APPLICATION OF CLASSIFICATION TREES FOR COMPARATIVE ANALYSIS OF CONSTRUCTION PROJECT MANAGER’S COMPETENCIES

Krzysztof Dziekoński

Abstract: Project managers’ competencies are one of the factors that have the greatest impact on the success of a project. Therefore, characteristics of a project manager is an important issue for each project based organization. The purpose of this research is to examine differences in the competencies of construction project managers in Podlasie (Poland) and Johor Province (Malaysia). As a result of that study a classification trees were constructed. The characteristics that differentiate competence of construction project managers are features related to personality (expressing confidence, self confidence, intellectual abilities, creativity) and managerial competence (ability to assess the impact of action taken, ability to work in a team, ability to formulate goals, ability to deal with stress and ability to make decisions) of the project manager. The research results contribute to a cross-cultural studies in project management through identification of features that differentiate project managers’ competencies in various countries.

Keywords: classification trees, competencies, project manager, construction industry

Introduction

Growing number of activities implemented through projects and led by project managers increases the importance of project leaders competencies. “Talent shortage” survey (Manpower, 2010, 2012) indicates that project managers are among the most needed professions (in 2010 - second place in 2012 - eighth place in the ranking) (Dziekoński, Rasli, 2015). Some companies operating in Poland has difficulty in finding an employee with the right skills to take position of project manager (Dziekoński et al., 2014). Therefore relation of project manager’s competencies and the project performance is the topic of academic research for a several years. Dulewicz and Higgs (2000) have proved that emotional intelligence can explain the variance in the effectiveness of project. Geoghegan and Dulewicz (2008) show that there are significant correlations between personality of project manager and project success. Zika-Viktorsson et al. (2003) identifies psychosocial aspects of construction project management, while Zhang et al. (2013) point out emotional competencies that can influence effectiveness of construction project managers. Głodziński (2013) suggests that issue of project manager choice shall be located in the area of strategic management.

Despite of the fact that project management competencies are an important topic for enterprises, not many researches undertake cross-cultural comparative studies of that phenomenon. Therefore the purpose of that paper is to undertake comparative studies and to examine differences in the competencies of construction

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project managers in Podlasie (Poland) and Johor Province (Malaysia) with the use of classification trees. The paper is structured as follows: in section 2 project managers’ competency is highlighted. In section 3 survey methodology and findings are presented followed by comparative analysis of required project manager’s profiles in Podlasie and Johor with use of classification trees.

**Project manager’s competency**

Project’s result is greatly dependent on the project manager, therefore choice of “good” manager is one of the most important decisions concerning the project (Ahsan et al., 2013). Project manager’s role varies from being the administrator of the project to managerial position. Therefore, the project manager needs a specific set of capabilities and competencies (Huemann et al., 2007). Posner (1987) groups the competencies of project managers into six areas: communication, organizational, team building, leadership, coping, and technological skills. Edum-Fotwe and McCaffer (2000) define role of the project manager leadership in three areas: establishing direction by developing a vision and strategy for transformation process needed for the realization of this vision, motivation of people involved in the project, supporting subordinates in overcoming political, bureaucratic, organizational and personal barriers in the process of project implementation. The project manager’s competency, as described by Project Manager Competency Development – (PMCD) framework (PMI, 2007), is a combination of knowledge, skills, personal characteristics and attitude that are applied to increase the likelihood of delivering projects that meet stakeholders’ requirements. PMCD define those on the basis of knowledge areas of PMBOK (PMI, 2004). International Project Management Association (IPMA, 2009) defines 20 technical competency elements, 15 behavioral competency elements, and 11 contextual competency elements. The Association for Project Management (APM) promotes the FIVE Dimensions of Professionalism (APM, 2008; APM, 2012). Prince 2 (TSO, 2009) defines roles and responsibilities in projects with key competences of each role.

The characteristics of project manager and its influence on effective project leadership is examined by many scholars. Hölzle (2010) considers that essential project manager competencies include: project-based expertise, problem-solving competence, leadership, and social competence. El-Sabaa (2001) indicates communication, organizational, team building, leadership and technological skills. Hao and Świerczek (2010) sees the ability to delegate authority, to negotiate, to coordinate, to make decisions, and to understand their roles and responsibilities as the most important project manager’s competencies. Dainty et al (2004, 2005), Mei et al. (2005) and Madter et al. (2012) shows main features that create a successful construction project manager. These are: reasoned and considered decision-making, team leadership, directiveness/assertiveness, achievement orientation, analytical thinking, flexibility, teamwork & co-operation, initiative, information seeking, conceptual thinking, impact & influence, focus on client's needs. Hölzle (2010) adds to that list intercultural competence. Gonzales et al. (2013) in their
study of Colombian construction industry find out that leadership, ethics, decision making, analytical skills, and teamwork are the features of successful project managers.

Some studies were related to issues of relationship between competencies of project managers and characteristics of implemented projects. Müller and Turner (2010) research project manager leadership competency profiles in relation to different types of projects. They find that simple projects involve more transactional style of leadership, while complex ones transformational leadership style. Hölzle (2010) adds that short-term specialized and low-budget project require different competencies than a long-term, strategic, and large-scale project.

A different approach to project managers’ competencies shows Loufrani-Fedida and Missonier (2015). Inspired by Hitt et al. (2007, p. 1385) statement, that “most management problems involve multilevel phenomena, yet most management research uses a single level of analysis”, created multilevel approach that combines the three levels of competencies (i.e., individual, collective, and organizational). Results of their work suggests a collective competence as a coexistence of individual functional competencies, organizational integrative competencies, and collective mechanisms as collective competence of a project team. The collective competencies are the product of interactions between individual competencies, organizational integrative competencies and collective mechanisms.

In Poland, project managers competencies were studied by Dziekoński and Jurczuk (2013), pointing to a significant “demand” for project leaders who have decision-making skills, effective communication and abilities to motivate the project team members. Similar studies were done by Musiol-Urbańczyk (2010). Baran (2014) believes that project managers should also have competence to the flexible implementation of projects in order to find and take advantage of the key factors affecting the success of the project. Model of interdependence between managerial competence and effectiveness of project management is presented by Kożuch and Sienkiewicz-Małyjurek (2013). Czajkowska and Kadłubek (2015) proved that irregularities in the construction project are significant factor reducing quality of construction processes. Chmielarz (2012) described development trends in management of projects. Spałek (2013) evaluates project management maturity in machine industry in Poland. Generally, the literature studies suggest that project managers competencies can have an impact on the success of a project, therefore characteristics of a project manager is an important issue for each project based organization.

**Survey methodology and findings**

Comparative studies carried out in such a culturally distant countries are not often published. The results of investigations in countries like Poland and Malaysia may constitute a basis for reflection on the degree of globalization. The studies are also one of the results of author’s internship at Universiti Teknologi Malaysia at Johor Bahru. To establish competencies of construction project managers that the most needed in Poland and Malaysia the pilot study of construction companies in
Podlasie (Poland) and Johor province (Malaysia) was conducted. Both provinces are characterized by similar population, similar conditions of economic development arising from the proximity of strong economic centers (Warsaw and Singapore) and similar structure of enterprises in the construction industry. Structured questionnaire survey has been distributed from January 2014 to June 2014. Respondents ranked level of competency on a five point Likert scale with 5 as the highest rank. A total of 112 Polish and 87 Malaysian companies were investigated. Characteristics of the sample is shown in Table 1.

| Characteristics of the sample                  | Malaysia | Poland |
|-----------------------------------------------|----------|--------|
| No of surveyed companies                      | 87       | 112    |
| Average number of projects in the last 12 months | 14.6     | 5      |
| Average duration of project (weeks)           | 4.8      | 27.4   |
| Average number of project team members        | 10       | 14     |
| Average Project Budget* (RM/PLN)              | 469 111  | 416 826|
| Share of micro enterprises in the sample      | 18%      | 21%    |
| Share of small enterprises in the sample      | 49%      | 43%    |
| Share of medium enterprises in the sample     | 11%      | 24%    |
| Share of large enterprises in the sample      | 22%      | 12%    |

Table 1. Characteristics of the sample

Exchange rate of RM and PLN is 1:1

The studied sample include companies operating in different cultures therefore main aim of the investigation was to find out which competencies are specific and can differentiate between Polish and Malaysian construction project managers. A following research question was adopted: which are the project manager competencies that differentiate and can be used to predict the origin of project manager? Following steps were taken in order to answer question: (1) adoption of construction project manager key competences from the literature, (2) collecting sample data, (3) creation of a classification tree, (4) analysis of results. Measures used for survey have been selected on a basis of literature studies. These measures describe personal characteristics as well as managerial abilities. Following 27 measures of project manager’s competency were used for questionnaire: experience in project management, intellectual abilities, ability to make decisions, ability to assess the impact of actions taken, creativity, ability to formulate goals, ability to organize work to subordinates, ability to communicate, expressing confidence, ability to motivate team members, help in solving problems, focus on the goals, assertiveness, self-confidence, authority, integrity and honesty, empathy, ability to use appropriate project management methodology, competence in the area in which project is implemented, ability to manage the scope, time and cost of the project, ease of establishing contacts, ability to work in a team, ability to resolve conflicts, ability to negotiate, aspiration, ability to deal with stress, flexible management style.

The classification of construction project managers’ competencies was made with a use of CART (Classification and Regression Tree) multivariate analysis technique

* Exchange rate of RM and PLN is 1:1
That is a method of classification that splits sample into homogeneous classes. The purpose of classification is to create a precise classifier or to discover the predictive structure of a problem. Method provides a set of conditions that will explain the reasons behind the splitting data into classes or to provide a knowledge of which of the observed variables influence the dependent variable. Classification trees provide a graphical, intuitive way of presenting the interpretations of the classification rules, even for complex models. They deliver ranking of variables ability to discriminate, which is helpful in assessing the impact of independent variables on the classification of the studied phenomenon (Matusik et al., 2012). Classification with CART models are used for several applications from a medical studies (Kitsantas et al., 2007), predicting financial condition of enterprises (Dębkowska, 2015), customer loyalty analysis (Michalak, 2007), income distribution (Kompa, Witkowska, 2013), tourism (Bąk, 2012), educational evaluation (Sanzana et al, 2015) and many others.

In the analysis of project managers’ competencies in Podlasie and Johor province, Gini index was used as a splitting criterion, error classification rule as a pruning criterion and equal cost of a priori misclassification. The analysis was done using STATISTICA (StatSoft, 2014). Classification tree of construction project managers’ competencies in Podlasie (Poland) and Johor (Malaysia) is shown on figure 1.

Fig.1. Classification tree of construction project managers competencies in Podlasie (Poland) and Johor (Malaysia)
Source: own work.

Diagram from figure 1 is a graphical representation of the relationship between the values of variables describing the competencies of construction projects managers and the country of respondent. The boxes (leaves of the tree) present the codes of
the country, the number of elements, and a histogram showing the number of analyzed categories elements.

CART analysis revealed five end nodes that are indicated with bold line. Each classification process leads to a particular status of the dependent variable, which is the respondent's country of origin - Poland, Malaysia. If the respondent indicates a project managers **ability to assess the impact of action taken** as medium, low and very low, respondent works as a construction project manager in Malaysia, but if the respondent indicates a project managers **ability to assess the impact of action taken** as high and very high, respondent works as a construction project manager in Poland. However, due to insufficient homogeneity of data, subset sample required further divisions using additional criteria. As a result, respondent can be classified as a one that works as a construction project manager in Poland when indicates a project managers **ability to assess the impact of action taken** as high and very high AND **expressing confidence** as medium, high and very high AND **self confidence** as high, medium, low, very low AND high **intellectual abilities**. Therefore expressing confidence, self confidence and intellectual abilities are the project managers’ characteristics that “trigger” profile division and clearly differentiate requirements for profiles of construction projects managers in Poland and Malaysia. Thus, the characteristics of project managers that fundamentally differentiate Poland and Malaysia are: ability to assess the impact of action taken, expressing confidence, self confidence and intellectual abilities. Accuracy of prediction of the country of origin of the respondent was 94.51% for Poland and 94.25% for Malaysia.

Classification tree analysis gives additional information on predictors’ importance. It allows to evaluate the average impact of each variable on the accuracy of predictions. Ratings are ranked in the range from 0 to 100, where 0 represents the lowest and 100 the highest predictor importance. Ranking of predictors’ importance is shown in table 2.

**Table 2. Predictors ranking**

| Competency measure                                         | Rank |
|-------------------------------------------------------------|------|
| Intellectual                                               | 100  |
| Creative                                                   | 82   |
| Ability to work in a team                                  | 73   |
| Ability to formulate goals                                 | 71   |
| Ability to deal with stress                                | 70   |
| Ability to assess the impact of actions taken              | 68   |
| Ability to make decisions                                  | 50   |

*Source: own work.*

The results of the predictors ranking does not have to be consistent with the classification tree. Predictor importance is calculated as the average of the importance on every step of the classification tree analysis, while classification tree is built on the strongest predictors on a given step (Breiman et al., 1984). To predict respondents country of origin the most important are intellectual abilities, then creativity, ability to work in a team, ability to formulate goals, ability to deal
with stress, ability to assess the impact of actions taken and ability to make decisions. That also means that above characteristics differentiate the expected behavior of construction project managers in Podlasie and Johor.

**Summary**

Classification trees analysis revealed that ability to assess the impact of action taken, expressing confidence, self confidence and intellectual abilities are the characteristics that fundamentally differentiate project managers in Podlasie and Johor. Additionally creativity, ability to work in a team, ability to formulate goals, ability to deal with stress and ability to make decisions revealed to be features with the greatest impact on the prediction of country of project manager origin. The factors that essentially differentiate competence profiles in both countries are features related to personality (expressing confidence, self confidence, intellectual abilities, creativity) and managerial competence (ability to assess the impact of action taken, ability to work in a team, ability to formulate goals, ability to deal with stress and ability to make decisions) of the project manager. These results are in harmony with the described in literature characteristics of successful construction project manager (Dainty et al., 2004, 2005; Madter et al., 2012; Hölzle, 2010; Dziekoński, Jurczuk, 2013). The research results contribute to a cross-cultural studies in project management through identification of features that differentiate project managers' competencies in various countries. Globalization gives that issue a particular importance.

Predictive capabilities of CART offer a potential for effective management of competences. That is postulated by Jędrzejczyk (2013) who shows that managerial competences in Polish enterprises are not sufficiently managed. Proposed framework can be easily implemented in companies that want to measure and manage their employees. It can be useful in recruitment process and/or correct choice of a project manager or team members. Use of classification trees is particularly attractive in practice because of the ease of its graphical presentation, and through it, ease to understand the complex relationships and conditions that form project managers’ competence profile.

The key limitation of this study is relatively small sample size and its geographical structure. Results cannot be generalized for the entire population. The reasons of revealed differences in competency profiles was not studied. It is assumed that these are a result of cultural differences, also including cultural role of project manager. To clarify those issues additional studies are needed.

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DRZEWÁ KLASYFIKACYJNE W ANALIZIE PORÓWNAWCZEJ KOMPETENCJI KIEROWNIKÓW PROJEKTÓW BUDOWLANYCH

Streszczenie: Kompetencje kierowników projektów są jednym z czynników, które mają największy wpływ na powodzenie projektu. Dlatego cechy kierownika projektu są ważną kwestią dla każdej organizacji projektowej. Celem badań jest określenie różnic w kompetencjach kierowników projektów budowlanych w Podlasiu (Polska) i prowinci Johor (Malezja). Analizy miar kompetencji kierowników projektów budowlanych dokonano przy wykorzystaniu drzew klasyfikacyjnych. Kompetencje, które różnią profile kierowników projektów budowlanych w Podlasiu i w prowincji Johor związane są z cechami osobowości (zaufanie, pewność siebie, zdolności intelektualne, kreatywność) oraz kompetencjami kierowniczymi (zdolność do oceny skutków podjętych działań, umiejętność pracy w zespole, umiejętność formułowania celów, umiejętność radzenia sobie ze stresem i zdolność do podejmowania decyzji). Wyniki przeprowadzonych badań przyczyniają się do wzbogacenia spojrzenia na efekty różnic kulturowych w praktyce zarządzani projektami, poprzez identyfikację cech, które znacząco odróżniają kompetencje kierowników projektu w różnych krajach.

Słowa kluczowe: drzewa klasyfikacyjne, kompetencje, kierownik projektu, budownictwo