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Systematic Literature Review of Implementing the Project Control System Using Earned Value Management (EVM)

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ABSTRACT

Project control is considered as one of the major and key issues in organizations. The project is assessed from three dimensions including time, cost, and scope. Therefore, the purpose of this study is to review the methods and criteria that have been used in the project control literature. This study is a systematic review of 40 papers that have been published in two time periods between 2006 and 2017 or from 1387 to 1392 according to the electronic databases. It was found that 20 of these articles that form 50% of the total articles have not used the Earned Value Management method for project control. Therefore, there are still other methods that can be applied for implementing in the project control system. The results revealed that Earned Value Management is one of the popular methods for implementing the project control system by controlling the project time and costs. Ultimately, the case study papers and their aims have been analyzed in this study.

Keywords: *Project control, Earned value management, Project time, Project costs, Systematic literature review*

Introduction

The project is a set of activities to achieve a certain goal or purpose. Projects include activities that should be done in appointed dates with appointed costs. Requisite conditions for succeeding in each project are achieving in all of these parameters at the same appointed time, costs and desired quality. Outgoing from each of these parameters can eventuate to an unsuccessful and

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uneconomic project. Project control is a process for keeping the project in its direction and achieving an economic balance between all these parameters; costs, time and span during execution of the project, which uses its specified tools and techniques during this procedure. Indeed, control is the exact and complete execution of an predefined plan for the project in the way that by recognition of reasons and forming the most economic activities in the time of exiting from that program, returning the project to the nearest possible position in its initial and original way (Project Management Institute, 2013). To achieve this purpose, project control uses these three parameters:

a) Determination of real situation of the project
b) Comparing the real situation with the plan
c) Considering the corrective action (Sabzeparvar, 2016)

Supervision of the project and decision making about the corrective action is from the main parts of decision support system of monolith project management control. Earned value management/Earned schedule (EVM/ES) is a method of project control which is usually applied to project time schedule control from top to bottom (Colin, Martens, Vanhoucke, & Wauters, 2015; Colin & Vanhoucke, 2015). Earned value management is actually a technique of project management which is applied for determination of project progress in objective methods. According to project management institute, if it is applied in a its right way, EVM prepares the early time function problem warner (Moslemi Naeni, Shadrokh, & Salehipour, 2014).

In recent years, the accuracy of exact anticipated project time is very important to do a project. This method of project control is widely used. In other words, EVM prepares a basis to anticipate a project time (Batselier & Vanhoucke, 2017). EVM is also used for better anticipating the costs of finishing the project during its execution and there are lots of studies in both aspects of anticipating the project time and project costs (Acebes, Pajares, Galán, & López-Paredes, 2013; Asgari Dehabadi, Salari, & Mirzaei, 2014; Chen, & Lin, 2016; Colin & Vanhoucke, 2014; Faris Khamidi, Waris, & Idrus, 2011; Forouzanpour, Mirzazadeh, & Nodoust, 2016; Huang, Pan, Li, Zhu, & Liao, 2014; Hunter, Fitzgerald, & Barlow, 2014; Khamooshi & Golafshani, 2014; Kim, Koo, Hong, & Park, 2015; Lipke, Zwikael, Henderson, & Anbari, 2010; Vandevoorde & Vanhoucke, 2010; Vanhoucke & Colin, 2016; Willems & Vanhoucke, 2015).

Project control is a field that has been attracting and involving academic people for decades. Control systems show the orientation of changes in primary programming variables in comparison to the real function of the project. About the aberration of current project from the planned function, it's a warning which is shown by the system for corrective actions. Khamooshi and Golafshani (2014) revealed that EVM is actually a tool for cost management and control which is developed for following the plan and using the costs represents the project function for controlling the project time.

EVM framework is the integration of domain, cost, time and plan of the project (Acebes et al., 2013). Design and development by U.S. Department of Defense during the 60s, has let the project managers measure and evaluate the project progress and recognize the aberration from the planning stage of the project and do the primary corrective actions according to these aberrations, so they anticipate new costs and time of activities and the time of finishing the project according to the results (Acebes et al., 2013). Using this method of project control is common in the United States and also other countries like United Kingdom, Australia and South Korea (Faris Khamidi et al., 2011).

Earned value technique is a technique that can be useful for answering these three main questions about controlling the plan and the costs of the project:

a) How true percentage of project progress according to the plan can be measured.
b) How true percentage of consuming of the expenses according to the estimated amounts can be determined.
c) Which parameters can be used in the measurement and controlling the plan and spent expenses.

The earned value technic formed in the late 80s in the United States. In December 1996 this technic developed and hugely improved by U.S. Department of Defense and approved as a standard with 32 criteria named "Earned Value Management System (EVMS)". In 1998, ownership of EVMS transferred to the private sector and in July 1998, it registered in American national standard institute as a standard of ANSI/EIA#748.

EVMS is a standard that causes integration of the control reports and supervision of time schedule and project costs. Unfortunately, most of the management systems used in big projects are not in line with each other and work separately, because they have been created for different needs. For example, duties of accounting unit about the expenses are separate from the time schedule of the project and its relevant unit. Because the measurement basis (i.e. ruler) is different, so unanimous and contradictory reports are expected (Huang et al., 2014).

The main purpose of this research is a review of used methods and criteria in the implementation of project control system with EVM by 40 articles in order to suggest and apply to the implementation of project control system. Later, the method of this literature review will be discussed and findings of this study will be described and finally, results of this article will be revealed.

Research method

This article is presented as a systematic literature review. The purpose of this study is to evaluate the systematic literature review (which is called "secondary study"), so this study as a literature review is divided into four categories (Bjørnson & Dingsøyr, 2008). Stages of this systematic literature review have been recorded as follows:

Studies review

This study is a systematic review in the period of 2006 to 2017 and 1387 to 1392 consisting of 40 articles about implementation of project control system with EVM. Reviewing the chosen articles, this article evaluates and discusses the methods, parameters, criteria, and targets discussed in these 40 articles. The purpose of this study is to show a general view of project control methods which are under study.

Research identification

A comprehensive and unbiased research is the key factor for a systematic review. Our systematic review has begun with the identification of the keywords and expressions of the research. We have used the general keywords in research which may be used for identification of relevant articles. Journals which are applied in this review are noted (table 1) and also the mentioned articles are adopted from databases of ScienceDirect, GoogleScholar, Civilian, and Magiran.

Table 1

Keywords and Reviewed Journals

Keywords	Reviewed Journals
Project control	Project Management
Earned value	International Conference on Management and Service Science
Earned duration	Procedia – Social and Behavioral Sciences
Earned schedule	Research Gate
Project management	Advanced Materials Research Vols
Earned value management	Omega
Cost estimate at completion	Acta Astronautica
Regression analysis	Expert System with Applications
Evaluation index	Cleaner Production
Weight earned value	Decision Support Systems
Fuzzy regression	4th International conference on project management
Schedule performance index	Caisson periodical
Costs performance index	2nd National conference on the system and industrial engineering
Real Costs	6th National Congress of civil engineering
Estimation indexes	National conference on accounting and management
	Conference on strategies and challenges' management

(Source: ScienceDirect, Google Scholar, Civilian, and Magiran)

Quality evaluation and classification

40 specified articles are classified in two categories:

1) articles about EVM
2) articles about other methods of project control.

40 articles are classified separately and are reviewed by paying attention to the framework. Before comparing the results, differences in classification are discussed. So far, all of the results of studies are adopted from Industry. The focus of this study is on the quality of chosen articles with relevant classifications. This study is accepted as an experiential study, not a report of the

learned subjects. After quality evaluation, we had 20 articles about project control by EVM and 20 articles about other methods of project control.

Synthesis

Classified articles are applied in the framework as synthesis. In order to avoid relevant problems, the covered concepts, main findings and research method for each article are extracted ,discussed and evaluated.

Results

Out of 40 articles about the implementation of project control system with EVM, 20 articles have used EVM method which consists 50% of all the articles, three articles have used statistical methods which consists 7.5% of all the articles. Moreover, two articles have used Monte Carlo method and two articles have applied fuzzy regression method, and each of these two methods separately consists 5% of all the articles. EDM and EVA methods are applied by two other articles which means each of these two methods separately consists 2.5% of all the articles and finally, 11 articles which are about 27.5% of all the articles have applied other methods like downward approach, etc. This information are demonstrated in figures 1 and 2 and table 2.

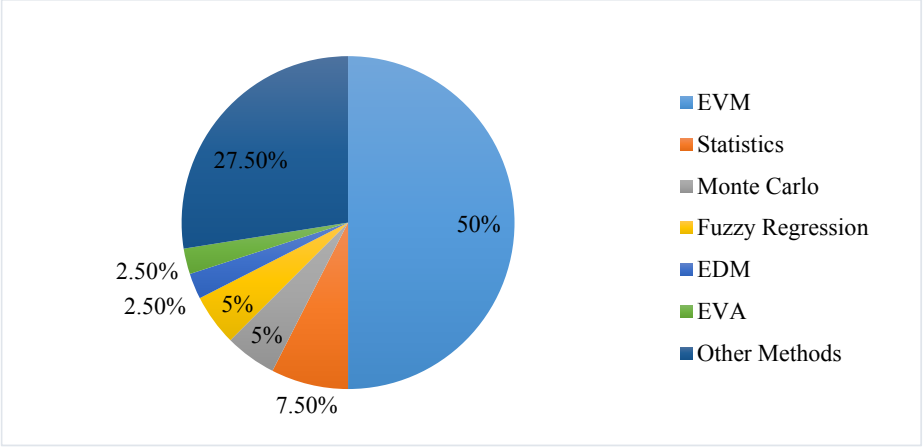

Figure1.Percentage of each method in reviewed articles

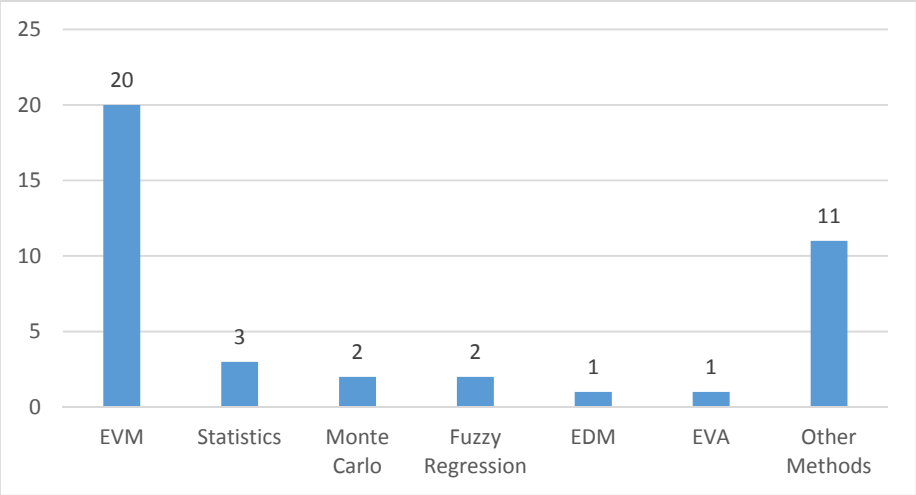

Figure 2. The number of reviewed articles about each method

Figure 3, demonstrates project time and costs either with EVM or other methods. In 2006, an article consisted 2.5% of all the articles. In 2008, three articles with 7.5% of all the articles, in 2009, an article which with 2.5% of all the articles, in 2010, two articles with 5% of all the articles, in 2011, seven articles with 17.5% of all the articles, in 2012, two articles with 5% of all the articles, in 2013, three articles with 7.5% of all the articles, in 2014, nine articles with 22.5% of all the articles, in 2015, six articles with 15% of all the articles, in 2016, four articles with 10% of all the articles and in 2017, two articles with 5% of all the articles are demonstrated in figure 3.

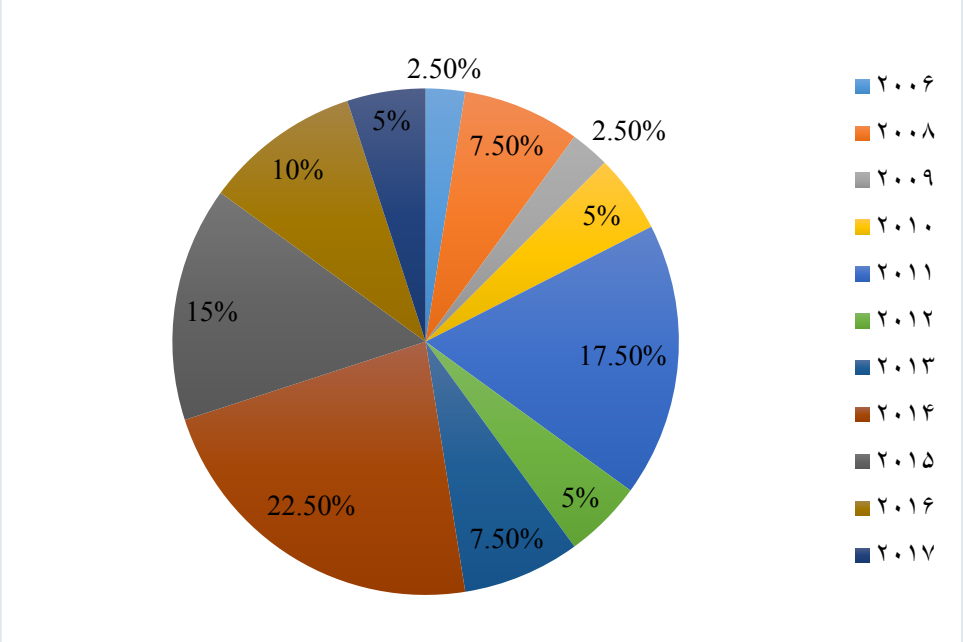

Figure3.Reviewed articles in 2006 to 2017

Furthermore, according to table 2, Batselier and Vanhoucke (2015, 2017); Cabri and Griffiths (2006); Chen et al. (2016); Dodson, Defavari, and de Carvalho (2015); Hoseini, Shokri, and Safarpour (2014); Huang et al. (2014); Hunter et al. (2014); Kahrizi, Mir Muhammad Sadeghi, and Qhorbani Salanqhouch (2009); Lipke et al. (2010); Lorghaba, Salahshour, and Adib (2013); Moslemi Naeni and Gorouban (2009); Moslemi Naeni et al. (2014); Naderpour and Mofid (2011); Narbaev and De Marco (2014); Nejati and Rabiei (2011); Nilipour Tabataei and Salavatipour (2009); Savoji and Kheirkhah (2008); Vandevoorde and Vanhoucke (2010); Warburton (2011); Wood (2017), used EVM method in their researches. Also, Colin and Vanhoucke (2014); Lipke et al. (2010); Nahavandian and Barhrampour (2011), applied statistical methods in their researches, and Acebes et al. (2013); Nahavandian and Barhrampour (2011), used Monte Carlo Method in their researches. Further, Asgari Dehabadi et al. (2014), used fuzzy regression and Khamooshi and Golafshani (2014), used EDM method. Faris Khamidi et al. (2011), used EVA method in their research. Some other methods were applied by Colin et al. (2015); Colin and Vanhoucke (2015); Forouzanpour et al. (2016); Kim et al. (2015); Soltanpanah, Faroughi, and Abdi (2012); Vanhoucke and Colin (2016); Von Wangenheim, Savi, and Borgatto (2012); Warburton and Cioffi (2016); Wauters and Vanhoucke (2014); Willems and Vanhoucke (2015); Zhong and Wang (2011).

Table 2
Methods used by Researchers

Methods	Researchers
Method EVM	(Batselier & Vanhoucke, 2015, 2017; Cabri & Griffiths, 2006; Chen et al., 2016; Dodson et al., 2015; Hoseini et al., 2014; Huang et al., 2014; Hunter et al., 2014; Lorghaba et al., 2013; Moslemi Naeni & Gorouban, 2009; Moslemi Naeni et al., 2014; Naderpour & Mofid, 2011; Narbaev & De Marco, 2014; Nejati & Rabiei, 2011; Nilipour Tabataei & Salavatipour, 2009; Savoji & Kheirkhah, 2008; Vandevoorde & Vanhoucke, 2010; Warburton, 2011; Wood, 2017)
Statistical methods	(Colin & Vanhoucke, 2014; Lipke et al., 2010; Nahavandian & Barhrampour, 2011)
Monte Carlo Method	(Acebes et al., 2013; Shahbaznia & Taleghani, 2011)
Fuzzy Regression	(Asgari Dehabadi et al., 2014)
EDM Method	(Khamooshi & Golafshani, 2014)
EVA Method	(Faris Khamidi et al., 2011)
Other Methods	(Colin et al., 2015; Colin & Vanhoucke, 2015; Forouzanpour et al., 2016; Kim et al., 2015; Soltanpanah et al., 2012; Vanhoucke & Colin, 2016; von Wangenheim et al., 2012; Warburton & Cioffi, 2016; Wauters & Vanhoucke, 2014; Willems & Vanhoucke, 2015; Zhong & Wang, 2011)

Table 3
Amount and Percentage of Each used Criteria in All the Articles

Criteria	Amount	Percentage
Earned Value	14	35
Earned Schedule	9	22.5

Planning Value	11	27.5
Actual Cost	10	25
Cost Variance	12	30
Schedule Variance	14	35
Cost Performance Index	20	50
Schedule Performance	23	57.5
Budget at Completion	6	15
Estimate at Completion	8	20
Estimate To Complete	2	5
Estimate at Completion (t)	5	12.5
To Complete Performance Index	2	5
Quality Earned Value	1	2.5
Actual Time	1	2.5
Percentage Complete	1	2.5
Completion Factor	1	2.5

Also according to table 3 and the reviewed articles, Asgari Dehabadi et al. (2014); Chen et al. (2016); Colin et al. (2015); Colin and Vanhoucke (2014); Dodson et al. (2015); Forouzanpour et al. (2016); Hoseini et al. (2014); Lorghaba et al. (2013); Moslemi Naeni et al. (2014); Nejati and Rabiei (2011); Vandevoorde and Vanhoucke (2010); Warburton (2011); Wood (2017), used Earned Value criterion consisting 35% of all the articles. Either, Asgari Dehabadi et al. (2014); Colin et al. (2015); Moslemi Naeni and Gorouban (2009); Moslemi Naeni et al. (2014); Narbaev and De Marco (2014); Vandevoorde and Vanhoucke (2010); Wauters and Vanhoucke (2014); Wood (2017), applied Earned Schedule criterion including 22.5% of all the articles. Moreover, Asgari Dehabadi et al. (2014); Chen et al. (2016); Colin et al. (2015); Colin and Vanhoucke (2014); Dodson et al. (2015); Hoseini et al. (2014); Lorghaba et al. (2013); Narbaev and De Marco (2014); Nejati and Rabiei (2011); Vandevoorde and Vanhoucke (2010); Warburton (2011), used Planning Value criterion including 27.5% of all the articles. Actual Cost criterion which consisted 25% of all the articles was applied by Asgari Dehabadi et al. (2014); Chen et al. (2016); Dodson et al. (2015); Forouzanpour et al. (2016); Hoseini et al. (2014); Lorghaba et al. (2013); Narbaev and De Marco (2014); Vandevoorde and Vanhoucke (2010); Warburton (2011); and Wood (2017). In other articles done by Cabri and Griffiths (2006); Dodson et al. (2015); Faris Khamidi et al. (2011); Forouzanpour et al. (2016); Hoseini et al. (2014); Huang et al. (2014); Kahrizi et al. (2009); Lorghaba et al. (2013); Moslemi Naeni and Gorouban (2009); Nejati and Rabiei (2011); Nilipour Tabataei and Salavatipour (2009); Zhong and Wang (2011), Cost Variance criterion consisting 30% of all the articles was applied. Furthermore, Cabri and Griffiths (2006); Colin et al. (2015); Dodson et al. (2015); Faris Khamidi et al. (2011); Forouzanpour et al. (2016); Hoseini et al. (2014); Huang et al. (2014); Kahrizi et al. (2009); Lorghaba et al. (2013); Moslemi Naeni and Gorouban (2009); Nejati and Rabiei (2011); Nilipour Tabataei and Salavatipour (2009); Savoji and Kheirkhah (2008); Zhong and Wang (2011), applied Schedule Variance criterion consisting 35% of all the articles. Asgari Dehabadi et al. (2014); Cabri and Griffiths (2006); Dodson et al. (2015); Faris Khamidi et al. (2011); Forouzanpour et al. (2016); Hoseini et al. (2014); Huang et al. (2014); Kahrizi et al.

(2009); Lipke et al. (2010); Lorghaba et al. (2013); Moslemi Naeni and Gorouban (2009); Moslemi Naeni et al. (2014); Nejati and Rabiei (2011); Nilipour Tabataei and Salavatipour (2009); Vandevoorde and Vanhoucke (2010); Warburton (2011); Wauters and Vanhoucke (2014); Wood (2017); Zhong and Wang (2011), applied Cost Performance Index criterion consisting 50% of all the articles. Further, Asgari Dehabadi et al. (2014); Cabri and Griffiths (2006); Colin et al. (2015); Colin and Vanhoucke (2014); Dodson et al. (2015); Faris Khamidi et al. (2011); Forouzanpour et al. (2016); Huang et al. (2014); Kahrizi et al. (2009); Lipke et al. (2010); Lorghaba et al. (2013); Moslemi Naeni and Gorouban (2009); Moslemi Naeni et al. (2014); Narbaev and De Marco (2014); Nejati and Rabiei (2011); Nilipour Tabataei and Salavatipour (2009); Savoji and Kheirkhah (2008); Vandevoorde and Vanhoucke (2010); Warburton (2011); Wauters and Vanhoucke (2014); Wood (2017); Zhong and Wang (2011), used Schedule Performance Index criterion consisting 57.5% of all the articles. Colin et al. (2015); Forouzanpour et al. (2016); Lipke et al. (2010); Lorghaba et al. (2013); Moslemi Naeni and Gorouban (2009); Narbaev and De Marco (2014), used Budget At Completion criterion consisting 15% of all the articles. Likewise, Batselier and Vanhoucke (2017); Cabri and Griffiths (2006); Kahrizi et al. (2009); Lorghaba et al. (2013); Moslemi Naeni and Gorouban (2009); Narbaev and De Marco (2014); Warburton (2011); Wauters and Vanhoucke (2014), used Estimate at Completion criterion consisting 20% of all the articles. Similarly, Cabri and Griffiths (2006); Lorghaba et al. (2013), used Estimate To Complete criterion consisting 5% of all the articles. Additionally, Batselier and Vanhoucke (2017); Faris Khamidi et al. (2011); Lorghaba et al. (2013); Moslemi Naeni and Gorouban (2009); Savoji and Kheirkhah (2008), used Estimate at Completion (t) criterion consisting 12.5% of all the articles. Besides, Kahrizi et al. (2009); Lorghaba et al. (2013), used Complete Performance Index criterion consisting 5% of all the articles and finally, Colin et al. (2015); Dodson et al. (2015); Narbaev and De Marco (2014); Vandevoorde and Vanhoucke (2010), applied Quality Earned Value criterion, Actual Time criterion, Percentage Complete criterion and Completion Factor criterion respectively, each consisting 2.5% of all the articles.

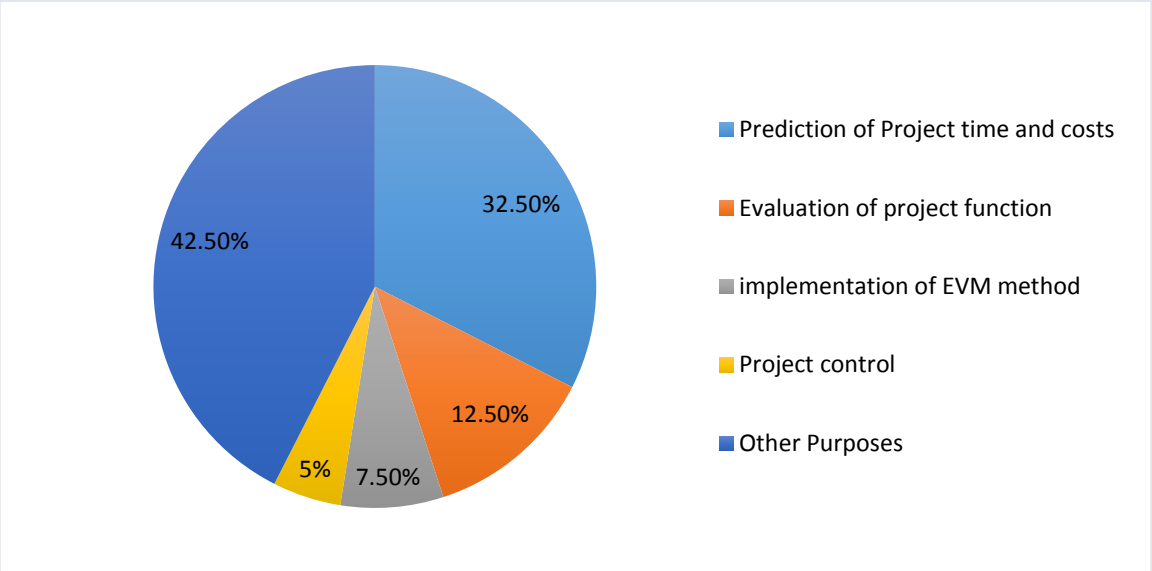

Figure 4.Checked purposes and percentages in the articles

According to previous studies and figure 4, the purpose of 13 articles was anticipation of the time and cost which consisted 32.5% of all the articles. Aditionnally , the purpose of 5 articles was evaluation of project function which consisted 12.5% of all the articles. Moreover, the purpose of 3 articles was the implementation of EVM method which consisted 7.5% of all the articles. Besides, the purpose of 2 articles was the project control which consisted 5% of all the articles and other 17 articles had other purposes which consisted 42.5% of all the articles.

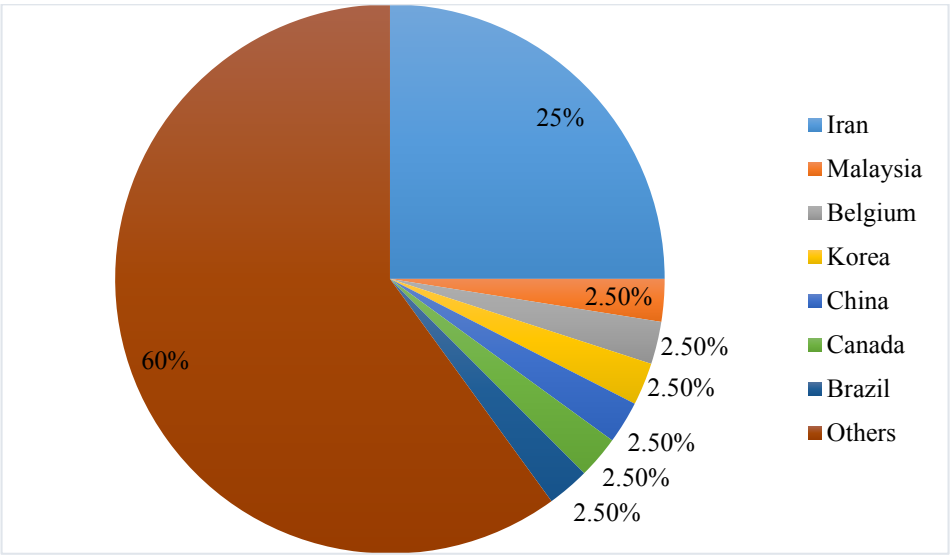

Figure.5 Checked countries and percentages in the articles

According to the studies and figure 5, 10 articles had a case study in Iran which consisted 25% of all the articles. Further, 6 articles had case studies in Malaysia, Belgium, Korea, China,

Canada and Brazil, each consisted 2.5% of the total articles. Finally, the remaining 24 articles consisted 60% of total articles, didn't have any case studies.

Conclusion

The purpose of this study was a systematic review about the applied methods and criteria in project control by EVM and other methods of 40 articles, in order to suggest and use those methods and criteria in a proper control on projects. After the review, it is concluded that 20 articles have used EVM method and other 20 articles have used other methods of project control in which, Earned Value, Earned Schedule, Planning Value, Cost Variance, Schedule Variance, Cost Performance Index, Schedule Performance Index and Budget at Completion criteria have been used more than other criteria respectively. Moreove, these articles have been published mostly in 2014, 2011 and 2015 respectively, and 50% of the articles have used only Earned Value criterion for project control and other 50% articles have used other methods of project control. Results revealed that most of the articles didn't have any case studies.

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