

# Practices and Future of Earned Value Management: Insights from Turkey

## Kazanılmış Değer Yönetimi Uygulamaları ve Geleceği: Türkiye Örneği

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*Abstract: This paper examines the Earned Value Management (EVM) practices in Turkey. The authors identify and analyze the factors affecting the awareness and implementation of the methodology and derive implications for its future use. A comprehensive questionnaire was designed and semi structured interviews were conducted with experienced managers from several industries. This study is original in the sense that it brings an in depth analysis on the factors affecting the acceptance and frequency of use of EVM in Turkey. The authors report that the industry, project management experience, role in projects and the use of project management software are the factors that affect EVM awareness. Regarding the implementation, the authors observe that respondents who work in defense and production sectors are more likely to use EVM. Companies that are using lump-sum and unit price projects are more likely to use EVM while companies that are using in-house projects are less likely.*

*Keywords: Project Management, Project Control, Earned Value Management, Performance Assessment*

*JEL Classification: M11, M15, C83*

*Öz: Bu çalışma Türkiye'de Kazanılmış Değer Yönetimi (KDY) uygulamalarını incelemektedir. Yazarlar, KDY farkındalığını ve uygulamasını etkileyen faktörleri belirlemekte, veriler ışığında analiz etmekte ve bu proje yönetim aracının geleceğine ilişkin çıkarımlarda bulunmaktadır. Çalışmanın veri toplama yöntemi kapsayıcı anket ve çeşitli sektörlerden deneyimli yöneticilerle gerçekleştirilen yarı yapılandırılmış görüşmelere dayanmaktadır. Bu araştırma, Türkiye'de KDY'nin benimsenmesini ve kullanım sıklığını etkileyen faktörleri derinlemesine incelemesi bakımından özgün bir çalışmadır. Yazarlar, bir işletmenin faaliyette bulunduğu sektörün, proje yönetimi deneyiminin, projelerde üstlendiği rollerin ve proje yönetimi yazılımı kullanım alışkanlığının KDY farkındalığını etkilediğini ortaya koymaktadır. Savunma ve üretim sektörlerinde çalışanların KDY kullanma olasılıklarının daha yüksek olduğu gözlemlenmektedir. Götürü bedel ve birim fiyat projelerinde KDY kullanma olasılığı daha yüksekken kurum içi projelerde bu olasılık daha düşüktür.*

*Anahtar Kelimeler: Proje Yönetimi, Proje Kontrolü, Kazanılmış Değer Yönetimi, Performans Değerlendirmesi*

*JEL Sınıflandırması: M11, M15, C83*

## 1. Introduction

In today's competitive business environment, companies, in either manufacturing or service sectors, have been doing business in a more and more project-oriented manner. This choice helps them to facilitate coordinating the activities, controlling the progress, and communicating the performance. Nevertheless, it requires applying effective project management (PM) approaches/techniques to gain or reinforce business competency. In this respect, the monitoring and control role of the project managers becomes more significant. As the monitoring and control methodology, the authors study the Earned Value Management (EVM), which is a measurement and control methodology to assess the performance of projects in terms of time and cost, to ensure achievement of project goals.

All projects confront many sources of uncertainty such as variability in resource availabilities, quality problems and needs for reworks. Because of these variations or unexpected disruptions, deviations from planned performance are common in project management practice. To minimize the amount of deviations, project work need to be regularly monitored and controlled throughout the project life cycle (Shtub et al., 2014). Thus, managers can undertake corrective or preventive actions such as rescheduling on time (Hazır, 2015). However, deciding on the timing of the interventions and implementing an effective monitoring and control system is a difficult task for project managers. Therefore, managers may use EVM to observe the status of the project, analyze the cost and schedule variances together and make intervention decisions (Kim et al., 2003).

EVM compares the planned work with the actual work based on monetary units and this common unit of measurement enables the recording of deviations from the time-phased budgets. These deviations are communicated through illustrative

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graphical tools paving the way to easier evaluation of project performance (Anbari, 2003; Hazır and Shtub, 2011). EVM trend analysis and projections have a determinant role in the decisions of interventions and corrective actions. In addition to tracking the project progress in terms of time and cost, EVM has been used to predict the future performance. These support roles have enhanced the effective use of EVM since 1960s, independent of the industry and size of the project. EVM has grown in popularity after project management software included EVM metrics.

Main objective of this research is to reveal the current EVM practices in an emerging market, Turkey. The authors consider projects undertaken in different industries with different budgets, try to find out the factors affecting the awareness and implementation of the methodology, and derive implications for future use. For this purpose, the authors have conducted a comprehensive questionnaire and semi-structured interviews. Even though, a number of studies (Abdul-Rahman et al., 2011; Netto et al. 2015; Nkiwane et al, 2016; Morad and El-Sayegh, 2016), investigate project management and control practices in developing countries, they do not examine the implementation and usage frequency in detail. In this respect, main contribution of this study is to bring an in depth analysis of the factors affecting the awareness, implementation and usage frequency of EVM based on evidence from Turkey. In the analysis, user characteristics, methodological features and project environments are considered. Moreover, the effects of industrial and contractual differences are investigated.

In the sequel, the authors first present a literature review on EVM followed by the research methodology including detailed information about the surveys and semi-structured interviews conducted. The authors then present the findings and discuss the results in comparison with literature. Finally, the authors interpret the current situation and policy implications. In this regard, this study provides insights about EVM usage in developing countries based on evidence from Turkey.

## 2. Literature Review

EVM integrates time and cost project performance criteria, records the cost and schedule variances and presents several variance based performance metrics. Project managers can assess performance of their projects through these metrics and take timely corrective actions. The authors refer to the books of Fleming and Koppelman (2005) and Vanhoucke (2009) for the underlying principles and commonly used metrics of EVM. Christensen (1998) lists and presents a comprehensive conceptual framework for comparing the costs and benefits of implementing EVM. In a comprehensive review, Willems and Vanhoucke (2015) classified the papers based on six attributes: research problem, contribution, methodology, analysis, validation and application.

Vanhoucke (2012) investigated the success factors of EVM implementation and schedule risk analysis and performed tests using simulation experiments. They have shown that the topological structure of the project network significantly affects the variability in project performance and efficiency of the project control efforts. Bryde et al. (2018) followed a different approach to investigate the success factors and presented a framework which bases on design and operational aspects of EVM system and agency related characteristics. Decision support tools play a significant role in project success (Hazır, 2015). In this regard, Kerkhove and Vanhoucke (2017) and Kim et al. (2018) have recently worked on early warning systems and addressed the signal quality to support managerial decision-making.

In practice, project teams generally use EVM to quantify project performance throughout the life of a project. However, it has also been employed to forecast the project termination time and total cost. There are studies that presented forecasting methods based on EVM metrics and compared them in terms of prediction accuracy (Vandevoorde and Vanhoucke, 2006). Probability models and statistical tools have also been employed to predict the performance by several researchers (Lipke et al. 2009, Caron et al. 2013, Narbaev and De Marco, 2014, Kim and Pinto 2018). Researchers have also been working on developing new EVM based metrics. Pajares and Lopez-Paredes (2011) combined EVM and risk analysis and developed two new metrics. Khamooshi and Golafshani (2014) proposed to measure the schedule performance using time based metrics, instead of monetary values, and formulated the earned duration in place of EVM.

Researchers have also been exploring the usage of EVM across different industries, whereas many of them focus on construction, software, defense and aerospace industries. Kwak and Anbari (2012) reviewed the historical development of EVM through examining the EVM practices at NASA. Recently, Batselier and Vanhoucke (2015a) created a real-life project database covering several industries. Efe and Demirörs (2013) investigated the underlying factors why software companies are less likely to implement EVM, compared to other companies. Based on two case studies, they identified a number of difficulties in EVM implementation but they concluded that EVM's benefits might outweigh its drawbacks with good project management. Olawale and Sun (2015) surveyed the project control practices in UK construction industry and examined several methods, including EVM. Abdi et al. (2018) studied implementation of EVM and developed metrics to assess the green house emission performance of the project throughout the execution. They showed that their proposed control and monitoring model successfully calculates project greenhouse gases variance and predicts the project performance.

Literature on awareness and implementation of EVM in developing countries is scant. Nkiwane et al (2016) provided evidence from South Africa based on interviews with construction supervisors and managers. They observed that the EVM awareness was high among the clients/project managers; on the contrary, it was low among the contractors. They emphasized the relationship between project management maturity and EVM implementation and argued that even projects conducted by organizations at lower maturity levels may benefit from EVM. Netto et al. (2015) suggested that successful EVM

implementation is related to project maturity level of the company and the training of project staff based on public sector construction projects in Brazil. Morad and El-Sayegh (2016) investigated the EVM usage and the factors for successful EVM implementation in the United Arab Emirates' construction industry. They identified the level of acceptance among project managers, communication among project team members and support from top management as the most important factors. They also noted that although the majority of the companies confirm the necessity of EVM implementation, many of them do not apply the methodology in practice. Interviews conducted with construction project managers in Malaysia brought similar results. Based on the interview results, Abdul-Rahman et al. (2011) concluded that although EVM offers benefits and there are governmental initiatives to increase its use, it has not been widely used in Malaysian construction industry.

There is room for research about EVM use in developing countries. Published research in Turkey is also limited. The existing studies for Turkey are mostly master theses (Artun, 1998; Gürbüz, 2010; Duran, 2016) and focus on specific firms and industries. Artun (1998) conducted a survey among 15 leading construction companies in İstanbul and found that majority of the companies in Turkey were not aware of EVM. The closest study is the survey analysis undertaken by Duran (2016) which examined the performance measurement in projects and control efforts in general. While, he listed utilities and disadvantages of EVM implementation, the authors conduct a more in-depth analysis of EVM practices. The authors examine both the awareness and implementation in the project-based firms. The authors investigate the frequency of use as well and integrate several factors to analyze the implementation. In addition, in cases of low frequency of use, the authors inquire the underlying reasons.

### **3. Data and Methodology**

#### **3.1. Sampling Frame**

The authors collected primary data through a questionnaire designed for this study and targeted at practitioners of project management. The authors invited the members of the Turkey Chapter of Project Management Institute (PMI), which has been operating since 2007 and has more than 1000 members, to respond to the online survey between April 11, 2017 and May 30, 2017. The authors received 167 responses, of which 116 were complete. Following the surveys, semi-structured interviews were conducted to obtain further information regarding EVM practices in Turkey.

#### **3.2. Data Collection: Questionnaire and semi-structured interviews**

The main objective of the questionnaire is to understand the factors affecting EVM awareness and implementation in Turkey. The authors explore the following key variable groups: 1) Individual and company level characteristics 2) Use of project control tools and software programs at the respondents' companies 3) The level of awareness and implementation of EVM 4) Utilities of EVM method and the frequency of usage 5) Reasons for not using EVM.

Follow-up semi-structured interviews were conducted with six experts to gain further insight. Interviewees have noteworthy senior-level project management experience in industries such as construction, defense, telecommunication and logistics. Interviews were audio recorded and transcribed for the analysis.

#### **3.3. Methodological Analysis**

The authors start with a descriptive analysis of the survey data. Then, the authors investigate and identify significant factors that affect the likelihood of EVM awareness and implementation using probit analysis. Finally, the authors summarize the semi-structured interview findings and highlight the common challenges and benefits.

In probit analysis, following the study of Kim et al (2003), the authors group the factors affecting EVM awareness and implementation in three common groups: 1) User 2) Project monitoring and control methodology 3) Project environment. The authors also add the "implementation process" as the fourth group in the implementation analysis. For users, the authors consider their education, job title, project management and work experience. Project monitoring and control methodology factors address mainly company's choice of software system and project control tools such as Gantt Chart, Critical Path Method (CPM), Program Evaluation and Review Technique (PERT) etc. Project environment factors focus on the company's industry and roles in projects as well as the project types (turn-key, lump sum, unit price or in-house project). Regarding the implementation, the authors analyze the reasons for usage, EVM experience, functional purposes of the method and reasons for not using. Another important factor that the authors integrate is the EVM training of the project team. The factors categorized under these four main groups and the associated variables are summarized in Table 1.

Table 1. Description of Variables

<b>Variable</b>	<b>Description</b>
<b>Panel A: DEPENDENT VARIABLES</b>	
<b>EVM Awareness</b>	The authors use an indicator variable, which takes the value of one if the individual states that he/she is aware of EVM, and zero otherwise.
<b>EVM Implementation</b>	The authors use an indicator variable that takes the value of one if the respondent uses EVM, and zero otherwise (if respondent does not use or rarely use EVM).
<b>Panel B: EVM USER</b>	
<b>Education</b>	The authors use an indicator variable, which takes the value of one if the individual has a Master's Degree or PhD, and zero otherwise.
<b>Job Title</b>	The authors use a categorical variable of 4 Groups (General Manager/ Senior Executive=4, Program / Portfolio Manager =3, Project Manager=2, Project specialist / Engineer=1)
<b>Years of Experience</b>	The authors use a categorical ( <b>ordinal</b> ) variable of 3 Groups (Less than 5 year, 5-10 years and Longer than 10 years)
<b>Years of Project Management Experience</b>	The authors use a categorical variable of 4 Groups (Less than 1 year, 1-5 years, 5-10 years and Longer than 10 years)
<b>Panel C: PROJECT MONITORING AND CONTROL METHODOLOGY</b>	
<b>Non-use of Project Management Software</b>	The authors use an indicator variable, which takes the value of one if the company does not use any project management software, and zero otherwise.
<b>Project control tools</b>	The authors use indicator variables for each project control method (Gantt Chart, Critical Path Method- CPM, Program Evaluation and Review Technique- PERT, Earned Value Management- EVM, S Curve, Other ). These variables take the value of 1 if the company uses that project control method and zero otherwise. The authors also use an indicator variable, which takes the value of one if there are no project control methods, and zero otherwise.
<b>Panel D: PROJECT ENVIRONMENT</b>	
<b>Industry</b>	The authors use indicator variables for construction, defense, manufacturing and software industries. These variables take the value of 1 if the company operates in a given industry and zero otherwise.
<b>Company Project Experience (Years)</b>	Continuous variable that takes values ranging from zero to 70.
<b>Company's Role</b>	The authors use indicator variables for each role (contractor /subcontractor, technical supervisor, consultant, administrator and client),. These variables take the value of 1 if the company has the stated role in projects and zero otherwise.
<b>Project Type</b>	The authors use indicator variables for each project type (turn-key, lump sum, unit price, in-house project, build-operate-transfer). These variables take the value of 1 if the company is involved in that type of project and zero otherwise.

**Panel E: EVM IMPLEMENTATION**

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**Panel E.1. If The Respondent Uses EVM**

<b>Reasons for EVM usage</b>	The authors use indicator variables for possible reasons of EVM usage (facilitation of project management, senior management decision, in-house standardization requirement, administration/contractor recommendation, specification requirement, other). These variables take the value of one if the respondent uses EVM mainly for a given reason and zero otherwise.
<b>EVM Experience (years)</b>	The authors use a categorical ( <b>ordinal</b> ) variable of 4 Groups (Less than 1 year, 1-5 years, 5-10 years and Longer than 10 years)
<b>EVM Training</b>	The authors use an indicator variable, which takes the value of one if the employees in the company received EVM training before, and zero otherwise.
<b>Functional purposes &amp; Frequency of usage</b>	<p>The authors generate 3 main variables:</p> <p><b>1) Time Control</b>                      Schedule monitoring                      Estimating project completion time                      Assessing the impacts of problems on completion time</p> <p><b>2) Performance Evaluation and Decision Support</b>                      Overall performance evaluation                      Decision support                      Intervention decision                      Detailed problem analysis</p> <p><b>3) Cost Control</b>                      Assessing the impacts of problems on project budget                      Resource management                      Project cost estimation                      Project cost control</p> <p>Each item is evaluated on a scale from 1 to 4 (Never use (=1), Rarely use (=2), Frequently use (=3), Use all-the time(=4)) and the authors generate the main variables by taking the weighted average of items included</p>
<b>Frequency of EVM use &amp; Project Duration Relationship</b>	<p>The authors ask the respondents to assess the frequency of EVM use with respect to project duration. The authors use a categorical (<b>ordinal</b>) variable of 5 Groups (Less than 1 year, 1-3 years, 3-5 years, 5-10 years and Longer than 10 years)</p> <p>Each group is evaluated on a scale from 1 to 4 (Never use (=1), Rarely use (=2), Frequently use (=3), Use all-the time (=4)) and the authors generate the average score for each group by calculating the mean for each group.</p>
<b>Software used for EVM</b>	The authors use indicator variables for each software used for EVM (MS Project, MS Excel, Oracle Primavera, Deltek, Other) These variables take the value of 1 if the company uses that software for EVM and zero otherwise.
<b>EVM usage &amp; Project Budget Relationship</b>	The authors use an indicator variable, which takes the value of one if the individual states that use of EVM in his/her organization are related to project budget, and zero otherwise.

**Panel E.1. If The Respondent Does Not Use EVM**

<b>Reasons for not implementing EVM &amp; Relative importance of reasons</b>	<p>The authors generate 4 main variables:</p> <p><b>1) Managerial and Organizational Factors</b>                  Lack of senior management support                  Non-committed team members                  Technical incapability of the project team</p> <p><b>2) Complexity</b>                  Inadequate computer/ software infrastructure                  Continuous, detailed data collection and analysis requirement                  Detailed work breakdown structure (WBS) requirement                  Too many technical terms and rules</p> <p><b>3) Type of Contracts/Projects</b>                  High project uncertainty                  Project term flexibility                  Unit price contracts</p> <p><b>4) External Factors</b>                  Client requirement of EVM use                  Absence of legal regulations</p> <p>Each item is evaluated on a scale from 1 to 4 (Not important=1, Slightly important=2, Moderately important =3, Very important =4) and the authors generate the main variables by taking the average of items included.</p>
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Note: Table describes variables used in the analysis

The authors employ probit regression to model the relationship between the explanatory variables (i.e. the variables listed under user, project monitoring and control methodology, project environment and the implementation process) and binary dependent variables (EVM awareness and EVM implementation). Probit regressions take the following form:

$$Y = \Phi(X\beta + \varepsilon) \quad (\text{Equation 1})$$

Where Y equals 1 if the survey respondent is aware of EVM/uses EVM and 0 otherwise.  $\Phi$  is the cumulative distribution function (CDF) of the standard normal distribution. The authors formulate and test the following hypothesis on EVM awareness:

**H<sub>01</sub>**: Characteristics of the user, methodological features and the project environment have no effect on EVM awareness.

**H<sub>A1</sub>**: Characteristics of the user, methodological features and the project environment have an effect on EVM awareness.

The hypothesis for the implementation is:

**H<sub>02</sub>**: Characteristics of the user, methodological features, project environment and implementation features have no effect on EVM use.

**H<sub>A2</sub>**: Characteristics of the user, methodological features, project environment and implementation features have an effect on EVM use.

Based on prior empirical evidence (Kim et al. 2003, Netto et al. 2015, Nkiwane et al, 2016), the authors expect the signs of the probit marginal effects as follows: First, individuals who are more educated, tech savvy (proxied by work experience) and employed in project driven industries such as defense and software development are more likely to be aware of EVM. Second, work experience, resources for EVM training, project teams' competency, and the management support increase the likelihood of implementing EVM (Bryde et al. 2018 stress the importance of training and awareness raising; Netto et al. 2015 and Nkiwane et al. 2016 of the project maturity). Third, project manager's lack of understanding of the method, the high cost of EVM, lack of user participation, conflicts between managers and consultants and reluctance to report bad news would decrease the likelihood of implementing EVM (Kim et al., 2003).

## 4. Findings and Discussion

### 4.1. Findings of the Questionnaire

#### 4.1.1. Introductory Statistics

A great majority of the respondents, 75% of them, are either project managers or engineers working in project teams. Many of them have a master's or doctoral degree (43%), with an average work experience of at least ten years (53%) and project

management experience of more than five years (54%). Respondents work in several sectors: Construction (30%), defense (28%), software/IT (21%), manufacturing (15%) and others. On average, the companies in which the respondents work have been working on projects for 16 years (with a standard deviation of 12.7). The main roles that these companies play are illustrated in Figure 1, with ‘contractor’ being the leading role, followed by the ‘subcontractor’. Thus, most of the respondents have significant roles in the success of the projects, as they work at either contractor –or subcontractor companies.

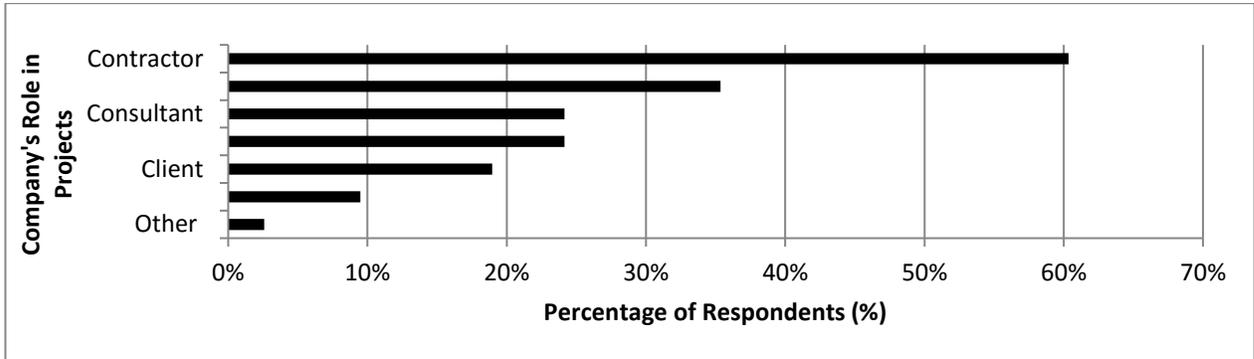


Figure 1. Company's role in projects (Multiple answers are possible)

In terms of the project management software, MS Project is widely used by companies (70%). Oracle Primavera is the second most popular software (25%) and it is mainly used in construction projects. MS Project and Oracle Primavera are also the most widely cited in the empirical literature (Pellerin ,2019; Baumann and Trautmann 2015; Cicibas, Unal, and Demir 2010; Hekimoğlu 2007). The respondents also stated lower levels of use for alternatives such as Jira (5%), Wrike(3%), Asana (3%), SAP (3%) and in-house developed software (4%). 13% of the companies does not employ any project management software at all. Project management generally consists of two main functions: the planning function, which includes project scheduling, and the project control function, focusing on project monitoring (Hekimoğlu, 2007; Willems and Vanhoucke, 2015). Figure 2 summarizes the functional purposes of using project management software. Software is commonly used for planning (85%), more specifically in creating the work breakdown structure (WBS) and scheduling the activities. Half of the respondents report that they use the software for cost and time monitoring. When the authors explicitly ask for the methods and tools applied for monitoring and control, 27% reports that they use EVM as a project control tool (Figure 3). This shows that, although half of the respondents monitor time and cost performance of projects using a software tool, only half of them make use of EVM modules of the software. Figure 3 shows the details of the statistics on the use of monitoring and control tools.

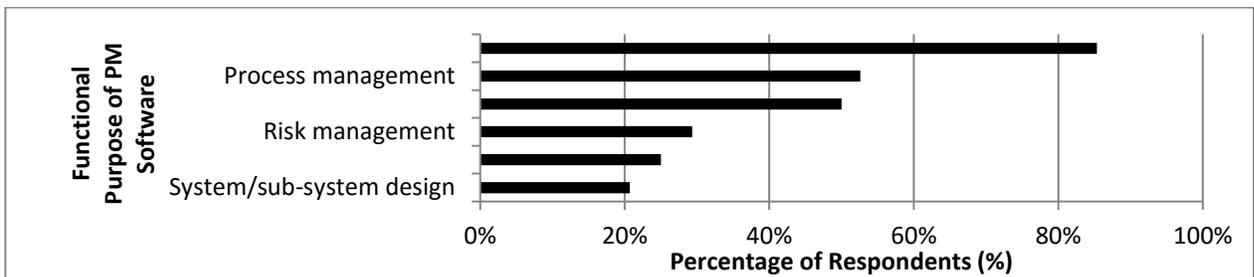


Figure 2. Functional use of project management software (Multiple answers are possible)

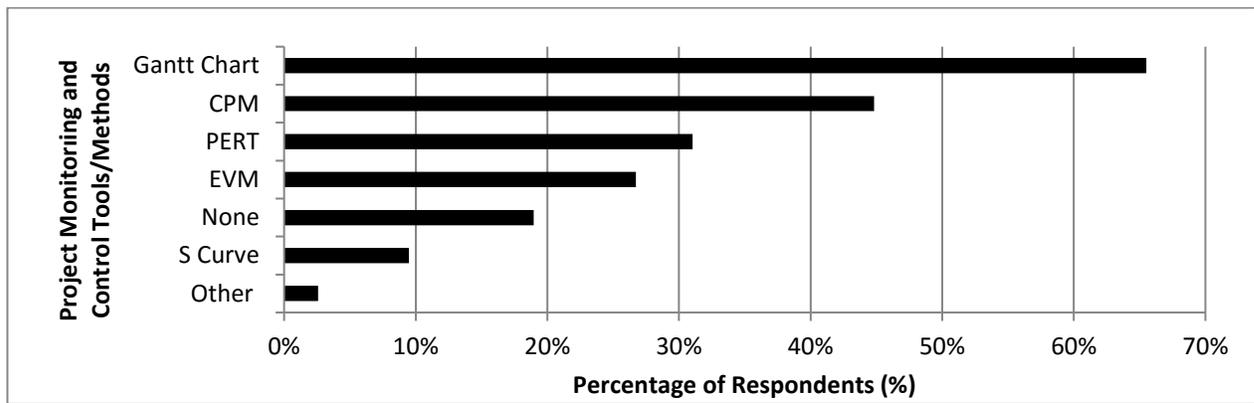


Figure 3. Tools/Methods used for monitoring and control (Multiple answers are possible)

Having given some descriptive statistics about the respondents and their preferred software and tools, the authors analyze the factors affecting EVM awareness and implementation.

#### 4.1.2. Descriptive Statistics on EVM Awareness and Implementation

Although more than half (53%) of the respondents are aware of EVM, implementation rate is rather low, only 26% use it quite frequently (Table 2). The level of EVM awareness is higher than many other countries except United States (Acebes et al., 2013; Vertenten et al., 2009; Keng et al, 2015; Dissanayake, 2010; De Marco et al., ,2013). The authors underline that training experience is a significant factor on the implementation of new approaches and methods. 34% of the respondents who are aware of EVM state that their company trained employees on EVM. This low training rate may be one of the factors that can explain the low implementation rates.

Table 2. EVM awareness and implementation

	Freq.	Percent (%)
Aware of EVM and use it quite frequently	30	25.9
Aware of EVM but use it rarely	15	12.9
Aware of EVM but does not use it	17	14.7
Not aware of EVM	54	46.6
<b>TOTAL</b>	<b>116</b>	<b>100</b>

Table 3 summarizes why the respondents use EVM in managing projects. The main factor is the facilitating role of the method in managing the projects (77%), followed by in-house standardization requirement (47%) and senior management’s decision to use EVM (43%).

Table 3. Main reasons for implementing EVM (Multiple answers are possible)

	Freq.	Percent (%)
Facilitation of project management	23	76.67
In-house standardization requirement	14	46.67
Senior management decision	13	43.33
Specification requirement	5	16.67
Recommended by the administration/contractor	4	13.33
Other	1	

The authors also investigate the functional purposes of EVM and how frequently respondents use it. The purposes are grouped into three: time control, cost control and overall performance evaluation/decision support. The respondents were asked to state the frequency of their EVM usage for a stated purpose on a scale from 1 to 4; where 1= never use to 4 = always use. In order to conduct reliability tests for the generated variables the authors calculate Cronbach’s alpha for each group and check for the internal consistency of the items included in each group. The test scale for all categories turned out to be higher than 70%, which is the generally accepted lower limit for reliability. Table 4 reveal that EVM’s time control function is more prevalent than the decision support and the cost control functions. EVM has been perceived as an effective time control tool

and it has widely been used to monitor the time progress and estimate the project completion time. This finding is in line with Batselier and Vanhoucke (2015b) as they argue that EVM constitutes a basis for forecasting project duration. After this, around 45% of the respondents frequently and 28% always use EVM as a decision support tool and in making intervention decisions. A key result is that respondents segregate cost and time control and use EVM for cost control less frequently than for time control in projects.

Table 4. Functional purposes and frequency of usage

Reasons	Obs	Never use (=1)	Rarely use (=2)	Frequently use (=3)	Always use (=4)	Mean (out of 4)
<b>Time Control</b>						<b>3.15</b>
Schedule monitoring	27	0%	15%	41%	44%	3.30
Estimating project completion time	28	0%	18%	39%	43%	3.25
Assessing the impacts of problems on completion time	28	0%	21%	50%	29%	3.07
<b>Cost Control</b>						<b>2.65</b>
Assessing the impacts of problems on project budget	27	15%	15%	44%	26%	2.81
Resource management	28	11%	36%	25%	29%	2.71
Project cost estimation	27	19%	22%	30%	30%	2.70
Project cost control	27	22%	22%	37%	19%	2.52
<b>Performance Evaluation and Decision Support</b>						<b>2.93</b>
Overall performance evaluation	30	7%	20%	33%	40%	3.07
Decision support	29	0%	28%	45%	28%	3.00
Intervention decisions	29	3%	24%	45%	28%	2.97
Detailed problem analysis	27	11%	26%	37%	26%	2.78

Regarding the project based factors, the authors investigated whether the project duration affects the implementation or not. When directly asked, 73% of the respondents indicate that project duration is a criterion to be considered in the decision to use EVM. Table 5 shows the relationship between EVM use and project duration. EVM is more frequently used for 3-5 year projects. Managers are less likely to use EVM for projects more than 5 years since requirements of these longer projects may change during the project life-cycle. 63% of the respondents do not use EVM or rarely use it if the project lasts less than a year.

Table 5. Project duration and frequency of EVM use

Time	Obs	Never used (=1)	Rarely used (=2)	Frequently used (=3)	Always used (=4)	Mean (out of 4)
Less than a year	22	18%	45%	27%	9%	2.27
1-3 years	24	4%	25%	42%	29%	2.96
3-5 years	21	14%	5%	38%	43%	3.10
5-10 years	18	28%	11%	28%	33%	2.67
Longer than 10 years	16	31%	6%	25%	38%	2.69

An analysis was done for the budget. 53% of the respondents state that EVM implementation is associated with the budget. Table 66 presents the relationship between EVM usage and the budget. As project budget increases, there is a tendency to use EVM more frequently. Based on the analysis of the industry related questions and the interviews, the authors find out that EVM is implemented more commonly in large-scale defense projects in Turkey. As these projects have higher budgets, the observed relationship with the budget is in-line with this finding.

Table 6. Project budget and frequency of EVM use

Budget	Obs	Never used (=1)	Rarely used (=2)	Frequently used (=3)	Always used (=4)	Mean (out of 4)
Low	22	45%	14%	27%	14%	2.09
Medium	22	9%	23%	55%	14%	2.73
High	22	9%	9%	50%	32%	3.05

The following section investigates the reasons for not implementing EVM. Respondents are asked to rank a number of reasons for not implementing EVM on a scale from 1=not important to 4 = very important. Table 7 shows the different reasons and average rankings by the respondents. EVM non-adoption is closely related to the implementation process and the reasons are classified under four groups: 1) Managerial and organizational factors 2) Project complexity 3) Type of contracts/projects 4) External factors. In order to conduct reliability tests for the generated variables the authors calculate Cronbach’s alpha for each group and check for the internal consistency of the items included in each group. The test scale for all categories turned out to be higher than 70%, which is the generally accepted lower limit for reliability.

Table 7. Reasons for not implementing EVM and their average rankings by respondents

Reasons for not implementing	Obs	Not important (=1)	Slightly important (=2)	Moderately important (=3)	Very important (=4)	Mean (out of 4)
<b>Managerial and Organizational Factors</b>	<b>28</b>					<b>2.68</b>
Lack of senior management support	28	18%	14%	29%	39%	2.89
Non-committed team members	28	25%	14%	29%	32%	2.68
Technical incapability of the project team	28	21%	11%	36%	32%	2.79
Inadequate computer/ software infrastructure	28	29%	21%	36%	14%	2.36
<b>Complexity</b>	<b>28</b>					<b>2.36</b>
Continuous, detailed data collection and analysis requirement	28	29%	4%	43%	25%	2.64
Detailed work breakdown structure (WBS) requirement	27	26%	19%	41%	15%	2.44
Too many technical terms and rules	28	43%	25%	21%	11%	2.00
<b>Type of Contracts/Projects</b>	<b>28</b>					<b>2.30</b>
High project uncertainty	28	25%	14%	32%	29%	2.64
Project term flexibility	28	39%	7%	36%	18%	2.32
Unit price contracts	28	43%	29%	21%	7%	1.93
<b>External Factors</b>	<b>28</b>					<b>2.27</b>
Client requirement of EVM use	28	32%	14%	46%	7%	2.29
Lack of legal regulations	28	36%	11%	46%	7%	2.25

Managerial and organizational factors are the most influential. More specifically, lack of senior management support is the most critical. To eliminate the reluctance of the managers, industry and business associations, business schools, and management institutes might increase their efforts to explain the methodology and emphasize the benefits. Project team’s lack of commitment and incompetency are also critical factors for not using EVM. To overcome possible employee resistance, EVM trainings may play an important role to facilitate the implementation.

Perceived complexity of the method is another preventing factor for non-adoption. In this category, continuous, detailed data collection and analysis requirements have the highest score (2.64). This complexity perception is related to data keeping, accounting and information systems structure of the companies. Thus, investing in these systems may also facilitate EVM implementation. Some of the respondents find EVM inefficient due to inherent uncertainty in projects. These findings are in line with Kim et al (2003), who cite the following reasons for not implementing EVM: high cost, project manager’s lack of competence of EVM, lack of user participation, conflicts between users and decision makers and reluctance to report bad news.

Finally, the authors ask the respondents about their future plans. 55% of respondents state that they plan to use EVM more frequently in the future. 30% aims to work on solving the data management problems, while 27% wants to receive

EVM training. 25% of the respondents wish to become a trainer of EVM and train other employees as well as the senior managers and project engineers.

#### 4.1.3 Probit Analysis on EVM Awareness and Implementation

This analysis focuses on understanding EVM awareness and EVM implementation. First, the authors discover which of the independent variables described in Table 1, affect EVM awareness. Second, the authors investigate what types of managers/companies are more likely than the others to implement EVM. The authors use two different indicator variables, which take the value of one if the individual states that he/she is aware of/implements EVM, and zero otherwise. Probit regression findings for EVM awareness and implementation are summarized in Table 8 and Table 9, respectively.

Table 8 shows that five factors significantly affect the likelihood that the respondent is aware of EVM. These factors include the industry, the software choice, the experience of the company, the company’s role and the use of project management software. Surprisingly, user characteristics (education and work experience) do not have a significant effect on the likelihood of EVM awareness. This might be related with the fact that the sample is highly homogeneous in terms of education (nearly 50% undergraduate and 50% graduate degrees). However, software usage and project environment have significant explanatory power. In particular, companies in construction industry are 25.7 percentage points less likely to be aware of EVM compared to other companies.

Table 8. Probit Regressions for EVM Awareness

Dependent Variable	Observations: 106		
EVM Awareness (1,0)			
	Coef.	Robust Std. Err.	Marginal Effects
<b>User</b>			
Education (Masters/PhD:1)	0.311	0.281	0.083
Work Experience (1-3)	0.163	0.187	0.044
<b>Project Monitoring and Control Methodology</b>			
Non-use of PM Software (1,0)	-1.335**	0.532	-0.357***
<b>Project Environment</b>			
Company Project Experience (years)	-0.033**	0.013	-0.009***
Construction Industry (1,0)	-0.961***	0.333	-0.257***
Project type-Turn Key (1,0)	0.813	0.317	0.217***
PM Software Purpose-Cost/time monitoring and control(1,0)	0.89***	0.310	0.238***
Company Role-Technical Supervision (1,0)	-1.566***	0.530	-0.418***
Constant	-0.084	0.575	

Notes: The first two columns of the table reports coefficient estimates and robust standard errors for the probit regression of EVM Awareness on the independent variables explained in Table 1. The last column reports the marginal effects. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5% and 10% levels, respectively.

The authors report that companies’ computer system resources and EVM awareness levels are linked. If there is no project management software at the company, the respondents are 35.7 percentage points less likely to be aware of EVM. As companies allocate more resources for automated computer systems, project teams are more likely to learn about PM software and their embedded modules. Many companies also provide trainings and seminars to the project teams in order to improve the utilization of software. Moreover, if the company uses PM software for time and cost control, project team members are 23.8 percentage points more likely to be aware of EVM.

Contrary to authors’ expectations, the authors observe that EVM awareness decreases as the project experience of the company increases. However, the marginal effect is -0.9 percentage points, which is very small in magnitude. Finally, employees who work in companies that act as technical supervisors are 41.8 percentage points less likely to be aware of EVM. These people focus on technical problems and usually do not perform analysis of time and cost performance of projects. Next, the authors analyze the implementation of EVM and present the results in Table 9.

Table 9. Probit Regressions for EVM Implementation

Dependent Variable EVM Implementation (1,0)	Observations: 55		
	Coef.	Robust Std. Err.	Marginal Effects
<b>User</b>			
Education (Masters/PhD:1)	0.149	0.486	0.031
Job Description (1-4)	0.318	0.304	0.065
Work Experience (1-3)	-1.127**	0.455	-0.231***
<b>Project Environment</b>			
Company Project Experience (years)	0.01	0.026	0.002
Construction Industry (1,0)	0.53	0.582	0.109
Defense Industry (1,0)	2.094***	0.740	0.43***
Manufacturing Industry (1,0)	1.72**	0.765	0.353**
Company Role-Contractor/Subcontractor (1,0)	1.172	0.831	0.241
Project type-Turn Key (1,0)	0.74	0.600	0.152
Project type-Lump Sum (1,0)	1.909**	0.861	0.392**
Project type-Unit Price (1,0)	1.341**	0.563	0.275**
Project type-In-house Project (1,0)	-1.22**	0.529	-0.251**
<b>Implementation Process</b>			
EVM Training (1,0)	0.984	0.617	0.202*
Constant	-1.7	1.189	

Notes: The first two columns of the table reports coefficient estimates and robust standard errors for the probit regression of EVM implementation on the independent variables explained in Table 1. The last column reports the marginal effects. \*\*\*, \*\*, and \* denote statistical significance at the 1%, 5% and 10% levels, respectively.

In this analysis, the sample includes respondents who are aware of EVM. Table 9 indicates that more experienced respondents are less likely to use EVM as represented by -23.1 percentage points in the marginal effects column. The authors consider that new graduates and younger managers might be more likely to implement software based data analysis tools. More experienced PMs might prefer to use heuristics or basic methods that require less detailed data analysis. The authors also report that respondents working in defense and production sectors are 42 and 35.3 percentage points more likely to use EVM, respectively. Companies that are using lump-sum and unit price projects are more likely to use EVM while companies that are using in-house projects are less likely to use EVM. This finding addresses the contracts, project execution, delivery requirements, and reporting standards. It could be expected that if there is no specific methodology implementation or reporting standards requirement, it is less likely that PMs implement EVM.

#### 4.2. Semi-structured Interviews and Results

In addition to questionnaire analysis, the authors conducted semi-structured interviews to collect experts' opinions and benefit from their expertise in the analysis. The authors compared the questionnaire findings with their responses. Interviewees were chosen in a way to ensure diversity regarding expertise, job titles and the industries. They are project engineers and managers working in construction, defense, software, telecommunication, logistics and e-commerce industries. Table 10 presents a summary of the findings of six semi-structured interviews.

All of the interviewees agree that EVM implementation is beneficial to track project progress effectively. However, they add that adopting a common EVM terminology in the companies is critical for successful implementation and they stress the importance of data accuracy and training of the teams. Senior management's support and leadership are stated to be vital. They also believe that project contracts assume an important role in the implementation of the methodology (see the case study of Picornell et al. (2016) for the implementation in unit price contracts). They consider that companies usually do not invest in training or do not adopt the methodology unless it is a contractual obligation.

Some of them underlined that EVM is especially appropriate for longer-term contracts in which monitoring, planning and cost control are critical and which have fixed delivery dates. They claimed that the defense industry might largely benefit this method and EVM is especially beneficial for projects for which delays may result in contractual penalties and loss of prestige. Interviewees also note that EVM implementation might be perceived as an additional constraint/difficulty for small projects. The authors note that these remarks support the findings from survey analysis. Majority of the interviewees consider

EVM usage as difficult and time consuming which makes it inefficient in short projects. These remarks bring explanation to the reasons for not implementation presented in Table 7.

Other interesting notes are as follows: One of the interviewees noted that EVM awareness has increased in Turkey with the increase of PMI certified PMs. Another one believes that EVM is still not widely used in Turkey because it is perceived as complicated and underlines the role of user-friendly software systems. One of them states that EVM implementation would be easier for projects that are of similar nature. For example in projects such as dam, road and hotel construction even though the details vary, items of work are very similar. On the other hand implementation of EVM, in terms of work breakdown and cost structure, may not be very straightforward for R&D projects which are for prototypes or unique in nature.

## 5. Conclusion

This study investigated the factors affecting EVM awareness and implementation based on a sample from Turkey. The results of the questionnaire with 116 respondents reveal that EVM awareness is affected by the industry, choice of project management software, the project management experience of the company, the role of the company in the project and the functional use of project management software. Regarding the EVM implementation, an interesting finding is that time control is more prevalent than cost control. Support of the senior management, project team's understanding and acceptance of EVM are the critical factors. Other important factors are the industry of the company and project type as well as the duration of the project.

To gain further insights, six in-depth interviews have been conducted as a follow-up of survey. The interviews confirmed the critical factors in implementing EVM: Project type, the size and the scheduling have been highlighted. Other critical factors are the support of senior management and the project team. Investment on software programs is another key factor for EVM implementation.

Based on questionnaire and interview results, the authors can conclude that EVM usage has not matured yet in Turkey. However, the results also confirm that project managers who are aware of EVM mostly consider the methodology as an effective project monitoring and control tool. Even though several implementation difficulties are cited, the benefits are numerous. Analyzing the current PM trends, the emergence of data analytics and open source software tools, increasing managerial emphasis on performance evaluation and benchmarking, the authors consider that EVM will increase its application areas, especially in developing countries. In this regard, the results constitute an initial step for further analysis of EVM practices in other developing countries. A follow up study could compare EVM usage and acceptance in developing countries.

Another interesting extension of the study would be focusing on the organizations and their project management maturity levels. Within the general framework of the project management practices and the adoption of methodological tools, the relations between the maturity level of project management and EVM implementation could be considered for further analysis.

Table 10. Summary of Semi-structured Interviews

Table presents a summary of six semi-structured interviews.

	<b>INTERVIEW 1</b>	<b>INTERVIEW 2</b>	<b>INTERVIEW 3</b>	<b>INTERVIEW 4</b>	<b>INTERVIEW 5</b>	<b>INTERVIEW 6</b>
<b>Education</b>	Industrial Engineer, MSc	Chemical Engineer, MBA	Civil Engineer, MSc	Industrial Engineer, MSc	Industrial Engineer, MSc	Mechanical Engineer
<b>Job Title</b>	Project Manager	Head of Sales & Marketing	Technical Office Senior Engineer	System Development Project Manager	PMO Coordinator	General Manager, owner
<b>Current Industry</b>	Defense –(R&D and production)	Telecommunication	Construction	Logistics, E-commerce	Defense, Software	Defense ( R&D)
<b>Scope of Projects</b>	National	National	National& international	National & international	National & international	National
<b>EVM usage</b>	EVM is used in all projects except the production projects as required by company policy.	First person to acquire an EVM certificate in Turkey. Used it in a pilot IT project by obtaining special permission.	EVM is not actively used in his company. However, he has received EVM training and holds a PMP certificate.	Actively uses EVM.	EVM has been used in all projects for the last 20 years as required by company policy.	EVM is not used in his company.
<b>Reporting Method</b>	Monthly reporting. Expert judgement method is used. The project managers collect the data from their teams, enter the information into the system, carry out reporting, and keep project metrics.	It was only applied in the one-year pilot project.	For reporting, MS Excel and AX are used. Project managers carry out the reporting.	It is being structured.	Reports are prepared every three weeks. SAP personnel collect data from the project team and run the report. Project team then presents the report.	-
<b>Time Control</b>	Analysis and reporting carried out on a monthly basis.	Uses ERP system.	Uses EVM for time control.	Uses EVM for time control. Most recent use of EVM is in the "Industry 4.0" Program during the digitization phase of their plants.	Uses EVM regularly to meet the calendar goals and milestone tracking.	

	<b>INTERVIEW 1</b>	<b>INTERVIEW 2</b>	<b>INTERVIEW 3</b>	<b>INTERVIEW 4</b>	<b>INTERVIEW 5</b>	<b>INTERVIEW 6</b>
<b>Cost Control</b>	EVM is not implemented on a cost basis, but on time and resource basis. Major source of resource is labor (50% of the project costs /resources) However, since the contracts are based on unit-price (rather than cost-plus), costs are not a concern. Hence, they do not plan to integrate cost in the short term, but cost will be integrated if they switch to the IFRS system.	The functional manager not the project manager monitors and controls the budget.	EVM is not used for cost control. It is carried out in accordance with the in-house procedure and reported to the senior management.	Uses EVM for cost control. Most recent use of EVM is in the "Industry 4.0" Program during the digitization phase of their plants.	Only resource control is used. Since it is a software company, main sources of costs are labor. The data is entered as man / hour, but the man / hour fees are not known by the project team.	-
<b>Software Used</b>	Initially Primavera was used for EVM. Then they developed a customized project tracking system and integrated it to SAS. A short time ago, they switched to SAP Hana.	SPI, CPI are integrated into the HP PPM software for the pilot project. MS Project, Primavera are also used.	They switched to ERP system and started using Microsoft Ax this year. MS Excel, Project and Primavera are also used.	He has used Oracle, Primavera, MS Project, SAP PS and JIRA until now. He finds the products of Oracle one-step ahead of Microsoft (because it has fewer limitations) and JIRA a more specific tool. He does not find SAP PS beneficial for project management.	He uses SAP PS even though he does not find it user-friendly.	The company uses in-house developed software. He recommends companies that work on similar projects to use ERP software blocks created for vertical sectors.
<b>EVM Training</b>	All new employees get a comprehensive training on project management and EVM from a PMI accredited company.	No training	No training	No training	Regular trainings at the company.	No training

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## REFERENCES

- Abdi, Abdollah, Sharareh Taghipour, and Homayoun Khamooshi. "A model to control environmental performance of project execution process based on greenhouse gas emissions using earned value management." *International Journal of Project Management* 36, no. 3 (2018): 397-413.
- Abdul-Rahman, Hamzah, Chen Wang, and Norjuma'ah Binti Muhammad. "Project performance monitoring methods used in Malaysia and perspectives of introducing EVA as a standard approach." *Journal of Civil Engineering and Management* 17, no. 3 (2011): 445-455.
- Acebes, Fernando, Pajares, J., Galán, J. M., & López-Paredes, A. "Beyond earned value management: A graphical framework for integrated cost, schedule and risk monitoring." *Procedia-Social and Behavioral Sciences* 74 (2013): 181-189.
- Anbari, Frank T. "Earned value project management method and extensions." *Project Management Journal* 34, no. 4 (2003): 12-23.
- Artun B. (1998). Implementation of Earned Value Concept in Turkish Construction Industry. Thesis submitted to Mimar Sinan University, Turkey.
- Batselier, Jordy, and Mario Vanhoucke. "Construction and evaluation framework for a real-life project database." *International Journal of Project Management* 33, no. 3 (2015a): 697-710.
- Batselier, Jordy, and Mario Vanhoucke. "Empirical evaluation of earned value management forecasting accuracy for time and cost." *Journal of Construction Engineering and Management*, 141(11) (2015b): 05015010.
- Baumann, Philipp, and Norbert Trautmann. "Resource-constrained project scheduling with project management information systems." *Handbook on Project Management and Scheduling* Vol. 2. Springer, Cham, 2015. 1385-1400.
- Bryde, David, Christine Unterhitzberger, and Roger Joby. "Conditions of success for earned value analysis in projects." *International Journal of Project Management* 36, no. 3 (2018): 474-484.
- Caron, Franco, Fabrizio Ruggeri, and Alessandro Merli. "A Bayesian approach to improve estimate at completion in earned value management." *Project Management Journal* 44, no. 1 (2013): 3-16.
- Christensen, David S. "The costs and benefits of the earned value management process." *Journal of Parametrics* 18, no. 2 (1998): 1-16.
- Cicibas, Halil, Omer Unal, and Kadir Alpaslan Demir. "A Comparison of Project Management Software Tools (PMST)." *Software Engineering Research and Practice*. 2010.
- De Marco, Alberto, and Timur Narbaev. "Earned value-based performance monitoring of facility construction projects." *Journal of Facilities Management* 11.1 (2013). 69-80
- Dissanayake, P. B. G. "Earned Value Management System as a project Management tool for major multi-disciplinary projects." *International Conference on Sustainable Built Environment* (2010): 14-21.
- Duran, Z. (2016). *Bir proje performans ölçüm sistemi olarak kazanılmış değer analizi ve bir araştırma* (Master's thesis, Pamukkale Üniversitesi Sosyal Bilimler Enstitüsü).
- Efe, Pinar, and Onur Demirörs. "Applying EVM in a software company: benefits and difficulties." In *2013 39th Euromicro Conference on Software Engineering and Advanced Applications*, pp. 333-340. IEEE, 2013.
- Fleming, Quentin W., and Joel M. Koppelman. "Earned value project management." Project Management Institute, 2016.
- Gürbüz A (2010) Method of earned value which is applied to a shipyard project, Thesis submitted to Gebze Technical University, Turkey.
- Hazır, Öncü. "A review of analytical models, approaches and decision support tools in project monitoring and control." *International Journal of Project Management* 33, no. 4 (2015): 808-815.
- Hazır, Ö., and A. Shtub. "Effects of the information presentation format on project control." *Journal of the Operational Research Society* 62, no. 12 (2011): 2157-2161.
- Hekimoğlu, O. Comparison of the resource allocation capabilities of project management software packages in resource constrained project scheduling problems. Diss. MS thesis, Middle East Technical Univ., Ankara, Turkey, 2007.
- Khamooshi, Homayoun, and Hamed Golafshani. "EDM: Earned Duration Management, a new approach to schedule performance management and measurement." *International Journal of Project Management* 32, no. 6 (2014): 1019-1041.
- Keng, Tan Chin, and Najihah Shahdan. "The application of earned value management (evm) in construction project management." *Journal of Technology Management and Business* 2.2 (2015).
- Kerkhove, L-P., and Mario Vanhoucke. "Extensions of earned value management: Using the earned incentive metric to improve signal quality." *International Journal of Project Management* 35, no. 2 (2017): 148-168.

- Kim, Byung-Cheol, and Jeffrey K. Pinto. "What CPI= 0.85 Really Means: A Probabilistic Extension of the Estimate at Completion." *Journal of Management in Engineering* 35, no. 2 (2018): 04018059.
- Kim, Chang-Won, Wi Sung Yoo, Hyunsu Lim, Ilhan Yu, Hunhee Cho, and Kyung-In Kang. "Early-warning performance monitoring system (EPMS) using the business information of a project." *International Journal of Project Management* 36, no. 5 (2018): 730-743.
- Kim, EunHong, William G. Wells Jr, and Michael R. Duffey. "A model for effective implementation of Earned Value Management methodology." *International Journal of Project Management* 21, no. 5 (2003): 375-382.
- Kwak, Young Hoon, and Frank T. Anbari. "History, practices, and future of earned value management in government: Perspectives from NASA." *Project Management Journal* 43, no. 1 (2012): 77-90.
- Lipke, Walt, Ofer Zwikael, Kym Henderson, and Frank Anbari. "Prediction of project outcome: The application of statistical methods to earned value management and earned schedule performance indexes." *International journal of project management* 27, no. 4 (2009): 400-407.
- Morad, Mohamed, and Sameh M. El-Sayegh. "Use of Earned Value Management in the UAE Construction Industry." In *2016 International Conference on Industrial Engineering, Management Science and Application (ICIMSA)*, pp. 1-5. IEEE, 2016.
- Narbaev, Timur, and Alberto De Marco. "An earned schedule-based regression model to improve cost estimate at completion." *International Journal of Project Management* 32, no. 6 (2014): 1007-1018.
- Netto, Joaquim Teixeira, Osvaldo Quelhas, Sérgio França, Marcelo Meiriño, and Valdir Lameira. "Performance Monitoring Using EVM Indicator: a study case of construction projects in the public sector in Brazil." *Sistemas & Gestão* 10, no. 1 (2015): 194-202.
- Nkiwane, Ntokozo H., Werner G. Meyer, and Herman Steyn. "The use of Earned Value Management for initiating directive project control decisions: A case study." *South African Journal of Industrial Engineering* 27, no. 1 (2016): 192-203.
- Olawale, Yakubu, and Ming Sun. "Construction project control in the UK: Current practice, existing problems and recommendations for future improvement." *International journal of project management* 33, no. 3 (2015): 623-637.
- Pajares, Javier, and Adolfo Lopez-Paredes. "An extension of the EVM analysis for project monitoring: The Cost Control Index and the Schedule Control Index." *International Journal of Project Management* 29, no. 5 (2011): 615-621.
- Pellerin, Robert, and Nathalie Perrier. "A review of methods, techniques and tools for project planning and control." *International Journal of Production Research* 57.7 (2019): 2160-2178.
- Picornell, Miguel, Eugenio Pellicer, Cristina Torres-Machí, and Monty Sutrisna. "Implementation of earned value management in unit-price payment contracts." *Journal of Management in Engineering* 33, no. 3 (2016): 06016001.
- Shtub, Avraham, and Shlomo Globerson. *Project management: Processes, methodologies, and economics*. (New International Edition). New York: Prentice Hall, 2014.
- Vandevoorde, Stephan, and Mario Vanhoucke. "A comparison of different project duration forecasting methods using earned value metrics." *International journal of project management* 24, no. 4 (2006): 289-302.
- Vanhoucke, Mario. *Measuring time: Improving project performance using earned value management*. Vol. 136. Springer Science & Business Media, 2009.
- Vanhoucke, Mario. "Measuring the efficiency of project control using fictitious and empirical project data." *International journal of project management* 30, no. 2 (2012): 252-263.
- Vertenten, M., L. Pretorius, and J. H. C. Pretorius. "Earned Value as a performance measurement tool for small and large construction projects in a South African environment." *AFRICON 2009. IEEE*, 2009.
- Willems, Laura L., and Mario Vanhoucke. "Classification of articles and journals on project control and earned value management." *International Journal of Project Management* 33, no. 7 (2015): 1610-1634.