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# Applying Bayesian networks to performance forecast of innovation projects: A case study of transformational leadership influence in organizations oriented by projects

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ABSTRACT

The focus of this work is the analysis of the influence of transformational leadership on organizational factors, and their impacts on the project performance. The factors considered are communication, flexibility, continuous delivery and continuous improvement, overlap of activities, and maturity of the team, in projects with a high degree of innovation. Bayesian networks were chosen as a simulation tool. Results showed that for a moderate level of overlap of activities, the maximum project performance is obtained when the leadership components individual consideration, inspirational motivation, idealized influence and intellectual stimulation, are either at moderate levels. This leads to high levels of team maturity, flexibility and continuous delivery, while continuous improvement and communication tend to be moderate. It is highlighted the characterization of the individual contribution of the variables to the project performance and the empirical application of Bayesian networks, as an alternative to statistical methods commonly employed in leadership and management studies.



## 1. Introduction

Better and more innovative products demand technological solutions that are socially and environmentally friendly, have added value, a low production cost, and are available in the market before the competition. This demand is closely linked to good planning and the orchestration of human, financial and material resources within the organization and the vision of the early success of the projects in order to introduce these products into market quickly and meeting the requirements of performance, reliability and safety. It is known that the interaction between the leadership and organizational factors contribute to the uncertainty of the success of this process, either because of the complexity of these relationships or due to the difficulty of analysis. Moreover, from the standpoint of the organization, resources are finite and are shared. Specifically in innovation projects the question of predictability of the performance is important because of the large number of variables that are involved, such as degree of innovation of the product, the technology level that is required, investments, deployment time, the allocation, and the profile of human resources (Lebcir, 2007; Shenhar et al., 2005). These are projects characterized by high levels of uncertainty both internally and externally in the organization. A prediction model is necessary for the assessment of the development of these projects, alignment or redirection of resources, management of expectations and results for decision making.

This scenario has motivated both organizations and researchers in the search for reliable ways of predicting performance. Examples of this work are studies conducted by Hoang and Rothaermel (2005) and Zollo, Reuer and Singh, (2002), that discuss the effects of partnerships between companies in research and development (R&D) and the ways of prediction (probability) of success of these projects. However, Vandevoorde and Vanhoucke (2005) address the question of predictability of cost and duration of projects. Huchzermeier and Loch (2001) and Terwiesch and Loch (1999) discuss the uncertainties in R&D and suggest ways of modeling this environment considering market factors (payoffs and requirements) and the project (budget, product performance and delivery). Tatikonda and Montoya-Weiss (2001) add further uncertainty arising from the novelty of the product, process and market to their forecasting model. Analyses conducted by Jing and Avery (2006) show that although many studies have been conducted in this area, most of them are focused on the results of satisfaction and individual performance and not the performance of groups. Few studies have been devoted to understanding the influence of the leader about the processes and organizational performance. Examples of such analysis are the studies regarding transformational and

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transactional leadership conducted by Jung and Avolio (1999), Barling et al. (1996), Waldmann and Yammarino (1999) and Emery and Barker (2007). Moreover, there is no clear explanation about how these relationships occur, its nature and the impacts. Most of the empirical work is dedicated to the establishment of the degree of correlation between the leadership factors, processes and organizational performance, or how they account for static analysis and timely results (pictures) or a more general comprehensive view of the relationship. However, several authors have proposed alternatives that go beyond the establishment of a degree of correlation and suggest ways of forecasting performance for application in various areas. Amongst the empirical work in the military areas are Bass, Avolio, Jung and Berson (2003), on leadership in hierarchical structures and their results, where an analysis is made of applying theories of transactional and transformational leadership in military personnel as a means of forecasting performance of the squads in combat. Another example is given by Chen and Bliese (2002) by addressing aspects of leadership from the perspective of the theory of traces. In organizations there may be cited studies by Sivasubramanian, Murry, Avolio and Jung (2002), Pillai and Williams (2004), Koene, Vogelaar and Soeters (2002) and Pirola-Merlo, Härtel, Mann and Hirst (2002), examining how the leadership within teams can be used as a means of predicting the performance of groups. Whereas Keller (2001) deals with the association of transformational leadership to projects that have a better financial performance (budget versus disbursement), delivery and quality, while Xenikou and Simosi (2006) establish a relationship between transformational leadership and organizational culture and use it as a way of predicting performance of organizational units. The same applies to Politis (2004) and Jung, Chow and Wu (2003), but focusing on the assessment and forecast of the levels of creativity in the workplace. Howell and Avolio (1993) and Howell and Hall-Merenda (1999) are dedicated to assessing and predicting the individual performance of employees in organizations.

The merit of all these works is on practical and experimental aspects, on the real data collection representative of everyday life situations of the organizations. On the other hand there is a lack of sensitivity analysis of outputs (performance) to the variation of the inputs (leadership factors) and how this manifests on the means (organizational factors). Part of this limitation is associated with the choice of the validation method of the relations for the forecasting tool for conducting the studies. These limitations are comprehensive in the leadership literature mainly due to the continuous applications of traditional statistical methods. Among the most widely used statistical methods for understanding the relationship between variables in a process are the analysis of correlation and regression analysis. The first is aimed at assessing the strength of the association between variables and cannot always be used for predictions. Linear regression analysis shows the relationship that exists between different variables of a process. This tool can be used as an estimate of future results, but taking due care with the question of the linearity of the model, their relationships and the ranges considered for the extrapolation of results. Both techniques have greater limitations than the actual ability to forecast results, particularly in the case where it is necessary to evaluate the sensitivity of the influence of one or more variables on another. An alternative to this situation is the analysis of the *t*-distribution which considers the magnitude of the effect of changing a particular input variable over an output variable, associated with the level of significance for the null hypothesis (indicating the percentage of two populations that are not statistically distinct). The magnitude of the effect provides information about which variables most significantly affect the outputs of the processes that are analyzed. The prerequisite for the application of these techniques is the existence of a normal distribution of the population. From a statistical point of view, it is interesting to combine the use of the techniques described above. The major limitation of the statistical techniques mentioned (regression analysis, correlation analysis and *t*-distribution) is in its application to systems with typical nonlinear behavior, as is the case of social systems and the need for attention to the condition of normality of the population. As a way of overcoming these restrictions, techniques of artificial intelligence (AI) arise.

Bayesian networks (BNs) belong to this group of techniques. They are graphical models used to establish the causal relationships between key factors and final outcomes (cause-effect relationships). The quantitative relationships between variables in the models are expressed probabilistically. BNs work by examining the conditional independence between variables. Model parameters can be updated using Bayes's theorem. Being probabilistic, the models readily incorporate small data sets or highly variable or vague information, with uncertainties being reflected in model outputs (Pollino, Woodbery, Nicholson, Korb, & Hart, 2007). BNs are particularly useful in modeling processes where only scarce data is available, and relationships are highly variable. They have been used in many different areas as psychology, ecology, medicine, genetics, risk and bankruptcy analysis.

The purpose of this work is to analyze, via a case study how leadership affects organizational factors and which are their impacts on the project performance. After evaluating the various methods we chose to use Bayesians networks as a prediction (simulation) tool of the results. This is due particularly to the characteristics of nonlinearity of the analyzed system and the possibility of conducting a sensitivity analysis of the variables. Another advantage is the possibility of performing bidirectional inferences, i.e., from the causes to the effects or from the effects to the causes. The use of AI tool represents a new approach to the organizational leadership and management studies, since up to now, only very few references in the literature considering this application in these areas have been found. Thus, a second expected outcome of this paper is the contribution on the advance of the application of AI tools in such areas. According to Schneider and Somers (2006) the reasons why AI tools are under utilized in leadership studies are the low awareness among management scholars and confusion about their use. Following this introduction, sections dedicated to the work description are presented. Section 2 deals with the proposed method, the definition of leadership and organizational (people) factors, and performance evaluation (research questions and methodology). Section 3 is related to the empirical study, where sampling procedure and data analysis are discussed. Section 4 deals with implications and conclusions.

## 2. The proposed method

### 2.1. Research variables

The performance of an organizational is always linked to its inherent components. According to Albrecht (1988) these components are the business strategy, systems (hardware & software) and people. Leadership can be considered as the fourth one, once it is also part of every organization. The definition of leadership adopted in this work is the one given by Northouse (2004), which considers the process related to the influence among leaders and followers, where an individual influences a group of people to achieve a common goal. In this sense, the only relationship that matters for the purpose of this paper is between leadership and people. Two groups of factors are considered, one related to leadership and one associated to people.

The first group is concerned with leadership factors. Transformational leadership was chosen to be evaluated in this study. It has been one of the most studied leadership theories in recent

times, especially regarding its application on the evaluation of individual and group performances. Transformational leadership ensures that followers transcend their individual interests for the good of the group, organization, or society, focusing on the progress and development in the long term (Bass, 1997). It is founded on four basic components:

- Charisma or idealized influence: it may be attributed or behavioral, it provides high standards of emulation, creating vision and trust;
- inspirational Motivation: provides challenges and the commitment of followers toward shared goals;
- intellectual stimulation: promotes the formulation of a vision, critical analysis and evaluation of situations, implementation of standards, and the generation of creative solutions;
- individualized consideration: this consists in treating followers as individuals, through their training, development, guidance in the pursuit of their growth.

Transformational leadership tends to be better suited to high performance organizations, focused on projects with a high degree of innovation. To Shenhar and Widemann (2000) projects with a high degree of innovation are characterized by entrepreneurial leaders with strategic thinking and a vision of the future, imaginative, who exude confidence and charisma. These leaders are concerned with people needs, treating all individuals as human beings, and considering them as the organization main asset.

The second group is related to organizational factors. Among the factors that affect organizational performance the most cited in the literature are communication, flexibility of individuals, maturity of the teams, continuous delivery and continuous improvement.

High performance organizations driven by projects are characterized by a highly interactive internal communication, with the clear disclosure of results and strategies for generating of the teams commitment (De Waal, 2007). This communication occurs between all the levels in an organization, sharing information and aligning project outcomes and the organization (Sharp, Hides, & Bamber, 2000).

The flexibility of the people also plays an important role for the participation of people in multiple simultaneous tasks, with the consequent alternation of roles. People were characterized by the acceptance of change, simultaneous tasks, the alternation of roles and living with the uncertainties resulting from this, as an integral part of the business (De Waal, 2007). The focus given to flexibility in this work is related to a more individualized and holistic approach, as that presented by Karrupan (2005) and Martín (2006). The types of flexibility are considered as intrinsic, malleable and relational of the people. The versatility of the application of the resource in many situations, in response to contingent situations, represents intrinsic flexibility. The malleability differs from the intrinsic flexibility because of the characteristic of processing resources in order to expand its training and employment in different situations. Relational flexibility is also linked to a transformation, more specifically the individual's capacity to establish networks with and between the available resources.

The maturity of the team is represented by the existence of teams working together, motivated, they are gifted, showing a great ability to improvise, able to make decisions with autonomy, self disciplined and organized. The leader provides the power distribution, authority and responsibilities among the members, contributing to the motivation and confidence of the team (Gunasekaran, 1999; Hackmann, 1987). Members of the teams participate in project planning. The planning is participatory and adaptive and is held together with customers, collaborators and managers. This happens continuously, with the planning being modified and adapted to each stage of the project (Cockburn & Highsmith, 2001).

Continuous improvement has been pointed as an alternative to survive in the actual markets, characterized by high levels of uncertainty, customized products, and short delivery time. It can be defined as a process that is extended to all organization, focused on continuous incremental improvement based on innovation (Bessant, Caffyn & Gallager, 2001). This concept is revised by Terziovski (2002), who considers that the search for the performance excellence is associated to a radical level of innovation, rather than incremental improvement. The evolution of this concept demonstrates how the survival of an organization nowadays is based on the competitiveness coming from the great innovation and continuous improvement of products and processes.

Continuous delivery represents the capacity of delivering results among the time. According to Terziovski (2002), results are obtained through people actions. The term continuous delivery is directly linked to organizational performance, and reflects the gathered results from actions over the processes. These actions can be related to continuous improvement or due to maintenance of well established routines. As it happens with continuous improvement, continuous delivery can be a result of individual efforts, like people performance, as well as organizational (group) performances like number of new developed technologies, patents, and market share. Continuous delivery plays an important role during the iterative project development phase.

Project performance is the most important outcome of any organization driven by projects. Project performance is evaluated based on the care of the technical characteristics (compliance), time delivery and budget disbursement. They are among the most representative control items used to follow the project development found in the literature.

### 2.2. Research methodology

The framework followed in this study can be found in Fig. 1.

The main assumption is that leadership factors affect the mean (organizational factors), and this impacts the project performance (output). Leadership factors can also impact directly the project performance, as well as organizational factors. The tool used to analyze and validate the proposed framework is AI, more specifically Bayesian networks (BNs). They are used as a way to provide a decision-support framework for problems involving uncertainty, complexity and probabilistic reasoning. The approach is based on conceptualizing a model domain (or system) of interest as a graph (i.e., network) of connected nodes and linkages. In the graph, nodes represent important domain variables and a link from one node to another represents a dependency relationship between the corresponding variables. A conditional probability table (CPT) is used to describe the probability of each value of the child node, conditioned on every possible combination of values of its parent nodes. These describe the strength of the causal relationships between variables. If a variable has no parents, it is described by a marginal probability distribution. The posterior probability distribution for a variable is calculated given new observations. The main use of BNs happens in situations that require statistical inference (probability of events), and there are known evidences, get from some events that have been observed, while there is a need of forecasting of

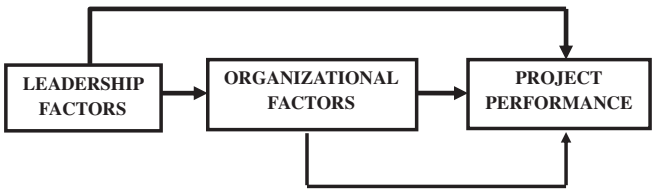


**Fig. 1.** Framework of the study.

**Table 1**
Example of the questionnaire used for data collection.

| Main feature | Component | Issues (indicate how often the following situations happen) |
|---|---|---|
| Flexibility | Intrinsic flexibility | If necessary, people allocate to this project/area can be easily moved to other jobs with similar responsibilities to their current jobs or more skilled |
| | Malleability skills | People on this project/area quickly learn new procedures and processes introduced in their work/routine and are determined to find their self development and empowerment |
| | Malleability behavior | People on your project/work area operate voluntarily and efficiently under circumstances shrouded in uncertainty and ambiguity and to solve problems, even when they do not have all the information about them |
| | Flexibility Relational | People in this project/area exchange ideas with people from different project/areas and develop solutions to problems, establishing partnerships, even if it is not under their responsibility |
| Response options | Never (1) – Seldom (2) – Sometimes (3) – Often (4) – Always (5) (** Between the brackets are the weights associated with each alternative **) | |

**Table 2**
Questionnaire for evaluation of project performance.

| Main feature | Component | Issues (according to your perception indicate how satisfied you consider the situations that are described below) |
|---|---|---|
| Project performance | Care of the technical characteristics | The results/outcomes of the project to date and in accordance with the stage of the project/ schedule (complying with the technical specifications in the project) |
| | Delivery | The progress of this project, taking into account the compliance of the schedule (deadlines, and delivery time) |
| | Budget conducted X provided | Expenses/costs of the project to date, taking into account the budgeted amount and according to the stage of the project (schedule) |
| Response options | Not satisfactory (1) – Not very satisfactory (2) – Reasonably satisfactory (3) – Satisfactory (4) – Higher than expected (5) (** Between the brackets are the weights associated with each alternative **) | |

other events, which have not yet been observed, as is the case of the system under evaluation in this study. This forecast ability represents an important feature of BNs. Many applications of BNs have been reported in literature, covering a wide range of different areas like medicine (Eom, Kim & Zhang, 2008; Wang, Qu, Liu, & Cheng, 2004), quality (Correa, Bielza, & Pamies-Teixeira, 2009) and financial analysis (Kirkos & Spathis, 2007).

The procedure used to construct the BN in this work is the one described by Nadkarni and Shenoy (2001). The first step consists on the construction of a causal map representing the cause – effect relations embedded in managers (leaders) thinking. In this study, the confirmatory approach is employed to construct the map. It means that the knowledge shown in the causal map is developed by individuals over a long period of time (experience) and is relatively stable in nature. Data is collected by means of structured techniques (structured interviews or questionnaires). Correlation analysis is used to identify the strongest linkages among the process (system) variables. It does not imply causation, but serves as a basis to reduce the complexity of the network. The combination of correlation analysis and temporal order (sequence of events over time) provides a best approach for causal map construction (Lagnado & Sloman, 2006).

Since the causal map is ready, the next step is the construction of the Bayesian network. It consists of three parts. The first part is related to the modification of the causal map structure in order to make it compatible with the BN. It concerns with analysis of conditional independencies, i.e., given a sequence of variables, an absence of arrow from a variable to its successors in the sequence implies conditional independence between these variables. Conditional independence is an important issue in making inferences since it specifies the relevance of information on one variable in making inference on another. Still in this first part of the procedure, it is also important the evaluation of the reasoning underlying the cause – effect relations. Individuals perceive this reasoning in two ways; deductive and abductive. The first one happens when

**Table 3**
Correlation matrix (bold numbers indicate high correlation levels – $r$ (absolute value) $\geqslant 0.75$).

| Variable | IC | IS | II | IM | FL | CI | CD | CO | TM | OV | PP |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IC | X | | | | | | | | | | |
| IS | 0.69 | X | | | | | | | | | |
| II | **0.75** | 0.49 | X | | | | | | | | |
| IM | **0.81** | 0.68 | **0.82** | X | | | | | | | |
| FL | **0.82** | **0.75** | 0.58 | 0.73 | X | | | | | | |
| CI | 0.71 | 0.57 | 0.58 | 0.59 | 0.73 | X | | | | | |
| CD | **0.81** | 0.71 | 0.66 | 0.74 | **0.82** | 0.69 | X | | | | |
| CO | **0.82** | 0.68 | 0.57 | **0.76** | **0.82** | **0.76** | **0.79** | X | | | |
| TM | **0.78** | **0.77** | 0.61 | 0.69 | **0.85** | 0.72 | **0.87** | **0.79** | X | | |
| OV | −0.74 | −0.64 | −0.57 | −0.69 | **−0.76** | −0.63 | −0.69 | −0.71 | **−0.79** | X | |
| PP | **0.88** | **0.77** | 0.64 | **0.83** | **0.89** | **0.79** | **0.85** | **0.92** | **0.87** | **−0.83** | X |

IC: Individualized Consideration.
IS: Intellectual Stimulation.
II: Idealized Influence.
IM: Inspirational Motivation.
FL: Flexibility.
CI: Continuous Improvement.
CD: Continuous Delivery.
CO: Communication.
TM: Team Maturity.
OV: Overlap of Activities.
PP: Project Performance.

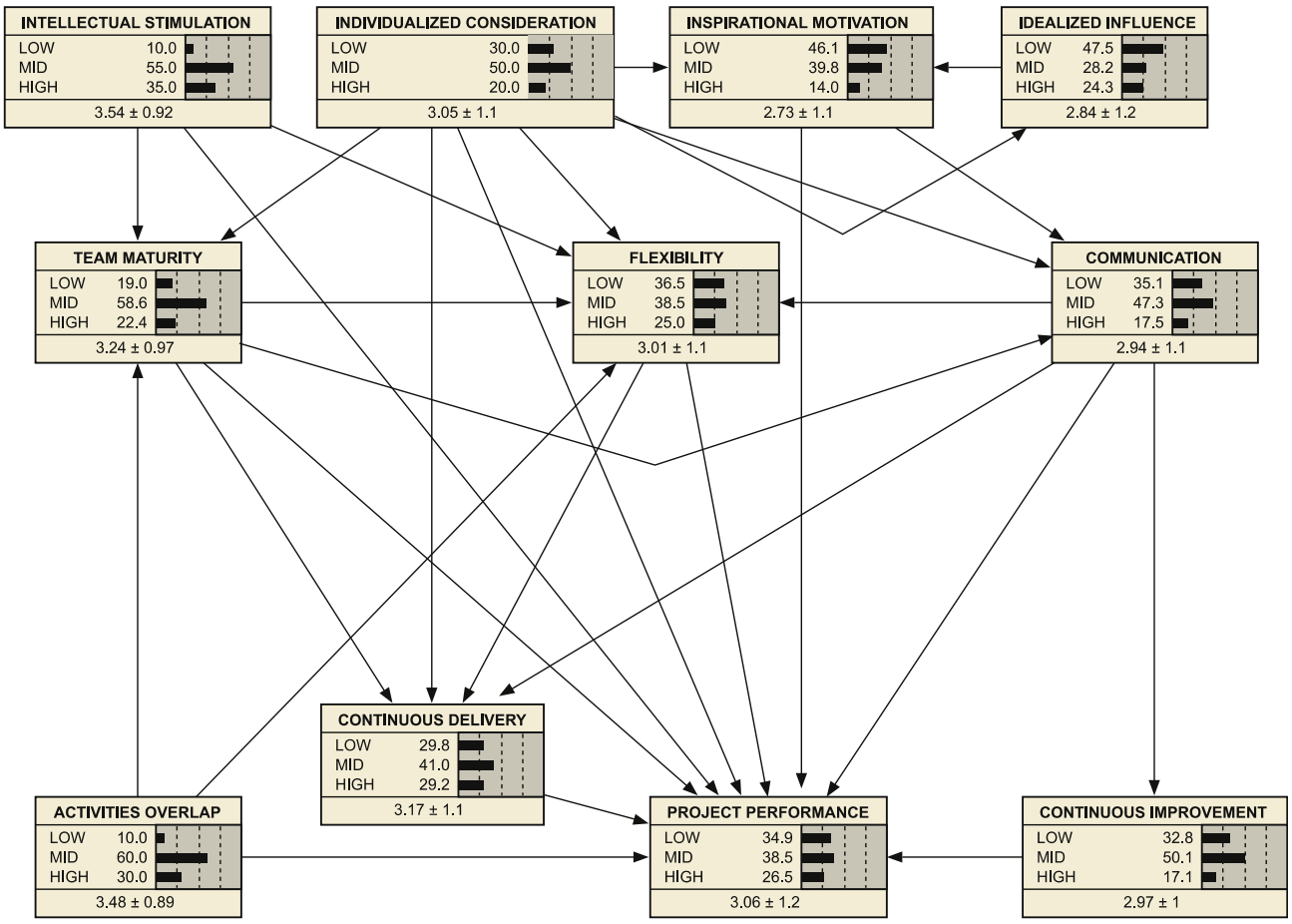


**Fig. 2.** Proposed Bayesian network (BN).

reasoning flows from causes to effects, i.e., in the direction of causation. The second happens when reasoning comes from effects to causes (opposite direction of causation). Distinguishing between direct and indirect relationships and elimination of circular relations also play an important role in this phase. The second part during the construction of BNs consists in the use of probability encoding techniques to get the numerical parameters of the modified structure. The last part (third) concerns with the BN validation. It is done in a qualitative basis, by achieving a consensus among multiple raters, or quantitatively by performing a sensitivity analysis under different scenarios, and comparing the results with the domain experts.

## 3. Empirical study

### 3.1. Instrument and sampling

The data collection of this study is based on the answers of questionnaires sent electronically (e-mailing) to the participants of the survey. The questionnaire is composed by 35 questions divided as follows; 18 about leadership style, three dedicated to project performance evaluation, four related to team maturity, two about communication, two concerning individual competences, four related to flexibility and two concerning stress factor. Based on these questions, survey participants were invited to point out what makes a project performance to be below expectations, satisfactory or outstanding. Examples of the questions can be found in Table 1. The final value of the major feature (factor) is obtained by averaging the responses obtained for each component. Considered as key features to be evaluated in this article are the components of leadership style (idealized influence, individualized consideration, intellectual stimulation, and inspirational motivation), organizational factors such as communication, continuous improvement, flexibility of people, team maturity, continuous delivery and project performance. The performance evaluation of the project is made from the perception of respondents about this feature (Table 2).

The concept of the perceived measures adopted in this paper considers the measures taken in relation to an operational definition, but with the measurement units being based on the perceptions of the individuals (Delaney & Huselid, 1996). A study conducted by Ketokivi and Schroeder (2004) in 164 organizations shows that the use of measures based on the perception of operational and financial performance, leads to satisfactory results in terms of reliability and validity, which ensures the application of this type of measurement provided that the assessment is not based on a single informant and biased data (Kennerly & Neely, 2003). For purposes of access to data on the leadership style, a questionnaire MLQ – Multifactor Leadership Questionnaire was used (Bass & Avolio, 1992).

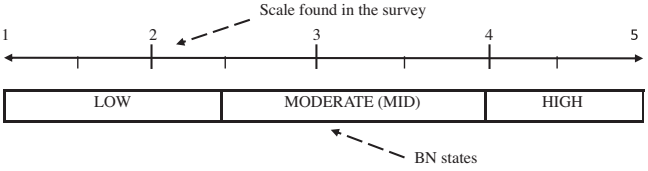


**Fig. 3.** Scale evaluation of survey results and correspondence with BNs states.

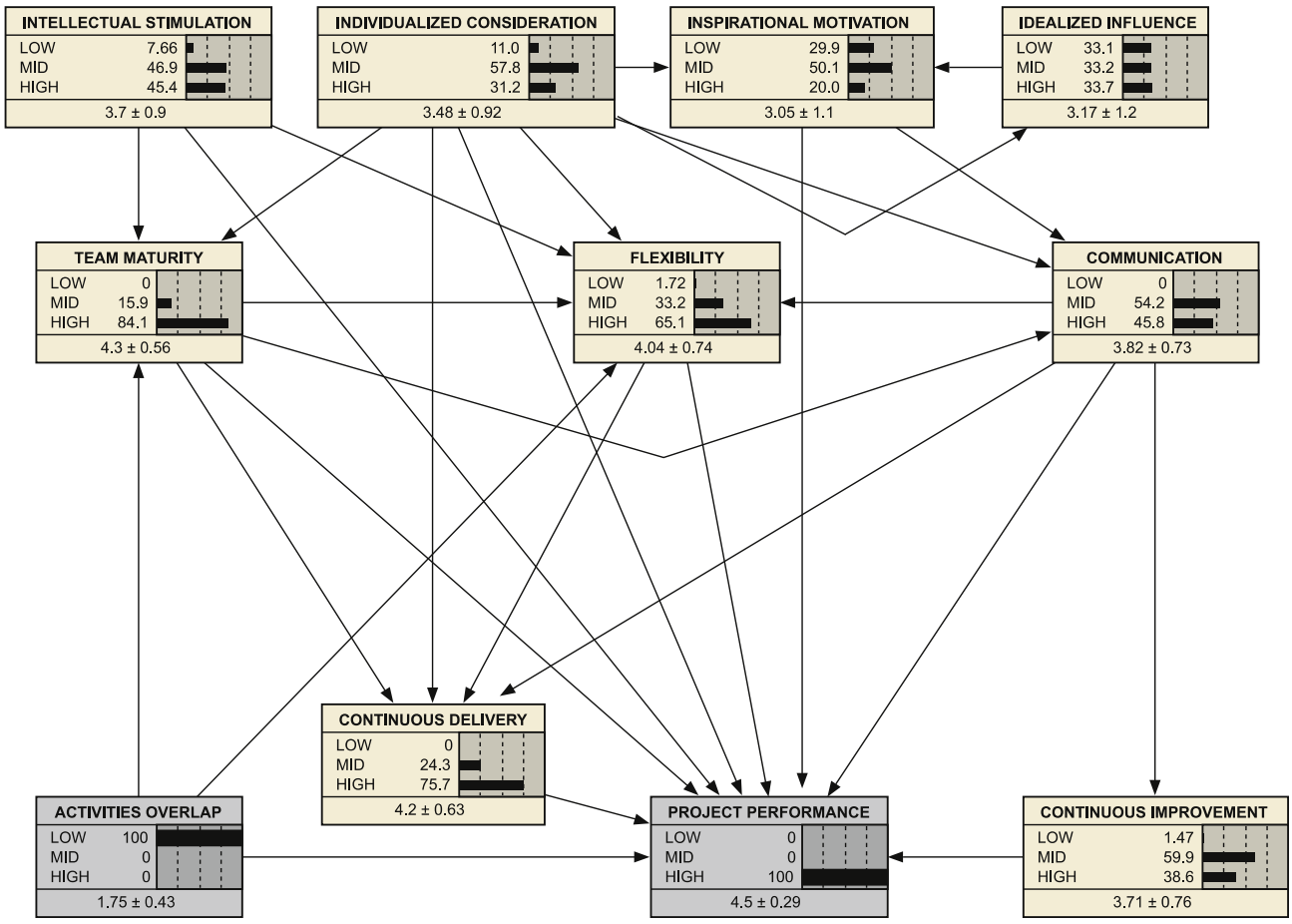


**Fig. 4.** First scenario – high performance and low overlap of activities.

### 3.2. Sample characteristics

The environment where the research is carried out is a research and development (R&D) area. The organizational structure is composed by a group of professionals within their respective specialties compounding, in turn, a larger group called a pool of resources. The strategy that defines the allocation of resources is described below:

- The people and material resources are allocated per project, in temporary and multifunctional teams, via a contract for doing these activities;
- human resources in R&D are arranged in the form of a single pool, composed of technology groups;
- these groups provide resources for all types of projects (small, medium, large and technological development, whose classification depends on the duration and degree of the innovation);
- resource management occurs in two dimensions: resource versus the portfolio of projects;
- resources are managed through the array allocation and abilities;

This makes it possible that the same leader is responsible for one or more projects with different teams and duration. The same happens with the team members that participate in one or more projects simultaneously.

The focus of this work is only on the development projects with a high degree of technological innovation. The group responsible for this type of project in the analyzed company is composed by 154 people and manages an average of 15 new development projects simultaneously. The survey sampling is composed by 32 of the most senior researchers that have been working as project leaders during the last 5 years. The workforce is predominantly male (95%) and highly educated. The sampling is composed by post graduated engineers (35%), graduated engineers (65%), with 45% of the sampled population showing longevity of more than 10 years in the company and 55% less than this. The participants were asked to answer the questionnaires based on their perceptions (experiences) about what makes a project to present a performance below, within or exceeding expectations. The number of responses was 96, considering 32 participants in the survey and three arrays of answers per each of them (performances below expectations, satisfactory or outstanding). In a second step, half of the participants (16 people) were also invited to give their impressions about the actual leadership style and level of overlap of activities in the R&D area, as well as to criticize the proposed causal map and correlated BN.

### 3.3. Data analysis

The survey was conducted on July, 2010, at the R&D area of the analyzed company. Only projects presenting high degree of innovation were considered in this study. The data gathered in the survey was used to perform the correlation analysis (Table 3).

Only correlation coefficients greater than 0.75 (absolute value) were considered to causal map construction purposes. These correlation levels revealed a strong association among the variables. The causal map was constructed based on this data and considering the

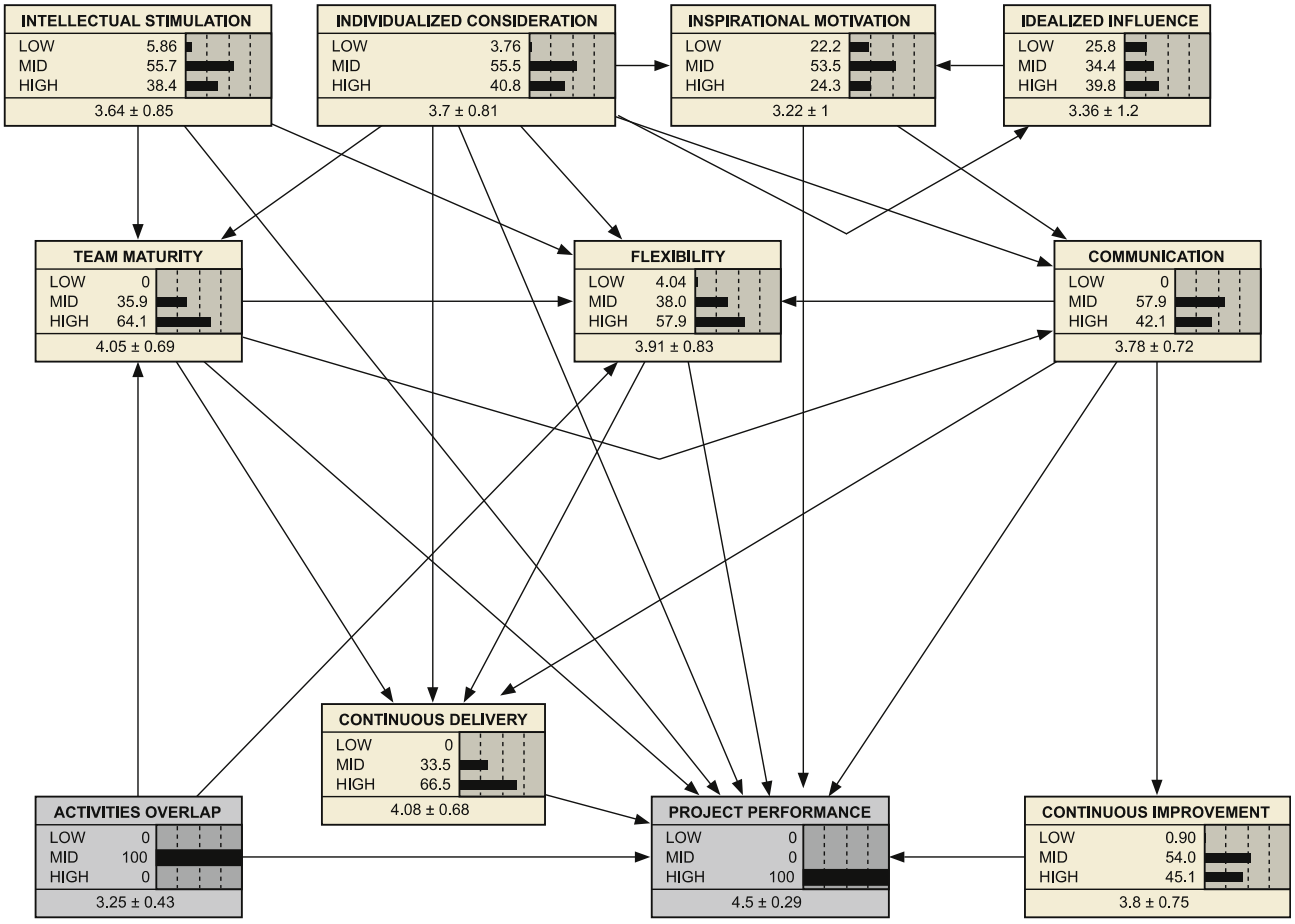


**Fig. 5.** Second scenario – high performance and moderate overlap of activities.

information obtained during the interviews with the participants. It means that factors like temporal order, correlation level and causality check (participant perception about the BN) were used for validation of the relations. The BN constructed in this work is shown in Fig. 2. The software used to construct the BN was NETICA.

The scale of assessment of the survey results can be found in Fig. 3, where it is shown the relationship between the numerical values obtained (survey scale) in the research and its corresponding states in the BN (low/mid/high).

The conditional probabilities were obtained from the survey data. The frequency of occurrence of each situation was considered to find out the probability values.

The inferences were made considering the evidence (100% of chance) of having high performance of innovation projects and three levels of overlap of activities (low/mid/high). The main idea was to understand under which conditions (variables and their states) it is possible to achieve high performances, varying the overlap of activities level. In the first scenario (Fig. 4), under low overlap of activities condition, the highest probabilities of all leadership components lied on the middle (moderate) range, with flexibility, continuous delivery and maturity of team at the high range. Major chances of moderate levels of communication and continuous improvement completed the set of conditions to face high project performances.

No significant changes on the probabilities of individualized consideration and inspirational motivation were found when the overlap of activities became moderate (second scenario – Fig. 5), although increasing probabilities of moderate levels of intellectual stimulation (46.9–55.7%) and high levels of idealized influence (33.7–39.8%) appeared. There was a decrease of the probability of high levels of team maturity (84.1–64.1%), flexibility (65.1–57.9%), continuous delivery (75.7–66.5%), while the chances of high levels of continuous improvement increased (38.6–45.1%). Communication did not change significantly.

When the variable overlap of activities reached high levels (third scenario – Fig. 6), major chances of moderate levels of individualized consideration appeared (72.8%), while the chances of flexibility (67.6%), continuous delivery (64.4%) and maturity of team (100%) to lie at moderate levels increased. The probability of high levels of continuous improvement rose to 65.3%.

It was also analyzed the individual contribution of each variable to the project performance (sensitivity analysis), as it can be seen in Fig. 7. The situation considered in this analysis is the one related to BN shown in Fig. 2.

The variables that presented major influence on the project performance were communication, continuous improvement, continuous delivery, flexibility, team maturity and individualized consideration. This last variable (individualized consideration) contributed directly to the project performance as well as indirectly, by influencing organizational factors, and these affecting the performance. This indirect effect can be seen in Fig. 8, showing the sensitivity analysis of the organizational factor to the other variables.

Influences of leadership factors like individualized consideration, inspirational motivation and idealized influence appeared, while organizational factors were not significantly affected by intellectual stimulation. It is important to mention that the sensitivity analysis can lead to different results according to the situation to be taken into account.

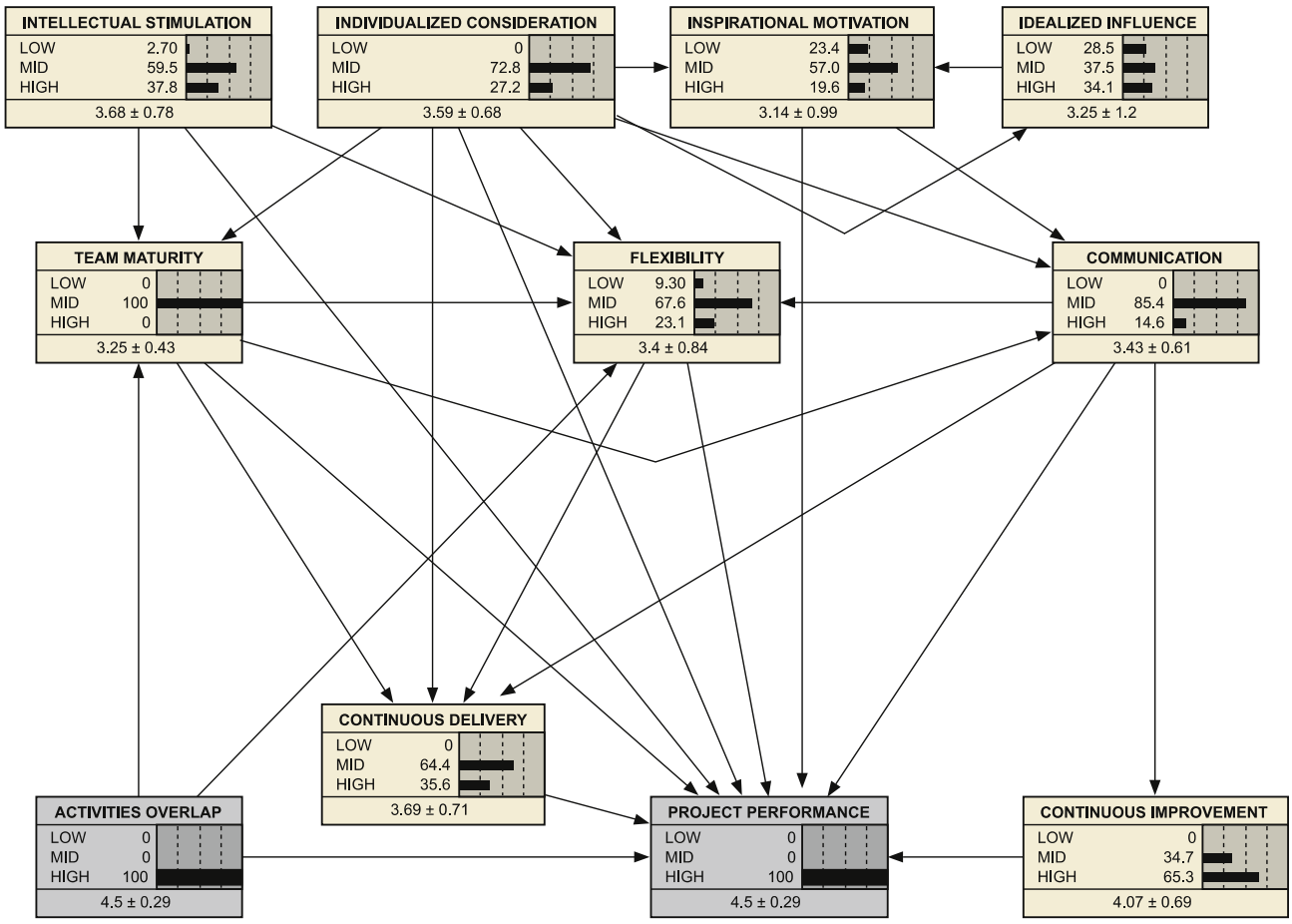


**Fig. 6.** Third scenario – high performance and high overlap of activities.

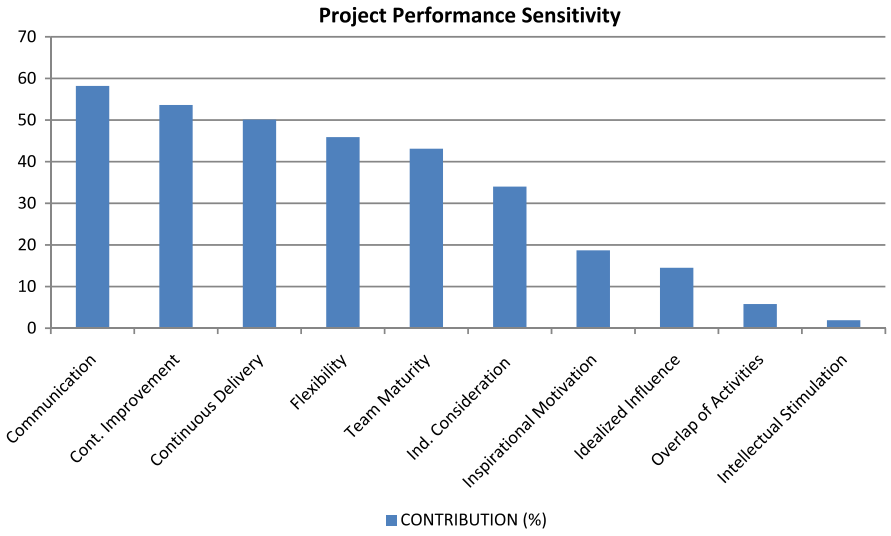


**Fig. 7.** Project performance sensitivity analysis.

### 3.4. Discussion

The analysis undertaken in this article shows that with transformational leadership, better project performances are obtained. This fact is corroborated by studies conducted by Barling et al. (1996), Howell and Avolio (1993), Keller (2001), Prabhakar (2005) and Jung and Sosik (2002) among others, establishing a relationship between this type of leadership and the performance of project teams. The variable overlap of activities plays an important role in this case. Low and moderate levels of overlap of activities associated to a moderate transformational leadership can drive to high performances, by means of high levels of flexibility, continuous delivery and maturity of team. It is observed that at high overlap of activities, flexibility, continuous delivery and maturity of team reduced their levels from high to moderate. In this situation continuous improvement becomes high, what represents

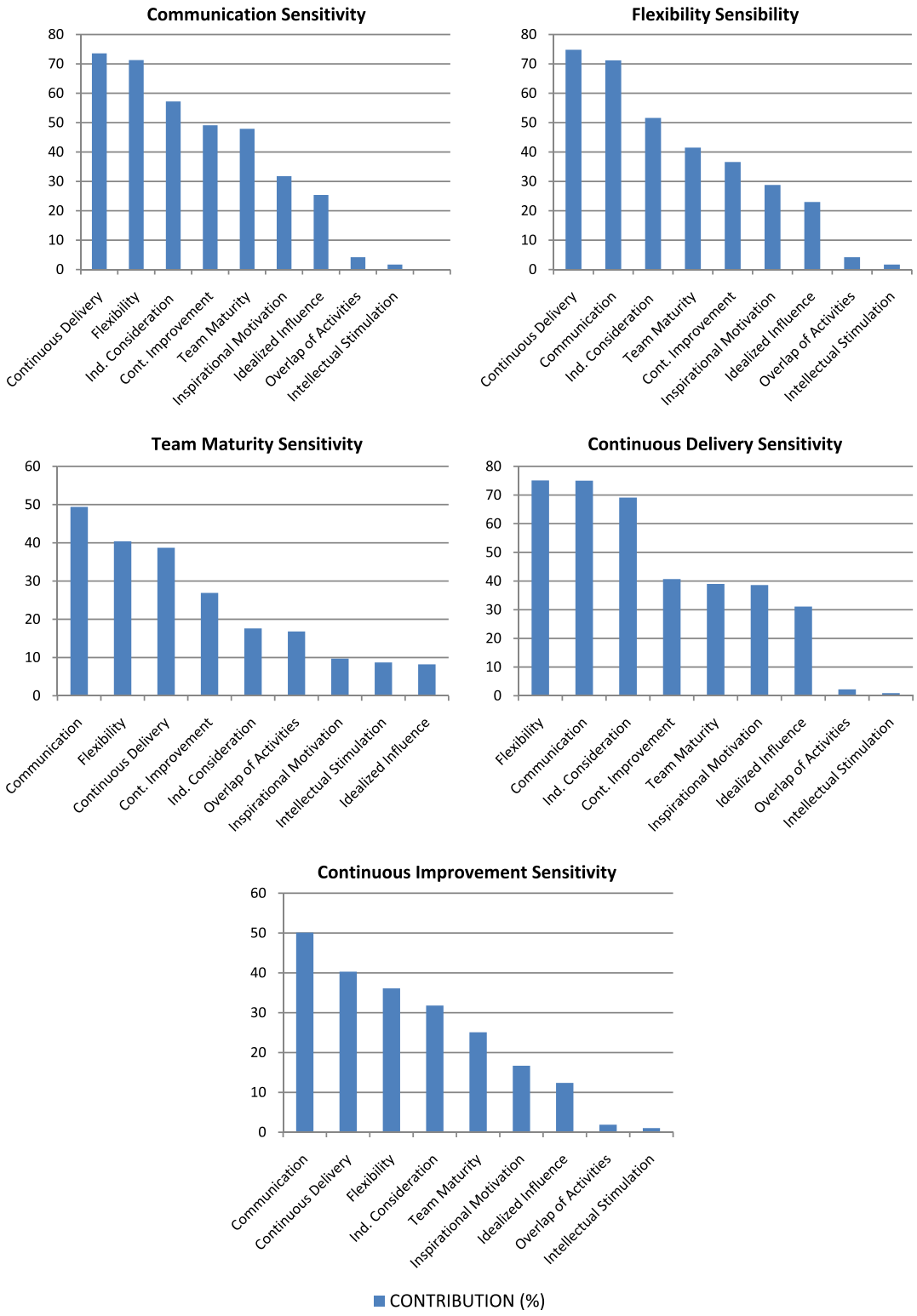


**Fig. 8.** Organizational factor sensitivity analysis.

that high performances are supported by a strong process improvement (robust processes). From the sensitivity analysis of the project performance it is noticed that the leadership factor presenting highest influence is the individualized consideration. This influence can happen directly to the project performance or indirectly, through the influence on the organizational factors, and these ones propagating their influence over the project performance. All organization factors (communication, flexibility, continuous delivery, continuous improvement, team maturity) also have a significant contribution to the project performance. All these findings confirm the validity of the proposed framework.

## 4. Implications and conclusions

The present results that were obtained in this work are in line with several studies on transformational leadership in projects

and in innovation environments. We can conclude that the main objective of this study was achieved through the characterization of boundaries and the ways of influence of the components of transformational leadership on organizational factors and quantification of these effects in the project performance. The results that were obtained show large managerial implications, because they help in understanding how there is an increase in performance levels in innovation projects. These also serve as the basis for the development of leadership strategies and the forecast of their impact on organizational factors for improvement of performance. It is believed that this is an important new contribution to the studies of leadership, either by the nature of the application of AI tools for forecasting and sensitivity analysis, aimed at overcoming some limitations of the statistical methods commonly employed, such as the approach given to transformational leadership in organizations driven by projects with a high degree of innovation.

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