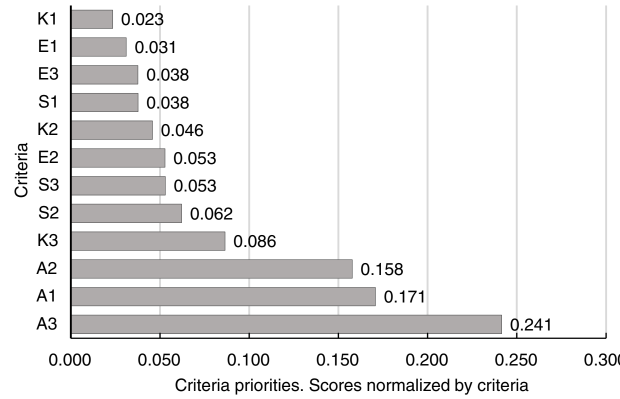

Fig. 7. Criterion priorities.

same cluster. The *normalized-by-criteria* matrix column shows the relative priorities among all criteria. Fig. 7 shows graphically these priorities normalized by criteria. In this ANP model the weights of the criteria are influenced by the specific stakeholders of this case study. Taking into account all the influences in the network, the Project Manager considered that the most relevant criterion was A3 "*Providing financials*" followed by criterion A1 "*Financial security*" and A2 "*Providing resources*", all of them belonging to the *Assets* cluster. The least influential criteria are K1 "*Expert knowledge*" and E1 "*Dependency to external factors*". These results are logical because this project is promoted by the Human Resources Department of ADIF and depends on this department's budget. The technology needed to develop the project is well-known and its dependence on external factors is very low.

6. Conclusions

In this paper we have presented a new method to analyze the stakeholders' influences within a project from the point of view of the Project Manager. Our model is a novel proposal for the definition of "influence" among stakeholders in a project, based on a given set of twelve criteria taken from the Project Management literature about stakeholders' analysis. We have used ANP to obtain an index for each stakeholder which represents his individual influence with respect to the rest of the stakeholders of the group.

Our ANP model answers the two questions stated at the beginning of this research: i) Which is the individual influence of each stakeholder on the project and ii) how can we measure it?

With this, the method allows the PM to perform the quantitative analysis of how much the different stakeholders influence the management of his project. With this tool, complementary to the qualitative analysis presented in the literature, the PM will be able to carry out an adequate identification of ST (Process 13.1 Identify stakeholders). After that he will be able to carry out adequate planning, management and control of stakeholders, according to processes 13.2 Plan stakeholder management, 13.3 Manage stakeholder engagement and 13.4 Control stakeholder engagement (PMI, 2013).

To demonstrate the robustness of our proposal, the model has been applied to a technical maintenance project for the Spanish National Railway Infrastructure company. In this project we have analyzed the influence of eight stakeholders on the management of the project.

The results of the analysis show that the most influential stakeholders are the *Contractor* and the *Signaling systems provider* with almost 40% of influence on the project. According to the PM this makes sense because if these two stakeholders have problems (delays, overruns or lack of specifications), the project will be severely affected. The application of the model to the case study has helped the Project Manager to be aware of these stakeholders and make close monitoring of them.

Table 7
Final priorities of criteria.

		Limit matrix	Normalized by cluster	Normalized by criteria
01 Knowledge	K1. Expert knowledge	0.016	0.151	0.023
	K2. Professional competence	0.031	0.294	0.046
	K3. Experience	0.058	0.555	0.086
02 Social skills	S1. Representativeness	0.025	0.247	0.038
	S2. Affiliating with others	0.042	0.407	0.062
	S3. Manipulating others	0.036	0.347	0.053
03 Assets	A1. Financial security	0.115	0.300	0.171
	A2. Providing resources	0.106	0.277	0.158
	A3. Providing financials	0.162	0.424	0.241
04 External	E1. Dependency to external factors	0.021	0.256	0.031
	E2. Public image	0.036	0.434	0.053
	E3. Hierarchical position	0.025	0.310	0.038

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Regarding the procedure followed, the PM concluded that the questionnaire had many questions but they were easy to answer by someone who has a deep knowledge of the project.

Finally, we want to highlight two main facts:

– It has been clearly demonstrated that ANP is an appropriate tool to analyze stakeholder influence
– as important as the correct application of the methodology is the in-depth knowledge of the project that the PM gains during the process.

As a limitation of this work we consider that this is a first proposal for discussion. Although the proposed model is a general one, the arrangement of the criteria and clusters should be analyzed by the Project Manager and his/her team, whenever one wishes to apply it to a different project.

6. Conflict of interest

The authors declare that we have no conflict of interest in the performance of this work.

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