# MODELLING OF KNOWLEDGE MANAGEMENT FACTORS IN PROJECT ORGANIZATIONS

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**Abstract:** The main factors of knowledge management in organizations that implement capital projects, and their effect on the achievement of project goals, are analyzed in the paper. A conceptual model and three research hypotheses are proposed. The main objective of the paper is to test and validate the proposed model. The Structural Equation Modeling (SEM) approach is used. Testing involved a sample of 1892 respondents from 68 different types of organizations. The outcomes of empirical research validate the hypotheses and indicate that there is a positive correlation among them. The results are suitable for comparison with those of similar studies, conducted in both developed and transition economies.

**Key words:** Knowledge management factors, Project organizations, SEM methodology, Statistical analysis.

## 1. INTRODUCTION

In the contemporary business environment knowledge is one of the most important resources. Jackson and Klobas (2008) claim that from a knowledge perspective, a project is a set of activities based on the development of a common interpretation and understanding aimed at achieving project goals. Both personal and collective knowledge is generated during the course of project implementation, as pointed out by Prencipe and Tell (2001). The knowledge gained in this manner contributes to more efficient accomplishment of project tasks and objectives. In the long term, a knowledge warehouse is formed which is an important resource for the organization in terms of future project implementation efficiency (Ebert & De Man, 2008). Almeida and Soares (2014) point out that this process takes place only if organizations manage knowledge appropriately and use adequate means to generate, accumulate and distribute the knowledge to project teams, where the knowledge is re-used, developed and improved.

The shift from a centrally programmed to a market oriented economy was a radical change in Serbia. Even though Serbia's transition economy is becoming increasingly similar to western economies, the competitiveness of certain organizations is still riddled by remnants of the former political and economic system. Namely, the contemporary way of conducting business requires appropriate knowledge management to achieve project goals.

This subject matter motivated the research, whose objective was to assess the level of development of the knowledge management concept in Serbian organizations that implement capital projects.

Also, following a detailed review of relevant literature the conclusion was that the effect of knowledge management factors on the achievement of project goals is a problem addressed in many studies undertaken in developed economies worldwide. However, reports that deal with this issue in transition economies are rather rare. Based on available literature, no similar research has been conducted in Serbia. As such, the authors believe there is a gap in the study of knowledge management in transition economies, which is partially bridged by the present research.

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The scientific contribution of this research could be reflected in the fact that the results would be suitable for a comparative analysis with the results of research in other regions. This would enable the establishment of universal correlations that could contribute to the development of the knowledge management concept. An additional contribution would be to narrow down the previously mentioned research gap.

The present research aimed to determine the mechanisms by which knowledge management drivers affect the achievement of project goals from the standpoint of an individual engaged by an organization that implements capital projects. The knowledge management factors (KMT-knowledge management tools, KW-knowledge warehouses and KD-knowledge distribution) are latent variables in the structural model (SEM-*Structural Equation Modeling*), and their interaction (structural equations) actually defines the mechanism.

Questions were formulated based on the above facts, including: What is the level of development of project management in Serbia with regard to knowledge management in organizations engaged in capital projects? Do organizations engaged in capital projects develop and use knowledge based on project learning to achieve project goals? These questions were addressed by researchers from countries with developed economies in (Wong et al., 2009; Chen & Liu, 2011; Reich et al., 2012; Ahern et al., 2014; Sokhanvar et al., 2014).

## 2. LITERATURE OVERVIEW AND DEVELOPMENT OF HYPOTHESIS

De Fillippi (2001) stressed that the implementation of capital projects creates excellent conditions for generating new knowledge, which has a favorable effect on the achievement of project goals. This is especially the case where projects have a long timeline (Sydow et al., 2004). However, in the case of short-term projects that involve multidisciplinary teams, experience shows that what is good for the project is not necessarily good for the organization, and vice-versa (Sydow et al., 2004). For this reason learning and knowledge distribution are rather difficult and often in conflict with organizational learning and values. As such, there are often trade-offs between gaining knowledge and project management (Sydow et al., 2004).

Whyte and Lobo (2010) and Jackson and Klobas (2008) discuss the dual role of knowledge management tools and techniques. On one hand, they facilitate the flow and control of project information, while on the other they support knowledge distribution among project team members. The products of modern information technologies, such as the internet, e-mail, search engines, database management software and the like, are tools and techniques for knowledge management both within the organization and on particular projects. Knowledge integration, distribution and management are much more efficient when modern knowledge management tools are used (Adamides & Karacapilidis, 2006; Chen & Liu, 2011). Also, these tools and techniques help project managers and teams to complete specific tasks, but also gain knowledge during the course of the project (Chou & Yang, 2013), and thus improve the chances of project success. Considering the above, the authors propose hypothesis H1.

**Hypothesis H1**: *The use of knowledge management tools in organizations that implement capital projects has a positive effect on the achievement of project goals*.

Project implementation efficiency combines knowledge and learning, which increases the worth of the organization (Pemsel & Wiewiora, 2013). However, Swan et al. (2010) point out that due to the inherent nature of projects, the focus is on time, deliverables and services, rather than on the collection, warehouses, distribution and use of knowledge. This poses a high risk of the knowledge accumulated during the course of the project being irretrievably lost after the project has been completed. To prevent such an outcome and ensure that the knowledge gained is re-used and improved, it has to be adequately documented and stored in databases, from which it can later be retrieved and distributed (Almeida & Soares, 2014). Additionally, the stored knowledge, apart from being directly applied in future projects, generates new knowledge that contributes

further to the success of new projects (Enberg, 2012; Sokhanvar et al., 2014). As such, the authors propose hypothesis H2.

**Hypothesis H2**: *Warehouses of knowledge in organizations that implement capital projects has a positive effect on the achievement of project goals*.

The distribution of knowledge among employees is the greatest support to an organization's learning. Organizations that continually increase their knowledge are better prepared to deal with a dynamic and uncertain environment (Chen & Huang, 2009). To avoid duplication of knowledge or repeating mistakes, efficient processes of knowledge distribution and use within and among projects need to be ensured (DeFillippi, 2001; Prencipe, 2001; Almeida & Soares, 2014). Knowledge is distributed among projects and between projects and the parent organization (van Wijk et al., 2008). Knowledge is thus accumulated within the organization and the use of such knowledge improves performance on each future project and contributes to more efficient achievement of project goals (Sammarra & Biggiero, 2008; Park & Lee, 2014). However, there are cases where knowledge gained on earlier projects and distributed to the parent organization, and vice-versa, cannot be used because it is in conflict with the project goals. As a result, there are often knowledge and project management trade-offs between the parent organization and such projects (Sydow et al., 2004). Pemsel and Wiewiora (2013) and Zhao et al. (2015) point out that the distribution of knowledge among projects often has an adverse effect on the development of organizational and project management capabilities. They attribute the reason for this to the temporary nature of a project and project team members leaving the project, which leads to knowledge fragmentation and inapplicability. In general, the objectives of the knowledge management process are in essence related to project goals and ultimately to the goals of the organization. What is common to them is transfer of knowledge from lessons learned (Terzieva, 2014). In view of the above, the authors propose hypothesis H3.

**Hypothesis H3**: *The distribution and use of knowledge in organizations engaged in capital projects has a positive effect on the achievement of project goals.*

In accordance with H1-H3 hypotheses, the conceptual (research) model is defined, which is shown in Figure 1.

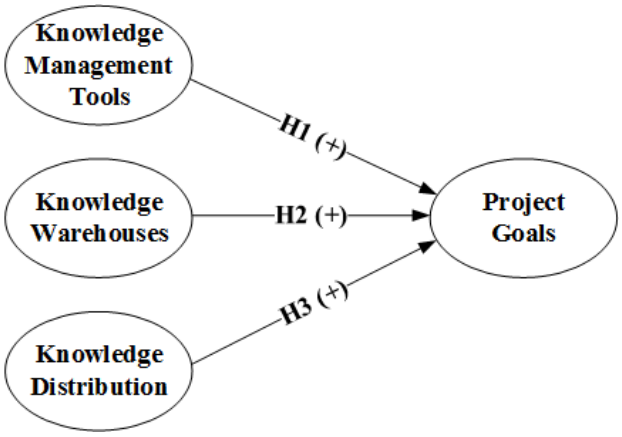


**Figure 1.** Conceptual model

The conceptual model was defined in order to determine the impact factors of knowledge management to the achievement of project objectives.

## 3. RESEARCH METHODOLOGY

A survey was used in the present research as the method of choice. The questionnaire was developed based on relevant and available

literature, and the starting point was the survey described in (Yang et al., 2014). The questionnaire contains 29 items (variables) that describe the factors of the knowledge management concept: KMT-knowledge management tools, KW-knowledge warehouses, KD-knowledge distribution and PG-project goals, which are shown in Table 1. Factors KMT, KW, KD and PG represent latent variables in the conceptual model. Also, the questionnaire contains 6 items of the demographic character which are shown in Table 2.

**Table 1:** Questionnaire items, means and standard deviations

| Item code | Item | Mean | Std. Dev. |
|---|---|---|---|
| KMT_1 | The internet is used on projects as a knowledge management support tool. | 3.65 | 0.753 |
| KMT_2 | E-mail is used on projects as a knowledge management support tool. | 3.79 | 0.963 |
| KMT_3 | An electronic system is used on projects to manage documentation. | 3.45 | 0.951 |
| KMT_4 | Search engines are used on projects as a knowledge management support tool. | 2.85 | 0.896 |
| KMT_5 | Data mining techniques are used on projects as a knowledge management support tool. | 2.31 | 0.901 |
| KMT_6 | Video conferencing is used for project meetings. | 2.15 | 0.753 |
| KMT_7 | Database managment software is used on projects as a knowledge management support tool. | 2.32 | 1.152 |
| KMT_8 | The knowledge management system functions both on projects and at the organizational level. | 2.22 | 0.923 |
| KW_1 | New ideas and knowledge are propertly documented on projects. | 2.63 | 0.798 |
| KW_2 | New ideas and knowledge are stored and periodically updated during project implementation. | 2.72 | 0.845 |
| KW_3 | Knowledge warehousing is a significant project task. | 2.78 | 0.923 |
| KW_4 | Different sources and types of knowledge are managed efficiently on projects. | 3.15 | 0.833 |
| KD_1 | Project team members share required knowledge. | 3.86 | 0.742 |
| KD_2 | Different departments communicate to acquire new knowledge, methods and techniques. | 3.55 | 0.865 |
| KD_3 | Project teams use the knowledge warehouse to solve problems. | 4.12 | 0.860 |
| KD_4 | Project teams use the knowledge warehouse to carry out activities more efficiently and more effectively. | 3.65 | 0.744 |
| KD_5 | Knowledge is applied in practice on projects. | 4.21 | 0.789 |
| PG_1 | Each stage of a project is implemented according to a predefined plan. | 4.15 | 0.963 |
| PG_2 | Project tasks are completed according to a predefined plan. | 4.12 | 0.689 |
| PG_3 | Projects can be completed before the planned deadline. | 2.77 | 1.101 |
| PG_4 | Projects are implemented according to clients' requirements and terms of reference. | 4.41 | 0.650 |
| PG_5 | Project quality assurance requirements are met. | 4.32 | 0.603 |

| | | | |
|---|---|---|---|
| PG_6 | Projects comply with the project budget. | 3.75 | 0.836 |
| PG_7 | Projects comply with environmental protection requirements. | 4.08 | 0.745 |
| PG_8 | Accidents during the course of a project are rare. | 4.02 | 0.865 |
| PG_9 | Injuries at work during the course of a project are rare. | 3.32 | 0.960 |
| PG_10 | Projects generate new knowledge, methods and techniques. | 3.58 | 1.120 |
| PG_11 | Project benefits exceed expectations. | 3.96 | 0.860 |
| PG_12 | Projects achieve excellent results. | 4.23 | 0.748 |

The survey included individuals directly tasked with project activities, as well as project team members involved in project implementation. This enabled the study of mechanisms by which knowledge factors on a project affect the achievement of project goals at the level of an individual.

**Table 2:** The demographics of the study sample (N = 1892)

| Variables | Category | Frekvency | % |
|---|---|---|---|
| Gender | Male | 1284 | 67.9 |
| | Female | 608 | 32.1 |
| Age | ≤ 29 | 341 | 18.0 |
| | 30-44 | 1067 | 56.4 |
| | 45-54 | 368 | 19.5 |
| | ≥55 | 116 | 6.1 |
| Educational level | Elementary school | 293 | 15.5 |
| | High school | 1294 | 68.4 |
| | Higher education | 158 | 8.3 |
| | University | 147 | 7.8 |
| Years of work experience | ≤5 | 571 | 30.2 |
| | 6-15 | 940 | 49.7 |
| | 16-25 | 279 | 14.7 |
| | ≥26 | 102 | 5.4 |
| Project position | Manager | 253 | 13.4 |
| | Worker | 1639 | 86.6 |
| Type of organizational activity | Construction | 497 | 26.3 |
| | Agriculture | 157 | 8.3 |
| | Production | 441 | 23.3 |
| | Telecommunications | 128 | 6.8 |
| | Energetics | 177 | 9.4 |
| | Forestry | 92 | 4.8 |
| | Traffic | 142 | 7.5 |
| | Public administration | 156 | 8.2 |
| | Other | 102 | 5.4 |

The data were collected through anonymous surveys of employees at 68 organizations in Serbia: 19 in the construction industry, 7 in agriculture, 12 in manufacturing, 5 in telecommunications, 3 in the energy sector, 5 in forestry, 8 in the transportation sector, 5 in public services, and 4 in other types of organizations. The responses were evaluated using the Likert five-point scale (1 – strongly disagree to 5 – strongly agree). A total of 1892 properly completed questionnaires were collected; 253 of the respondents were managers and 1639 were workers. The ratio of sample size to number of questions was 65.24, considerably above 5 recommended by Hair et al. (Hair et al. 2006).

## 4. RESEARCH RESULTS

SPSS 17.0 and LISREL 8.80 software was used for statistical analysis of the data and testing of the conceptual model.

### 4.1 Descriptive Statistics

Basic statistical parameters – average value and standard deviation – were used for descriptive statistics. The results are shown in Table 1. The average response was from 2.15 to 4.41 and standard deviation from 0.603 to 1.120. The data revealed that most of the respondents "agreed", providing positive feedback and expressing their positive stance vis-a-vis the questions posed.

### 4.2 Control model

First, the MSAs-test (*Measures of sampling adequacy*) was done. For this purpose KMO indicator (*Kaiser-Meyer-Olkin Measure of Sampling Adequace*) and Bartlett's test of sphericity were used. For latent variables, the KMO indicator value ranges from 0.748 to 0.892, and Bartlett's test of sphericity Sig.=0,000. The values obtained are above the recommended minimum values (KMO>0.6; Sig.≤0.05), which is in accordance with the recommendations in the paper (Hair et al. 2006). The MSAs (*measures of sampling adequacy*) led to the conclusion that the collected data was suitable for a factor analysis (KMO=0.748÷0.892 > 0.6) and that a correlation existed among the questions in a group (Sig. = 0.000 ≤ 0.05).

#### 4.2.1 Factor Analysis

Exploratory factor analysis (EFA) and Confirmatory Factor Analysis (CFA) were done using the SPSS 18.0. software package. EFA was undertaken to determine the unidimensionality of the main factors (latent variables) in the proposed model, and CFA to determine the reliability and validity of the control model. The outcomes are shown in Table 3. The results of EFA corroborate the unidimensionality of all the latent variables in the model, given that all the test items/survey questions (variables) were classified into one factor set each, whose eigenvalue was greater than 1. The factor loading of the variables was from 0.426 to 0.943, which is greater than 0.4 recommended for samples of more than 300, according to (Floyd Widaman, 1995). Based on the results, the latent groups of variables could be reliably described using pre-defined variables (survey questions).

**Table 3:** *The results of the EFA and CFA statistics for control (measurement) model*

| Latent variable | Variable | Exploratory Factor Analysis (EFA) PCA | | Confirmatory Factor Analysis (CFA) | | |
|---|---|---|---|---|---|---|
| | | | | Reliability | Convergent validity | |
| | | % variance that can be describe one-dimensional factor | Factor loading | Cronbach alpha | Factor loading | *t-value* |
| KMT | | 62.563 | | 0.905 | | |
| | KMT_1 | | 0.482 | | 0.621 | 31.19* |
| | KMT_2 | | 0.426 | | 0.581 | 19.64* |
| | KMT_3 | | 0.566 | | 0.752 | 22.13* |
| | KMT_4 | | 0.802 | | 0.835 | 10.44* |
| | KMT_5 | | 0.840 | | 0.789 | 11.60* |

| | | | | | |
|---|---|---|---|---|---|
| | KMT_6 | | 0.702 | 0.665 | 9.60 |
| | KMT_7 | | 0.685 | 0.653 | 13.19* |
| | KMT_8 | | 0.726 | 0.621 | 8.55 |
| | | 71.233 | | 0.917 | |
| KW | KW_1 | | 0.756 | 0.658 | 9.56 |
| | KW_2 | | 0.806 | 0.674 | 12.67* |
| | KW_3 | | 0.832 | 0.756 | 14.42* |
| | KW_4 | | 0.675 | 0.632 | 23.60* |
| | | 68.859 | | 0.875 | |
| KD | KD_1 | | 0.489 | 0.589 | 35.28* |
| | KD_2 | | 0.462 | 0.645 | 19.00* |
| | KD_3 | | 0.901 | 0.723 | 46.83** |
| | KD_4 | | 0.943 | 0.748 | 24.50* |
| | KD_5 | | 0.728 | 0.689 | 38.05** |
| | | 69.705 | | 0.883 | |
| PG | PG_1 | | 0.823 | 0.743 | 35.60** |
| | PG_2 | | 0.786 | 0.678 | 31.19** |
| | PG_3 | | 0.452 | 0.554 | 19.64* |
| | PG_4 | | 0.721 | 0.623 | 41.42** |
| | PG_5 | | 0.854 | 0.705 | 32.82** |
| | PG_6 | | 0.522 | 0.566 | 21.42* |
| | PG_7 | | 0.611 | 0.598 | 25.60* |
| | PG_8 | | 0.654 | 0.615 | 31.19* |
| | PG_9 | | 0.487 | 0.520 | 19.64* |
| | PG_10 | | 0.536 | 0.589 | 22.13* |
| | PG_11 | | 0.742 | 0.689 | 20.44* |
| | PG_12 | | 0.469 | 0.569 | 31.60** |

*Notes: The level of statistical significance:* * $p < 0.05$; ** $p < 0.01$

Internal consistency, measured by Cronbach's alpha coefficient, was used as a reliability indicator of the control model. In all the latent groups these coefficients were greater than the recommended value of 0.7 (Ho, 2006). This meant that the latent variables were internally consistent and that the variables (survey questions) were reliable for further analysis. Also, based on the factor loading and *t*-value (the last two columns in Table 3), it was apparent that convergent validity was achieved with each survey question within the considered groups. Factor loading of all variables was greater than the recommended value of 0.4 (Floyd Widaman, 1995), and the *t*-test values of most of the variables exhibited an appropriate level of statistical significance ($p<0.05$; $p<0.01$).

### 4.2.2 Fit indicators for the control model

The control model's goodness-of-fit indicators are shown in Table 4. The last column of Table 4 shows recommended values of goodness-of-fit indicators according to (Bentler & Bonett, 1980; Molina, 2007).

**Table 4:** FIT index values for the control model

| Fit indicators | Control model | Recommended values |
|---|---|---|
| Chi-Square ($\chi^2$) | 1291 | - |
| Degree of freedom (d.f.) | 453 | - |
| Relative Chi-Square ($\chi^2$/d.f.) | 2.85 | < 3.0 |
| Root Mean Square Error of Approximation (RMSEA) | 0.095 | < 0.08 – 0.10 |
| Goodness-of-Fit Index (GFI) | 0.87 | > 0.9 |

| | | |
|---|---|---|
| Adjusted Goodness-of-Fit Index (AGFI) | 0.90 | > 0.9 |
| Comparative Fit Index (CFI) | 0.93 | > 0.9 |
| Normed Fit Index (NFI) | 0.92 | > 0.9 |
| Non-Normed Fit Index (NNFI) | 0.92 | > 0.9 |

The relative chi-square value ($\chi^2$/d.f.=2.85<3.0) led to the conclusion that the initial questions of the survey were indeed representative. The RMSEA value of the control model indicators was 0.095, which is acceptable fitting. The GFI indicator was slightly below the recommended value (0.87<0.90), but could be accepted as exhibiting good control model concurrence. RMSEA and GFI indicated an absolute fitting of the model. According to other goodness-of-fit indicators (AGFI=0.90; CFI=0.93; NFI=0.92 and NNFI=0.92), there was a good fit and the data was truly representative. In other words, all the 29 variables (survey questions) could reliably and validly describe the four latent groups of variables, based on the proposed conceptual model.

### 4.3 Testing of the structural model

Following control model validation, the structural model was tested using LISREL 8.80 software, consistent with the proposed approach. Figure 2 shows the results of structural model analysis.

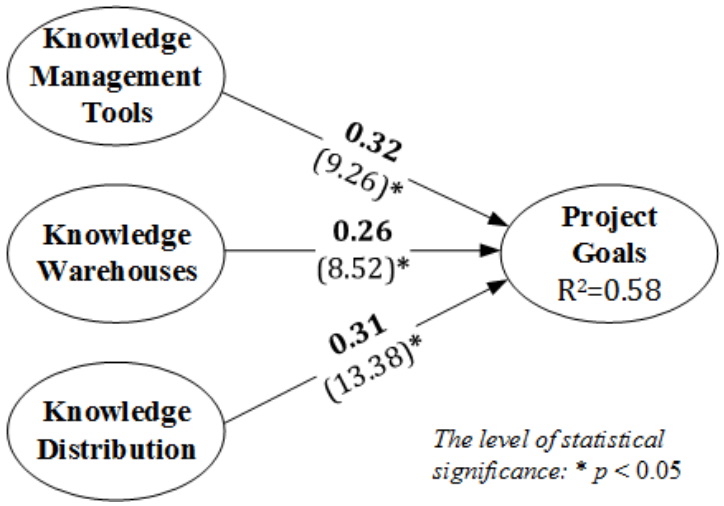


**Figure 2:** Structural model

The value of the regression coefficient explains the strength of the correlation between a dependent and independent variable and is shown above the arrows. The values of the *t*-test are given in parentheses. The asterisk denotes the level of statistical significance. The dependent variable cell shows the coefficient of determination ($R^2$), which is an indication of the proportion of the explained variability relative to total variability, or the variance of the dependent variable predictable from the independent variable.

The results led to the conclusion that all three hypotheses were validated, acceptable and statistically significant because the resulting values were H1($\beta$=0.32; $t$=9.26; $p$<0.05); H2($\beta$=0.26; $t$=8.52; $p$<0.05) and H3($\beta$=0.31; $t$=13.38; $p$<0.05). The value of the coefficient of determination ($R^2$=0.58) indicated that the effect of the latent predictors of the knowledge management tools, knowledge warehouses and knowledge distribution on the latent endogenous variable "project goals" could be calculated with a 58% variance.

## 5. DISCUSSION

Based on the results, the conclusion was that the organizations were duly cognizant about how to apply the knowledge management

concept and that the employees shared the same values and perceptions of the importance of applying the concept. Management had the necessary tools, methods, techniques and models at their disposal to adequately apply the knowledge management concept. However, the organizations tended to suffer from insufficient learning on a project or, in other words, not learning enough lessons from completed projects. This issue is also pointed out by (Bakker et al., 2011). The reason is likely the temporary nature of projects and project team members leaving the project. This trend leads to knowledge accumulation difficulties, as described by (Pemsel & Wiewiora, 2013: Zhao et al., 2015). The problem needs to be eliminated by the project implementing organization. At present, most of the knowledge generated during the course of implementation is irretrievably lost once the project is completed. The methods and mechanisms for addressing this problem would be a starting point of further research.

Another conclusion is that none of the knowledge management factors (knowledge management tools, knowledge warehouses and knowledge distribution) can independently contribute to the achievement of project goals. This means that only their synergy will result in effective creation of knowledge on a project, which is preferable for the organization. An attempt to improve the performance of any individual factor will not facilitate the achievement of project goals because the behavior of a complex system cannot be described solely by the behavior of its individual components. Instead, they need to act in synergy, as pointed out in (Whitty & Maylor, 2009).

Several constraints became apparent during this research. The first is reflected in the fact that the survey was conducted in Serbia, where the best conditions for the implementation of the knowledge management concept, such as exist in developed economies, have not yet been created. The second is that data were collected across Serbia, which required an additional physical effort. The third constraint was reluctance to participate in the survey, generally of older respondents. The reluctance was mostly due to distrust of the examiners, lack of familiarity with the subject matter or lack of understanding of the importance of the survey.

According to available literature, it appears that there are many papers that address this topic but in relation to developed economies. Virtually no such research in transition economies has been reported. Given that the survey was conducted in Serbia, a transition economy, the authors believe that this study is a step towards bridging the research gap and that it is a significant scientific contribution.

## 6. CONCLUSION

The research explored the main factors of the knowledge management concept (knowledge management tools, knowledge warehouses and knowledge distribution) in organizations engaged in the implementation of capital projects, as well as their effect on the achievement of project goals. A survey comprised of 29 questions was compiled for the purposes of the study, divided into four groups plus six demographic questions. A model with three hypotheses was developed and tested on a sample of 1892 respondents employed by 68 different types of organizations in Serbia. The SEM method was used to test and validate the hypotheses (i.e. the conceptual model). According to the results, all three hypotheses exhibited positive correlations and were thus validated, accepted and statistically significant.

The developed and studied model is deemed useful for researchers, given that the results of the present study can be compared with those of other research, conducted in both developed and transition economies. This might lead to the establishment of universal correlations that could be important for further development of project knowledge management.

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