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In-depth Investigation of Project Planning and Control Software Package Application in the Construction Industry of Iran

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ABSTRACT

Inefficient project planning and control have been identified as the main contributor to the reduced performance of the construction industry in Iran. Meanwhile, improper use of planning and control software packages (PPCSPs) in these projects can be a key factor in this reduced performance. This study investigates different aspects of the PPCSP applications to draw the role of PPCSPs in the planning and control processes of construction projects in the country using a survey-based method. It is found that only 32.5% of the construction companies in Iran highly or very highly use PPCSPs. The low level of skill and the lack of management support are two main contributing factors to this reduced PPCSP application. The quality of the academic and vocational project management training programs and the lack of dependable PPCSP technical support are argued as possible sources of the issue. The identified PPCSP pattern in Iran is compared with the results reported for several developed and in-transition countries. This comparison reveals that Iran and in-transition countries fall deeply behind in employing PPCSPs in their construction projects compared to the developed countries.

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NOMENCLATURE

ANOVA	Analysis of Variance	Ph.D.	Doctor of Philosophy
CEO	Chief Executive Officer	PM	Project Management
CPI	Cost Performance Indicator	PPCSP	Project Planning and Control Software Packages
MSP	Microsoft Project		

1. INTRODUCTION

A considerable effort during project implementation is made on planning and control processes [1]. Various methods and tools are introduced to facilitate and improve these two processes during the project implementation. Project planning and control software packages (PPCSPs) are among the most frequently used tools to assist these two project management processes [2]. Positive impacts of PPCSPs on project planning and control processes in general, on the project performance have been identified in the past research efforts [3, 4]. Applications of PPCSPs cover different areas of project management (PM) body of knowledge including time, cost, resource, and communication [5, 6]. It is found that the proper use of PPCSPs increases the chance of project success [3].

Gharaibeh [6] developed a scoring model to evaluate PPCSPs capabilities. He found time management as the most important feature of the PPCSPs with a relative impact weight of 33%. Subramani et al. [7] found that use of industrialized building systems and PPCSP could save a total of 405 days or 42% of the project duration in their 18-floor building case. Pellerin et al. [4] statistically analyzed actual data of 21 large engineering projects and found that large cost-performance improvement in projects with deep engagement of PPCSPs. Riņģis and Bērziša [8] studies revealed that using Redmine, a free

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project management software, improves cost performance indicator (CPI) of projects in the State Social Insurance Agency case.

Mellentien and Trautman [9] performed a benchmark test on 1560 instances of precedence resource-constrained scheduling problems to evaluate the resource allocation capabilities of five different software packages. They concluded that although these software packages are valuable supports for the management of resource-constrained projects, they still fall short in comparison to the best practices. Reddy et al. [10] used Primavera P6 in two construction projects in Dubai, Emirate, to individually and concurrently employ the resource leveling capabilities of the software. They found that the combined resource leveling can reduce resource demand by 5.65%. Aguilera et al. [11] performed a survey on 77 different project managers and found that proper use of PPCSP enhances project managers' performance by 24.6%. Hilmi et al. [12] surveyed the use of computer software in the construction industry of Iraq. In addition to the potential project cost and time improvement, they found that the use of computer applications can improve transparency and reduce corruption. Alojairi et al. [13] identified the positive impacts of PPCSPs on project scheduling and resource allocation in the case study of Saudi Arabia Telecommunication Company. However, they found two constraints to overcome during the project implementation for every three benefits created by the use of PPCSPs. Despite various advantages reported for PPCSPs in projects, there are also disadvantages and limitations found [14]. Their high cost, the complexity of their features, and the low flexibility in meeting specified project needs were identified disadvantages. Regardless of all advantages and disadvantages found for PPCSPs in the project management processes, the important role of PPCSPs in the PM is undeniable.

Currently, many construction projects in Iran suffer from time delays and cost overruns. Researchers have identified poor project planning and control as the main causes of the reduced performance. Asnaashari et al. [15] found traditional management style and poor project scheduling among the top causes of project delays in Iranian construction projects. Khoshgoftar et al. [16] identified poor project planning skills of contractors as one of the key influential factors on construction projects. Fallahnejad [17] identified inaccurate project schedule development as one of the main root causes of the project delays in gas pipeline projects. Rafieizonooz et al. [18] identified a mistaken time and cost estimation, low level of contractors project planning skill, and poor project control as the main causes of delays in construction projects conducted by Tehran municipality. Derakhshanalavijeh and CardosoTeixeira [19] found inaccurate cost estimations and improper planning as the main causes of cost overrun in oil and gas industry in the country. Alvanchi et al. [20] identified incorrect project duration estimation among the main causes of project delays in residential building projects in Mashad, Iran.

Given the considerable impacts of PPCSPs on the planning and control of construction projects, a part of current planning and control issues in the country might return to the PPCSPs. In this perspective identifying the current condition of PPCSPs in the construction projects of the country can provide valuable information for adjusting policies and future moves. It can help construction project managers to measure their organizations' standings and to adjust their efforts in employing PPCSPs in their projects. Likewise, it would be a guide for software corporations in the country to adjust their directions for PPCSPs' development and support. However, investigations on the PPCSPs' condition in the construction projects are still missing in the county. To respond to this need, the aim of this study was set to recognize the current pattern of PPCSPs applications in the construction projects in Iran. Following, in section 2, the questionnaire-based method adopted in the research is explained. In sections 3 and 4 different parts of the designed questionnaire are described and the pilot and actual questionnaire distributions are discussed. The research findings and results are presented and analyzed in section 5, and recommendations are made to properly respond to the identified issues of the PPCSP applications in the country. Finally, in section 6, the research outcomes are summarized and concluded.

2. RESEARCH METHODOLOGY

A comprehensive picture of the PPCSPs applications in the construction projects could be drawn from the collective experience of the practitioners engaged in the construction project planning and control processes. There is no accurate estimation of the population size of these practitioners. However, it is estimated that the construction market in the country has reached $154 billion in 2016 and about 500'000 civil engineers work in this market. Consequently, it was expected that the population size of the target practitioners reaches tens of thousands. With a large number of the target statistical society, a questionnaire-based survey was adopted in the research. Construction project planning and control specialists, construction project managers, construction job site superintendents, and chief executive officers (CEOs) working in construction companies were the main groups in the target society. Practitioners in each group were involved in project planning and control activities with different perspectives. This could help reveal different aspects of PPCSPs applications and their related issues.

In the adopted research method, first, similar investigations on PM computer software packages in different regions were reviewed. A questionnaire-based method was adopted in the research. Therefore, in the second step, the questionnaire was designed based on the identified factors from the literature and the experts' input. Third, a pilot distribution of the questionnaire was performed to estimate the required number of samples and validating the designed questions before the actual questionnaire distribution. The validated designed questionnaire was distributed among different individuals in the target society in the fourth step. In the fifth step, the statistical reliability of the collected data was investigated before analyzing the collected data. In the sixth step, the statistical analysis of the collected data was performed to draw the PPCSP application pattern in the country. In this step, descriptive statistic values were calculated to represent the current standing of the corresponding items. Furthermore, the impacts of various independent variables on the dependent variables were investigated using a one-way analysis of variance (ANOVA) test. Finally, the achieved results were discussed and concluded to draw an overall picture of the current standing of PPCSPs applications. Recommendations were made to overcome the identified challenging issues.

3. SURVEY DESIGN

A total of 26 questions were designed in five different sections to extract the current condition of different aspects of PPCSPs in the country. The questionnaire was initially designed based on the identified applications and features of PPCSPs in the literature. The questions were then refined in consultation with a group of three PM experts with more than 10 years of working experience in planning and managing construction projects in the country. Later on and before the actual distribution of the questionnaire, the questions were validated by 15 respondents who participated in the pilot run of the survey. The majority of questions were based on a five-level Likert scale with 1) very low, 2) low, 3) moderate, 4) high, and 5) very high scores assigned. Following, each question section is briefly explained.

Section 1. Background information of the respondents: In this section, five different independent factors from the survey participants were collected. The job position, education level, field of study, size of the construction companies, and the type of construction projects were collected in this section.

Section 2. Diversity of PPCSPs: In this section different types of PPCSPs used and their frequencies were asked.

Section 3. PPCSPs and project specifications: Frequency of PPCSPs applications in construction projects with different sizes and complexities were asked in this section.

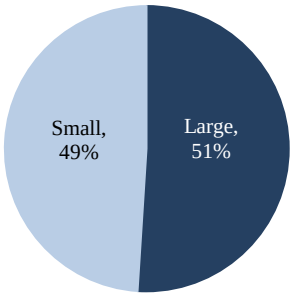
Section 4. PPCSP features: Three common planning and control features of PPCSPs in the construction projects, including tim [6,7,12,13], cost [4,8,12], and resource [9, 10,13], were questioned in this section.

Section 5. Management approach to PPCSPs: In this section levels of the top management's involvement and support in upgrading and purchasing PPCSPs, holding training sessions, and setting related guidelines and instructions for applying PPCSPs in the construction projects were asked.

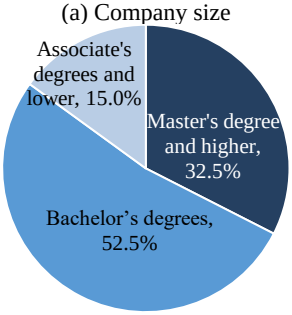
The pilot study was conducted in the participation of 15 practitioners. They were asked to, first, answer the questions and, then, state their opinions about the validity of the questionnaire structure. Several questions were adjusted according to the feedback received from the participants in the pilot survey. The achieved results in the pilot survey were also used for estimating the minimum number of responses required. According to Cochran [21], with the maximum standard deviation of 1.44 achieved for the scores of various questions in the pilot survey, accepted confidence level of 95%, and accepted error level of 0.2, the required number of valid questionnaire responses became 200.

4. DATA COLLECTION

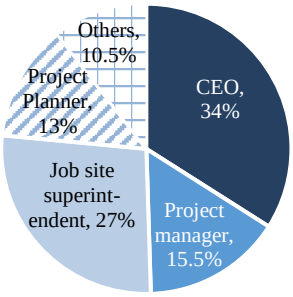
In the actual distribution, questionnaires were distributed among the target society and the responses were collected until 200 required responses were reached. In the end, a total number of 330 paper-questionnaires were distributed which indicated the response rate of 60%. To reach evenly distributed samples, a maximum number of three responses were collected from each contributing construction company. As a result, the collected responses were received from 74 different companies. The reliability of the collected data was confirmed by Cronbach's alpha test with a coefficient value of 0.879. About half of the respondents belonged to the construction companies with more than 50 personnel and the other half belonged to the construction companies with less than 50 personnel. Construction companies' CEOs with a frequency of 34%, job site superintendents with 27%, project managers with 15.5%, and project planners with 13%, respectively formed the highest share among the respondents. About 52.5% of respondents had an education background with Bachelor's degrees, 32.5% had Master's or Ph.D. degrees, and 15% had an Associate's degree. Figure 1 presents the frequency distribution of different groups of respondents. The majority of the respondents had experiences in the building construction projects with a frequency of 60.5% followed by the road construction projects with 49.5%, and the industrial construction projects with 32%.



(a) Company size



(b) Education



(c) Position

Figure 1. Demographic distribution of the survey participants

5. FINDINGS

Achieved results of the survey revealed different aspects of the PPCSPs applications pattern in the construction projects of Iran. Table 1 summarizes this pattern. Further explanation regarding the achieved results is provided in the rest of the section. In each sub-section, if applicable, comparisons were also made between the results achieved for the construction companies in Iran and the ones reported in the literature for other regions.

5. 1. Frequency of PPCSP Applications About 71% of respondents indicated they use some types of PPCSPs during the planning and control of construction projects. This percentage is less than the frequency of PPCSP applications reported in the past studies in 1994 in Australia with 77% [6], in the United States in 1992 and 2001 were 92 and 97%, respectively [22] and 100% portion achieved for international contracting companies [23]. However, it shows a higher percentage compared to the results achieved for Croatia with 40% [24] and Ghana with 39% [25] frequency of PPCSPs applications. The recent advances in information technology (IT) and its full-fledged penetration in different aspects of life raise the expectation that IT-based tools dominate in the construction industry. This takeover is conceivable from the trend of surveys in the western construction companies and is represented in the increased applications of PPCSPs in the construction projects. However, survey results from in-transition countries still do not represent this dominance.

TABLE 1. Summary of results achieved for application pattern of PPCSPs in the construction companies in Iran

Frequency of PPCSPs applications	71%
Frequency of high or very high level of PPCSPs applications	32.5%
Positive impacts of PPCSPs on costruction projects	70%
Most applicable PPCSPs	MSP, Primavera P6 and MS Excel
Identified contributing factors	Educational level, level of skill in using PPCSPs, top management support, company size, project size, project complexity
Identified non-contributing factors	Job position
Most employed feature	Time planning and control

Although 71% of the respondents indicated that they use PPCSPs in their construction projects, only 32.5% of them asserted that they highly or very highly use PPCSPs in the projects. Therefore, a majority of 67.5% of construction companies do not highly or very highly incorporate PPCSPs in their projects. They either depend on traditional planning and control methods or even lack implementation of proper planning and controlling processes in their projects. In the survey, about 58% of respondents from small companies, with less than 50 construction workers on the job site, indicated that they use PPCSPs in their projects. This portion was 83% for large companies, with more than 50 construction workers on the job site. A one-way ANOVA test identified the company size as a contributing factor to the frequency of PPCSP applications with a significant value of 0.02. This factor has also been identified as a contributing factor in the survey conducted by Ali et al. [3] among Project Management Institute's (PMI's) members.

5. 2. PPCSPs Impacts on PM About 70% of respondents found impacts of PPCSPs on the construction projects very highly or highly positive. Five-level Likert scores received for the positive impacts of PPCSPs were averaged based on different job positions as presented in Figure 2a. The average score of 3.73

achieved for CEOs of construction companies was the lowest among all four different job positions that participated in the survey. However, differences in different job positions were not identified as significant in the one-way ANOVA test. The relation between respondents' educational level and their perception about the positive impacts of PPCSPs was also assessed as presented in Figure 2b. The lowest average score here was achieved for practitioners with associate's degrees with an average of 3.23. In the one-way ANOVA test, the educational level of respondents was identified as a contributing factor to their perception about the advantages of PPCSPs with a significant value of 0.013.

5. 3. Type of PPCSPs Among a variety of computer software packages, Microsoft Project (MSP), Primavera P6 and Microsoft Excel were the only software packages used in the planning and control process of construction projects. No domestically developed PPCSP was reported. No practitioners indicated that they have embedded project planning and control modules into their organization's Enterprise Resource Planning or other management information systems. Among respondents with experience in using PPCSPs, MSP was the most popular PPCSP with a total frequency of 87%. It was followed by Primavera P6 with a frequency of 32% and Microsoft Excel with a frequency of 23%. Meanwhile, 50% of respondents with experience in using PPCSPs indicated they use MSP as their only PPCSP; 4% indicated that they use P6 as their only PPCSP; 23% of them indicated they use both MSP and P6 in their projects. About 9% responded that they only use Excel in project planning and control activities. Even though Excel is widely used computer software for general data management and calculations, it lacks many required capabilities from PPCSPs. Expectedly, many required planning and control features are ignored in these projects. Figure 3 presents the frequency of different combinations of PPCSPs used in the construction projects of the country.

Similar to the achieved pattern in Iran, in Malaysia, MSP was the most widely used PPCSP with 96% frequency followed by Excel (88%) and Primavera (65%). Likewise, In Australia, MSP was reported as the most widely used PPCSP with 65% frequency [6]. This order, however, was not the same in the US. According to Liberatore et al. [22], in the US Primavera with 51% and MSP with 24% were the most frequently used PPCSPs in the construction industry. Galloway [26] reported that 65% of contractors in the US use Primavera while 22% apply MSP in their projects. Primavera was also the most widely used PPCSP in Italy [27]. Nevertheless, the frequency of using PPCSP was completely different in Eastern Europe. According to Vukomanović et al. [28], the most prevalent PPCSP was Excel with 56% followed by MSP with 26.5%, GALA with 7%, and Primavera with 4.6%.

Although about 70% of respondents identified the use of PPCSPs in the construction projects very highly or highly positive, only 32.5% of them, highly or very highly, were applying PPCSPs in their projects. One reason for this gap can be linked to the low skill level of the practitioners in working with PPCSPs. For example, while 80% of practitioners with experience of using PPCSPs in the construction project were using MSP, only 46% of them were very highly or highly skilled in using this software. Here, a one-way ANOVA test was conducted by SPSS to assess whether the level of skill is a contributing factor to the level of PPCSPs applications in construction projects. The test identified the skill as a contributing factor to the level of PPCSPs applications with a significant value of 0.000. This Low level of skill in PPCSPs was despite different project planning and control courses offered in the engineering

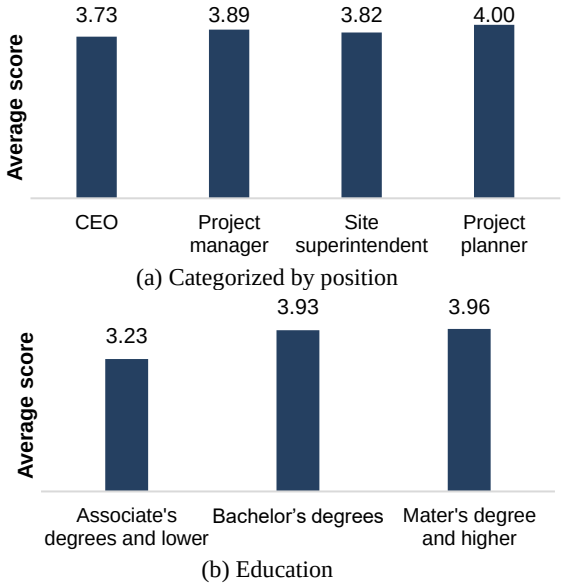


Figure 2. Respondents' perception about the positive impacts of PPCSPs on construction projects

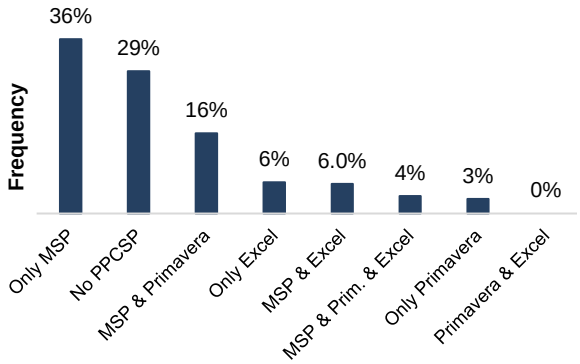
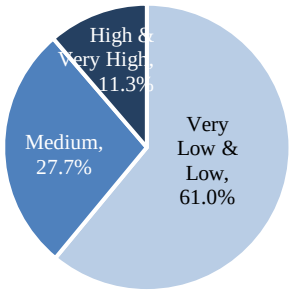


Figure 3. Frequency of different types of PPCSPs used in the construction projects

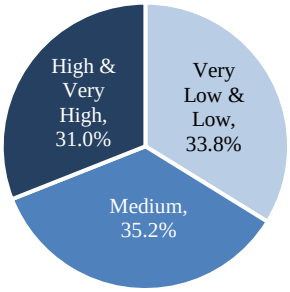
and management departments of the Universities across the country. There are also many MSP and P6 training courses held by vocational training institutions. Holding theoretical and non-practical courses in the engineering departments is an issue previously identified in Iranian Universities. This issue might have contributed to the lack of construction practitioner's knowledge about project planning and control and the way PPCSPs can be practically applied to construction projects.

5. 4. PPCSPs and Project Specification PPCSPs were more used in large and complex projects than small and simple projects. The PPCSPs applications range from 80% in the large to 11% in the small projects. The PPCSPs were used in 83% of the complex projects and were only used in 16% of the low complexity projects. The project size and complexity have also been identified as contributing factors to the level of PPCSP applications in past research efforts (e.g., [3, 5, 22, 23]). Figures 4 and 5 present results achieved for the frequency of PPCSPs applications concerning the project size and complexity.

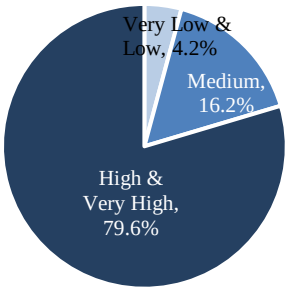
5. 5. PPCSPs Features Time planning and control is the main feature of PPCSPs used in construction projects. About 70% of the respondents indicated PPCSPs are very highly or highly used for time planning and control. This portion was achieved 50% for the cost and 43.5% for the resource planning and control features of PPCSPs. Figure 6 presents the extent of PPCSP applications in the planning and control of the construction projects' time, cost, and resources. Project scheduling has also been previously identified as the most applicable feature of PPCSPs in construction projects in Italy [27] and the top international contractors [23]. In the construction projects in Eastern Europe, however, cost and material-resource planning have been identified as the most prevalent features used [28].



(a) Small projects

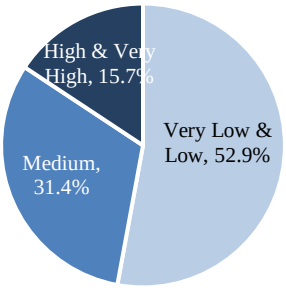


(b) Medium projects

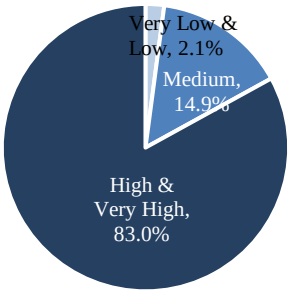


(c) Large projects

Figure 4. Frequency of PPCSPs applications in different sizes of construction projects



(a) Simple projects

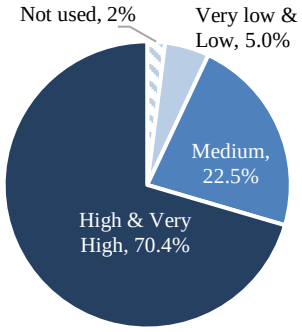


(b) Complex projects

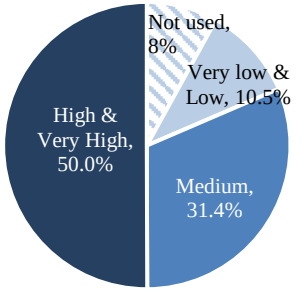
Figure 5. Frequency of PPCSPs applications with respect to the project complexity

5. 6. Management Approach to PPCSPs Four different aspects of management support investigated in the research were 1) purchasing and upgrading PPCSPs, 2) setting training sessions, 3) urging PPCSP applications in construction projects, and 4) acknowledging PPCSPs' advantages. Among those who were using PPCSPs, at least 60% asserted that the commitment and timely action of their companies' management to all four above-mentioned aspects are in the medium or low level.

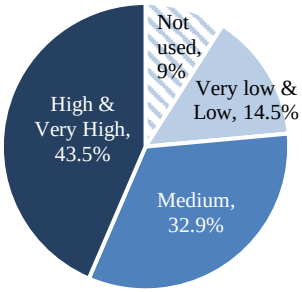
A low level of management support implies that companies' management does not see high benefits from PPCSPs applications in construction projects. Poor implementation of PPCSPs in construction projects



(a) Time



(b) Cost



(c) Resource

Figure 6. Extent of PPCSP applications in planning and control of project time, cost and resource

resulting in minimal advantages might be a cause. Here again, the size of the construction companies was identified as a contributing factor to the level of the management support for the PPCSPs in the conducted one way ANOVA test. The test identified that management support is lower in small companies compared to large companies. Figure 7 presents the frequency of high and very high levels of different aspects of management support to PPCSPs according to the company size. It was also investigated whether the respondents' position is a contributing factor to the achieved level of management support. One way ANOVA test, however, did not identify respondents' position, e.g., CEO, PM, site superintendent, and project planner, as a contributing factor here. This means respondents with different positions have fairly similar points of view regarding different aspects of the management support to PPCSPs in construction projects.

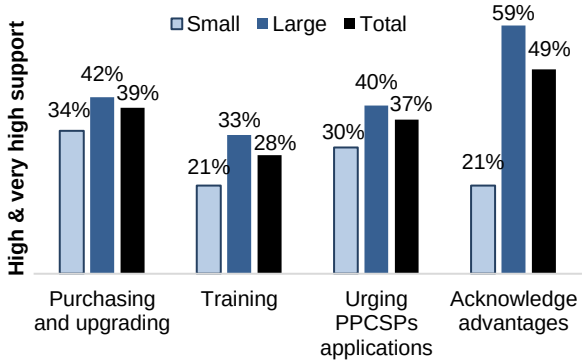


Figure 7. Frequency of high and very high level of different aspects of the management support to PPCSPs according to the company size

5. 7. Discussion The achieved results of the research indicated that despite the perceived benefits of PPCSPs in improving the construction project management, their applications are still quite low. The majority of construction companies depend on traditional project planning and control methods or even do not use them. Several contributing factors to the current conditions were identified in the research. A low level of skill was identified as a contributing factor to the low level of PPCSPs application in construction projects. Here, a reason can return to the education system which is unable to properly train and prepare prospective construction practitioners. The inability of the construction companies to hire qualified individuals can be another reason. Furthermore, the research identified the CEOs' perception of the positive impacts of PPCSPs on the project management processes the least among all other practitioners. This result conforms with the majority of responses claiming a low or medium level of their companies' management commitment and timely action to support PPCSPs implementation in construction projects. Lack of management knowledge regarding the importance of using proper project management tools can be a contributor. This means either non-qualified managers are assigned to the management positions in the construction companies or the education system lacks to properly train different aspects of construction project management.

6. CONCLUSION

Construction projects suffer from high-cost overruns, completion delays, and in general low project performance in Iran. Project planning and control software packages can make a big difference in the way that construction projects are run. Proper utilization of PPCSPs in the construction companies can improve project performance and consequently can increase the

profit margin of these companies. Given the current financial challenges imposed by foreign relations to the construction industry, internal improvement of project management methods can play an essential role. For the first time, this research investigated the pattern of project planning and control software packages and their impacts on the construction projects in Iran. The achieved results in this investigation indicated that a part of the reduced performance can be linked to the way PPCSPs are applied in the construction projects in the country. The PPCSP pattern identified in this investigation forms a basis for the construction companies to measure themselves and adjust their organizational policies regarding applications of PPCSPs. The achieved results alert the academics and contributors to the construction project management courses to update their curriculums and teaching methods. The results can also help PM software developers to extract the requirements of the construction companies and incorporate them into their prospective PPCSP development.

This investigation revealed that only one-third of the construction companies highly or very highly use PPCSPs in the planning and control processes of the construction projects. The skill level of the practitioners in working with PPCSPs and the level of management support were identified as contributing factors to this low level of PPCSPs applications. This condition is regardless of many PM-related courses and training programs offered at the country's universities and vocational institutes. This trend, however, puts the quality of the PM training programs in the country critically in doubt. Investigations regarding the adopted teaching methods and the materials taught in the project management training programs are required. The suitability of these training programs and their possible impacts on the low level of PPCSPs applications in construction projects should be assessed. Updates to the curriculum and topics taught in these courses are likely required. Especially, teaching PPCSP in parallel to the practical methods used in the construction projects can be beneficial. It should also be noted that currently there is no dependable technical support for the foreign PPCSPs applied in the country. Furthermore, there are no commonly accepted and widely known domestically developed PPCSPs in the country. New research efforts that investigate the condition of the PM software developers in the country and identifies the gaps they can fill for improving PPCSP applications are recommended.

Given the critical role of the building and construction projects in the country, any improvements in this sector can make a significant change in the country as a whole. As a result, further investigations in this area of research are strongly encouraged. One of the main sources of the identified deficiencies in this research returns to academia. Therefore, further research and investigations in this field performed by academics can directly be used in the teaching materials and reference books. Improved project management training courses and properly trained construction practitioners are the implicit results of these investigations.

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Persian Abstract

چکیده

برنامه‌ریزی و کنترل ناکارآمد پروژه به عنوان یکی از اصلی‌ترین عوامل کاهش بهره‌وری و کارایی در صنعت ساخت و ساز ایران شناخته شده است. در این میان استفاده نادرست از نرم افزارهای برنامه ریزی و کنترل پروژه در پروژه‌های عمرانی می‌تواند یکی از عوامل موثر در این کاهش بهره‌وری و کارایی باشد. این پژوهش به بررسی جنبه‌های مختلف نرم‌افزارهای برنامه ریزی و کنترل پروژه پرداخته است و نقش آن‌ها را در روند برنامه ریزی و کنترل پروژه‌های عمرانی کشور با استفاده از تحقیق میدانی شناسایی نموده است. در نتیجه انجام این پژوهش مشخص شد که تنها ۳۲/۵٪ از پیمانکاران پروژه‌های عمرانی در کشور به صورت موثر و جدی از نرم‌افزارهای برنامه‌ریزی و کنترل پروژه استفاده می‌کنند. سطح پایین مهارت مهندسین و کارشناسان فعال در پروژه‌های عمرانی در استفاده از این نرم‌افزارها و عدم حمایت مدیریت ارشد به عنوان دو عامل اصلی موثر در این امر شناخته شده اند. کیفیت پایین برنامه‌های آموزشی مدیریت پروژه که در دانشگاه‌ها و آموزشگاه‌های تخصصی کشور ارائه می‌شود و فقدان حمایت فنی و خدمات پس از فروش قابل اعتماد از نرم‌افزارهای برنامه‌ریزی و کنترل پروژه به عنوان عوامل احتمالی این مشکل در کشور شناسایی شده‌اند. در این میان الگوی شناسایی شده برای استفاده از نرم‌افزارهای برنامه‌ریزی و کنترل پروژه در ایران با نتایج ارائه شده برای چندین کشور توسعه یافته و در حال توسعه مقایسه شده است. این مقایسه نشان داد که ایران و سایر کشورهای در حال توسعه مورد مطالعه، به مراتب از سطح پایین‌تری از نرم‌افزارهای برنامه‌ریزی و کنترل پروژه در مدیریت پروژه‌های عمرانی در مقایسه با کشورهای توسعه یافته استفاده می‌نمایند.