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

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Abstract: Project managers' competencies are one of the factors that have the greatest impact on the success of a project. Therefore, a characteristic 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 cross-cultural studies in project management through identification of features that differentiate project managers' competencies in various countries.

Key words: 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 Group, 2010, 2012) indicates that project managers are among the most needed professions (in 2010 - second place in 2012 - eighth place in the ranking) (Dziekonski and Rasli, 2015). Some companies operating in Poland have difficulty in finding an employee with the right skills to take position of project manager (Dziekonski 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

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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 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 (1984) 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). 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 Swierczek (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 and co-operation, initiative, information seeking, conceptual thinking, impact and 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 the topic of project manager's competencies shows Loufrani-Fedida and Missonier (2015).

Inspired by Hitt et al. (2007) 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 suggest 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 Musioł-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 a 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. A characteristic of the sample is shown in Table 1.

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 %

∗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 manager's competencies was made with a use of CART (Classification and Regression Tree) multivariate analysis technique (Breiman et al., 1984). 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 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 and Witkowska, 2013), tourism (Bąk, 2012), educational evaluation (Sanzana et al, 2015) and many others.

In the analysis of project manager's 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.

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.
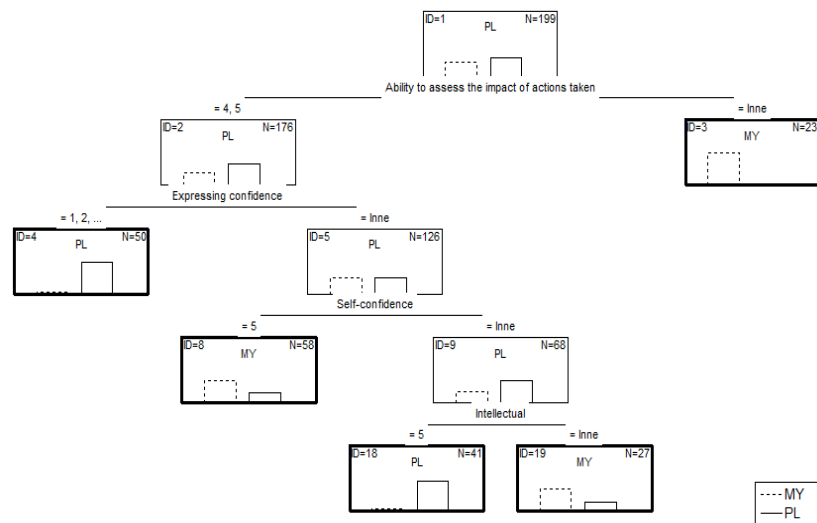
Figure 1. Classification tree of construction project managers'competencies in Podlasie (Poland) and Johor (Malaysia)

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.

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).

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

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 and Jurczuk, 2013).
The research results contribute to 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 tress 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 were 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.

References

Ahsan K., Ho M., Khan S., 2013, *Recruiting Project Managers: A Comparative Analysis of Competencies and Recruitment Signals from Job Advertisements,* "Project Management Journal", 44(5).

APM, 2008, *APM Competence Framework,* Buckinghamshire, Association for Project Management, UK.

Bąk I., 2012, *Wykorzystanie drzew klasyfikacyjnych I regresyjnych do analizy wyjazdów turystycznych gospodarstw domowych seniorów w Polsce*, „Metody Ilościowe w Badaniach Ekonomicznych", XIII/3.

Baran M., 2014, *Skuteczność utrzymywania strategicznej przewagi konkurencyjnej przez liderów branży budowlanej w świetle kryzysu w otoczeniu gospodarczym,* [In:] Baran M. (Ed.), Poszukiwanie przewagi konkurencyjnej, Wybrane uwarunkowania, Kraków, Uniwersytet Jagielloński.

Breiman L., Friedman J.H., Olshen R.A., Stone C.J., 1984, *Classification and Regression Trees,* Wadsworth, Pacific Grove.

Chmielarz W., 2012, *Trends in the development of IT projects' management*, "Polish Journal of Management Studies", 6.

Czajkowska A., Kadłubek M., 2015, *Management of factors affecting quality of processes in construction enterprises*, "Polish Journal of Management Studies", 11(1).

Dainty A.R.J., Cheng M.I., Moore D.R., 2004, *A competency-based performance model for construction project managers*, "Construction Management and Economics", 22,

Dainty A.R.J., Cheng M.I., Moore D.R., 2005, *Competency-based model for predicting construction project managers' performance*, "Journal of Management in Engineering", 21(1).

Dębkowska K., 2015, *Wielowymiarowa analiza kondycji finansowej przedsiębiorstw sektora e-usług,* Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu. „Taksonomia", 25(385).

Dulewicz V., Higgs M. J., 2000, *Emotional intelligence: A review and evaluation study*, "Journal of Managerial Psychology", 15(4).

Dziekoński K., Jurczuk A., Chmay M., 2014, *Kompetencje projektowe podlaskich przedsiębiorstw,* „Zeszyty Naukowe Politechniki Śląskiej. Organizacja i Zarządzanie", 73.

Dziekoński K., Rasli A., 2015, *Dimensions of profession of construction project managers in SMEs in Poland and Malaysia: owners and employees perspective,* [In:] Nikitenko P.G., Gurinovič A.D., Matvejčuk V., Levkevič V.E., Golubovoj O.S. (Eds.), Problemy organizacionno-ékonomičeskogo upravleniâ proizvodstvom, Minsk: Belorusskij Nacionalnyj Tehničeskij Universitet.

Dziekoński K., Jurczuk A., 2013, *Kompetencje osobowościowe lidera projektu,* „Przedsiębiorczość i Zarządzanie", XIV(11).

Edum-Fotwe F.T., McCaffer R., 2000, *Developing project management competency: Perspectives from the construction industry*, "International Journal of Project Management", 18(2).

El-Sabaa S., 2001, *The skills and career path of an effective project manager*, "International Journal of Project Management", 19.

Feldman D., Gross S., 2005, *Mortgage Default: Classification Trees Analysis,* "The Journal of Real Estate Finance and Economics", 30(4).

Geoghegan L., Dulewicz V., 2008, *Do project managers' leadership competencies contribute to project success?,* "Project Management Journal", 39(4).

Głodziński E., 2013, *Strategiczne zarządzanie przedsięwzięciami w przedsiębiorstwach projektowych – zakres i uwarunkowania*, „Przegląd Organizacji", 3.

González G.E.G, Casas G.H.P., Coronado C.A.L., 2013, *Project Manager Profile Characterization in the Construction Sector in Bogotá, Colombia,* "Project Management Journal", 44(6).

Hao C.T., Swierczek F.W., 2010, *Critical success factors in project management: Implication from Vietnam,* "Asia Pacific Business Review", 16(4).

Hitt M.A., Beamish P.W., Jackson S.E., Mathieu J.E., 2007, *Building theoretical and empirical bridges across levels: multilevel research in management,* "Academy of Management Journal", 50(6).

Hölzle K., 2010, *Designing and implementing a career path for project managers*, "International Journal of Project Management", 28.

Huemann M., Keegan A.E., Turner J.R., 2007, *Human resource management in the project-oriented company: a review*, "International Journal of Project Management", 25(3).

IPMA, 2009, *ICB IPMA competence baseline version 3.0*, Nijkerk: International Project Management Association, Netherlands.

Jędrzejczyk W., 2013, *Management of managerial competencies in Polish organizational Practice,* "Polish Journal of Management Studies", 7.

Kitsantas P., Moore T.W., Sly D.F., 2007, *Using classification trees to profile adolescent smoking behaviors*, "Addictive Behaviors", 32(1).

Kompa K., Witkowska D., 2013, *Applications of classification trees to analyze income distribution in Poland*, "Quantitative Methods in Economics", XIV(1).

Kożuch B., Sienkiewicz-Małyjurek K., 2013, *Kompetencje menedżerskie i czynniki sukcesu w zarządzaniu projektami,* „Przedsiębiorczość i Zarządzanie", XIV(11).

Loufrani-Fedida S., Missonier S., 2015, *The project manager cannot be a hero anymore! Understanding critical competencies in project-based organizations from a multilevel approach,* "International Journal of Project Management", 33(6).

Madter N., Bower D.A., Aritua B., 2012, *Projects and personalities: A framework for individualising project management career development in the construction industry*, "International Journal of Project Management", 30.

Manpower Group, 2010, *2010 Talent Shortage Survey,* http:// www. manpowergroup.com, Access on: 20.02.2016.

Manpower Group, 2012, *2012 Talent Shortage Survey,* http:// www. manpowergroup.com, Access on: 20.02.2016.

Matusik S., Pietrzak M.B., Wilk J., 2012, *Ekonomiczno-społeczne uwarunkowania migracji wewnętrznych w Polsce w świetle metody drzew klasyfikacyjnych,* „Studia Demograficzne", 2(162).

Mei I.C., Dainty A.R.J., Moore D.R., 2005, *What makes a good project manager?,* "Human Resource Management Journal", 15(1).

Michalak J., 2007, *On the application of classification trees to analyze customer loyalty and satisfaction,* "Acta Universitatis Lodziensis. Folia Oeconomica", 206.

Müller R., Turner R., 2010, *Leadership competency profiles of successful project managers,* "International Journal of Project Management", 28(5).

Musioł-Urbańczyk A., 2010, *Kompetencje kierownika projektu i możliwości ich kształtowania,* Wydawnictwo Politechniki Śląskiej, Gliwice.

PMI, 2004, *A Guide to the Project Management Body of Knowledge. Third Edition,* Newton Square, Project Management Institute, USA.

PMI, 2007, *Project manager competency development framework,* Newton Square, Project Management Institute, USA.

Posner B.Z., 1984, *What it takes to be a good project manager,* "Project Management Journal", 18(1).

Sanzana M.B., Garrido S.S., Poblete C.M., 2015, *Profiles of Chilean students according to academic performance in mathematics: An exploratory study using classification trees,* "Studies in Educational Evaluation", 44.

Spałek S., 2013, *Dojrzałość przedsiębiorstwa w zarządzaniu projektami*, Wydawnictwo Politechniki Śląskiej, Gliwice.

StatSoft Inc., 2014, STATISTICA (data analysis software system), version 12. http://www.statsoft.com, Access on: 20.02.2016.

TSO, 2009, *Managing Successful Projects with PRINCE2*, Norwich, The Stationery Office, UK.

Zhang F., Zuo J., Zillante G., 2013, *Identification and evaluation of the key social competencies for Chinese construction project managers,* "International Journal of Project Management", 31(5).

Zika-Viktorsson A., Hovmark S., Nordqvist S., 2003, *Psychosocial aspects of project work: a comparison between product development and construction projects*, "International Journal of Project Management", 21(8).

STOSOWANIE DRZEW KLASYFIKACYJNYCH DO ANALIZY PORÓWNANWCZEJ KOMPETENCJI KIEROWNIKA PROJEKTU BUDOWY

Streszczenie: Kompetencje kierowników projektów są jednym z czynników, które mają największy wpływ na powodzenie projektu. Dlatego też cechy kierownika projektu są ważną kwestią dla każdej organizacji opartej na projektach. Celem niniejszego badania jest zbadanie różnic w kompetencjach kierowników projektów budowlanych na terenie Podlasia (Polska) i prowincji Johor (Malezja). W wyniku tego badania zostały zbudowane drzewa klasyfikacyjne. Charakterystykami, które odróżniają kompetencje kierowników projektów budowlanych są cechy związane z osobowością (wyrażanie pewności, pewność siebie, zdolności intelektualne, kreatywność) oraz kompetencje kierownicze (zdolność do oceny skutków podjętych działań, umiejętność pracy w zespole, umiejętność formułowania celów, umiejętność radzenia sobie ze stresem i zdolność do podejmowania decyzji) kierownika projektu. Wyniki badań przyczyniają się do międzykulturowych badań w zarządzaniu projektami poprzez identyfikację cech, które odróżniają kompetencje kierowników projektu w różnych krajach.

Słowa kluczowe: drzewa klasyfikacyjne, kompetencje, kierownik projektu, przemysł budowlany

建築項目經理的競爭力比較分析應用分類階段

摘要：項目經理的能力是對項目成功有最大影響的因素之一。因此，項目經理的特點是每個項目組織的一個重要問題。本研究的目的是研究波蘭Podlasie和馬來西亞柔佛州建築項目經理的能力差異。作為該研究的結果，構建了分類樹。區分建設項目經理的能力的特徵是與個性（表達信心，自信，智力，創造力）和管理能力（評估所採取行動的影響，在團隊中工作的能力，制定能力目標，處理壓力的能力和作出決策的能力）。研究結果有助於項目管理的跨文化研究，通過識別各個國家項目經理能力的特徵。

關鍵詞：分類樹，能力，項目經理，建築業