



## Yazılım Süreç Geliştirme Modellerinin KOBİ'lerde Kabulü için Model Geliştirilmesi: Ön Bulgular

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### MAKALE BİLGİSİ

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### ÖZET

Yazılım endüstrisi tüm dünya ekonomilerinin gelişiminde önemli bir rol oynamaktadır. Bu firmaların çoğunluğu küçük ve orta ölçekli şirketlerden (KOBİ) oluşmaktadır. Bu şirketler, rekabetçi bir ortamda ürün kalitesini ve verimliliğini artırmak için Yazılım Süreç İyileştirmelerinden (YSİ) faydalanmayı amaçlamaktadır. YSİ uygulamaları beraberinde kurumsal değişim ve yeni araçlara, tekniklere ve iş uygulamalarına adapte olmayı gerektirdiğinden; kurumlar değişimden kaynaklanan çeşitli zorluklarla başa çıkmak zorundadır. Bu çalışmada, KOBİ'lerde kullanılan YSİ model ve / veya standartlarının başarısını ve benimsenmesini etkileyen faktörler sunulmaktadır. Ayrıca, KOBİ'ler için Davranışsal Teoriye dayanarak geliştirdiğimiz YSİ kabul modelinin ön bulguları sunulmaktadır. CMMI Seviye 3 firmasında çalışan 20 katılımcı ile modeli analiz etmek için pilot bir anket çalışması yapılmıştır.

## Towards Development of a Model for Acceptance of Software Process Improvement Models in SMEs: Preliminary Findings

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### ABSTRACT

The software industry is playing a significant role in development of economies all over the world. It is mainly made up of small and medium software enterprises (SMEs). These companies aim to benefit from Software Process Improvements (SPI) to increase product quality and productivity in a competitive environment. Several SPI models and frameworks have been developed to improve software quality in SMEs. As SPI require organizational change and adaptation to new tools, techniques and work practices; organizations have to handle with several challenges emerged from the change. In this study, we present the factors that influence the success and adoption of the SPI models and/or standards used in SMEs. We also present the preliminary findings of the SPI acceptance model that we developed based on an established behavioral theory for SMEs. A pilot survey study was conducted to analyze the model with 20 participants who work in a CMMI Level 3 company.

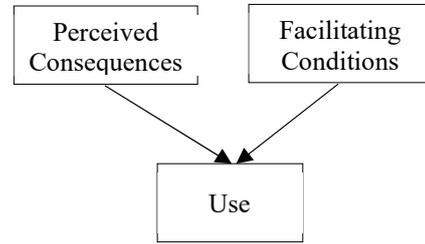
## 1. INTRODUCTION (GİRİŞ)

Software Process Improvement (SPI) is essential for organizations to increase product quality, productivity, efficiency and stakeholder satisfaction while decreasing development costs [1]. There are different SPI models and standards that assist to manage the software development activities. The Software Engineering Institute (SEI) and International Organization for Standardization (ISO) have expressed great importance in this research area and developed standards and models [2]. Capability Maturity Model Integration (CMMI) [3] and ISO/IEC 15504 [4] provide guidance in assessment and improvement of software processes. On the other hand, these two models are mainly intended for use in large-sized organizations [5, 6]. Therefore, implementing these models can be challenging for SMEs with resource constraints.

SMEs are the major contributors of the economies worldwide. SMEs (refers to employing up to 249 people) account for over 95% of businesses globally [7]. SPI is very important for these settings due to several reasons. One of them is efficiency. Efficient use of the limited resources is crucial for SMEs. SPI provides process optimization by simplifying business routines, reducing rework and removing unnecessary process steps. Another reason for adopting SPI models in software organizations is to increase customer satisfaction by delivering desired product functions in a timely manner. Last and foremost, if SMEs cannot continuously improve the way they perform their processes, they are likely to be overtaken by their competitors in the market. Therefore, continuous process improvement would help companies in achieving competitive advantage. Many new tools, tailoring frameworks, roadmaps and guidelines have been developed or tailored for SMEs to improve and assess their processes (e.g., COMPETISOFT [29], SAMAY [30] and Quicklocus [31]). On the other hand, it is obvious that implementation of these SPI studies introduces major changes to the organizations. At this point, employee acceptance and management of resistance to change becomes a very important issue for the success of SPI programs in SMEs. Davis (1993) proposes that acceptance is the key determinant of project or system success [8]. This research aims to explain the factors that affect the acceptance of the SPI practices in SMEs. We also present the preliminary findings of the SPI acceptance model that we developed based on an established behavioral model; Development Method Adoption (DMA) [9].

## 2. METHOD (METOD)

Participating software process improvement activities in organization is a behavior which can be explicated by well-defined behavioral theories such as Theory of Planned Behavior presented by Azjen [10], Theory of Interpersonal Behavior by Triandis [11] and Development Method Adoption (DMA) offered by Khalifa et al [9]. In this research, we have utilized the DMA model which can be tailored to any development process. The DMA model shown in Figure 1 has mainly three constructs: “Perceived Consequences”, “Facilitating Conditions” and “Use”. Basically, “Perceived Consequences” refers to the gains that we achieve at the end of use, on the other hand, “Facilitating Conditions” refers to the factors that make it easier for us to perform this behavior.



**Figure 1.** Development Method Adaption Model by Khalifa et al [9]

(Geliştirme Metodu Adaptasyon Modeli)

**Perceived Consequences:** “Each act or behaviour is perceived by the individual as having a potential outcome that can be either positive or negative” [9].

**Facilitating Conditions:** “These are objective factors in the environment that facilitate the performance of an act” [9].

**Use:** “Actual behavior of users” [9].

We have started developing the Software Process Improvement Acceptance Model in SMEs based on the DMA model. To identify the “Perceived Consequences” of SPI activities, we have analysed the benefits of SPI for SMEs in depth. McGibbon (1999) stated that two frequently cited SPI benefits are to enhance productivity of developers and to decrease development costs [12]. In addition, SPI is perceived useful due to its potential in increasing quality [12].

To support this idea and make a comprehensive analysis with SME focus, we have conducted a Systematic Literature Review (SLR). We have used ESCO Host, IEEE Explore, Scopus, ScienceDirect, Google scholar and MetuUnique (<https://library.metu.edu.tr>) database services for the SLR. The searching has been carried out through the

generic search terms such as “Process Improvement” and “SPI” combined with the “SME” and “small and medium” terms. The study has examined the papers published between January 2007 and March 2019. The collected papers have been analysed and eliminated in terms of their relevance. At the end of the elimination process, 56 studies have been identified. With a focus on identifying the benefits of SPI (Perceived Consequences), we have extracted related keywords from the papers and then categorized them. The results of the categorization process are shown in Table 1.

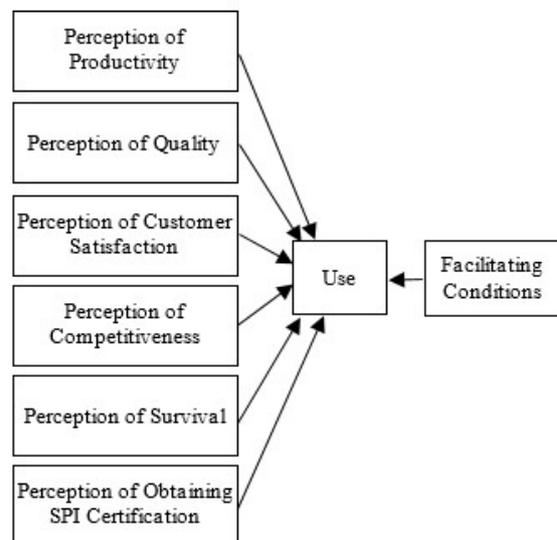
There are six SPI benefits (Perceived Consequences). Software quality is the most mentioned benefit in this study set. The key to the survival of SMEs is to produce and market quality software products [13]. In order to develop and deliver high quality software, SMEs have started to adopt SPI which has significantly positive impact on software product quality [13]. Furthermore, research has shown that SMEs can increase customers’ satisfaction with high quality products, operational effectiveness and efficiency [14]. According to our SLR results, SPI practices provide benefits to enhance customer satisfaction in SMEs, 14 papers indicate these benefits. Increase in productivity is another motivation for SMEs to implement software processes. The results have indicated that efforts to SPI can help reduce cost and time to market which are enhance the productivity [16, 17]. Ten papers of this SLR mention that SMEs perform SPI models to enhance the productivity. Beside these, SPI would be differentiator in being competitive when projects have better processes [6]. As stated in **Table 1**, SPI studies provide a competitive advantage and enable surviving in a competitive environment. Lastly, customers may require evidence of conformance to specific standards especially when bidding on government businesses. SPI appraisals that proofs the conformance of software processes might be essential for getting new business opportunities [18].

**Table 1.** Perceived Consequences of SPI Studies  
(YSİ Çalışmalarının Algılanan Sonuçları)

Benefits of SPI	Studies	#
Increase software quality	[13], [14], [16], [17], [26], [27], [31], [32], [33], [38], [41], [47], [53], [57], [61]	15
Increase Customer Satisfaction	[6], [14], [15], [16], [18], [40], [42], [45], [46], [47], [50], [51], [56], [57]	14

Increase productivity	[15], [16], [17], [27], [33], [35], [37], [40], [41], [44]	10
Survival	[6], [13], [30], [40]	4
Competitiveness	[6], [35], [48], [31]	4
Certification for software development	[18]	1

The “SPI Benefits (Perceived Consequences)” are represented on the left side of the Model as shown in **Hata! Başvuru kaynağı bulunamadı..** So that, we propose that, using SPI models in SMEs enhance software quality, customer satisfaction, productivity. Moreover, the model propose that using SPI enables SMEs to gain competitive advantage in business and to survive easily. Furthermore, having an SPI certificate allows SMEs to seize job opportunities where the certificate is a prerequisite.



**Figure 2.** Perceived Consequences of the SPI Acceptance Model  
(YSİ Kabul Modelinin Algılanan Sonuçları)

As the second step of developing the model, we defined the Facilitating Conditions which may support a particular behaviour and enhance the success of SPI implementation [9]. The success of SPI implementations has been extensively studied in literature [19]. Moreover, factors affecting the success of SPI studies have been discussed, critical success factors and barriers have been identified [20]. In order to address the facilitating conditions, we have extracted critical success factors from the literature and summarized them in Table 2. As listed below, seven factors have been found for facilitating the acceptance of SPI in SMEs.

**Table 2.** Facilitating Conditions of SPI  
(*YSİ'nin Kolaylaştırıcı Koşulları*)

Success Factor	Studies	#
Resources	[19], [20], [28], [36], [37], [39], [43], [46], [49], [52], [54], [55], [56], [57], [58], [59], [60], [61],	18
Skills	[6], [13], [19], [20], [30], [32], [38], [44], [47], [49], [54], [55], [57], [59], [60], [61]	16
Staff Involvement	[13], [18], [19], [20], [25], [26], [27], [30], [32], [38], [44], [46], [54], [56], [57], [59]	16
Management Support	[17], [18], [19], [20], [25], [26], [28], [30], [32], [35], [38], [41], [44], [54], [59]	15
Alignment with the Business Strategy and Goals	[5], [13], [19], [20], [29], [30], [34], [35], [39], [41], [48], [54], [56], [59]	14
Training	[19], [20], [29], [30], [32], [38], [40], [41], [42], [44], [47], [54], [57], [59],	14
Communication	[15], [19], [20], [29], [30], [40], [41], [44], [49], [54], [55], [57], [59]	13

The facilitating conditions are represented on the right side of the Model as shown in Figure 3.

According to **Table 2**, the most mentioned factor is resource. Implementing SPI models requires time, budget and human resource [20]. We propose that if the proper resource allocation is made, SPI program is implemented easily. This facilitates the acceptance behavior. The second facilitating condition is skill, experienced and qualified personnel are crucial for the efficient execution of SPI programs [30]. The third factor is staff involvement which means that the staff have same goal with an SPI program [38]. Staff involvement also indicates the eager to share their experience for performing SPI activities. Another factor is management support. Managers are responsible to facilitate restructuring of the processes, to provide resources and encourage the staff participating in the SPI program [19]. The next facilitating condition is goal alignment. If the managers define the SPI goal and indicate the value of SPI studies to their organization, the SPI usage motivation can be increase. Another factor is training, it enables developing new skills and knowledge which would facilitate implementation of SPI models [42]. Lastly, communication is an important facilitator, it fosters collaboration and raises awareness among staffs about SPI programs [49].



**Figure 3.** Facilitating Conditions of SPI Acceptance Model  
(*YSİ Kabul Modelinin Kolaylaştırıcı Koşulları*)

After determining the “Perceived Consequences” and “Facilitating Conditions”, we analyzed the “Use” construct of our model. “Use” construct has been extensively studied in technology acceptance scope. For example, Technology Acceptance Model (TAM) includes “Perceived Ease of Use” and “Usefulness” constructs to define the actual use. According to TAM, both constructs have a major impact on users' attitude towards using technology. These two factors are also valid in our context. We define the “Use” construct as “the degree of person believes that using SPI would be free of effort” (Ease of Use) and “the degree of person believes that using SPI would increase the job performance” (Usefulness) [21]. We added them into our model and established relationships between the constructs based on the following proposed hypotheses (Figure 4):

- **H1:** Higher perceptions of Software Productivity, Quality, Customer Satisfaction, Survival, Competitiveness and Obtaining Certification will be related to higher perceptions of the SPI usefulness.
- **H2:** Higher perceptions of Resources, Skills and Training will be related to higher perceptions of the ease of use of SPI.
- **H3:** Higher perceptions of Staff Involvement, Management Support, Goal Alignment and Communication will be related to higher perceptions of the usefulness.
- **H4:** Higher perceptions of ease of use will be related to higher perceptions of the usefulness.
- **H5:** Higher perceptions of ease of use and usefulness will be related to higher perceptions of SPI use.

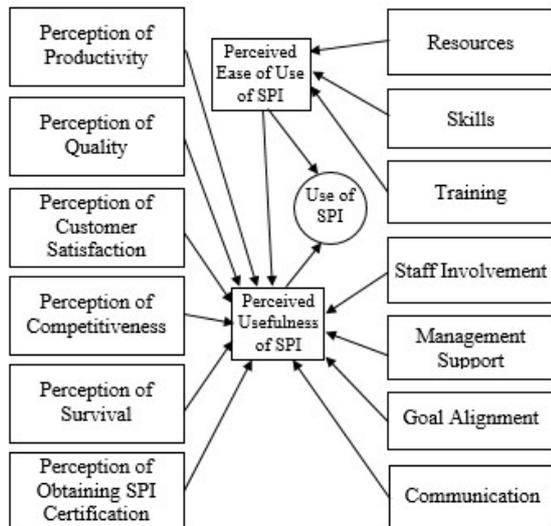


Figure 4. Proposed SPI Acceptance Model (Önerilen YSI Kabul Modeli)

We performed a pilot survey study for the initial analysis of proposed model. We developed a questionnaire that composed of two main parts. In first part, general information is collected from the participants such as age, experience and education level. The second part includes questions for each construct given in the model. There are 25 questions in the survey instrument that were presented with a Likert-type scale (1-5: very poor to very good). The sample question set is given in **Hata! Başvuru kaynağı bulunamadı..** The survey was performed in a company which develops command and control systems. The company has the CMMI Level 3 and ISO/IEC 9001 certificates. Twenty participants filled the questionnaire. The participants have approximately 6-9 years of experience. Previously, they have contributed in achieving the CMMI Level 3 and ISO/IEC 9001 certifications.

Table 3. Sample Question Set (Örnek Soru Seti)

Part 1		Education level
		Total work experience
Part 2	Perception of Productivity	Using SPI Models has speeded up my development speed
		Using SPI Models increases my productivity
		Using SPI Models increases my time management
	Perception of Quality	Using SPI Models increases the quality of software product
		Using SPI Models decreases the error rate of software product
		Using SPI Models increases documentation quality.

Ease of use	I found it easy to use SPI Model
	The tools and techniques of SPI Models are clear and understandable
	I find SPI Model is easy and flexible to implement
	It is easy for me to become skillful with using SPI Models
Perceived Usefulness of SPI	Using SPI Models improves my job performance
	Using SPI Models facilitates my task
	SPI Model is useful for my job
Training	Training facilitates the SPI adaptation process

### 3. FINDINGS (BULGULAR)

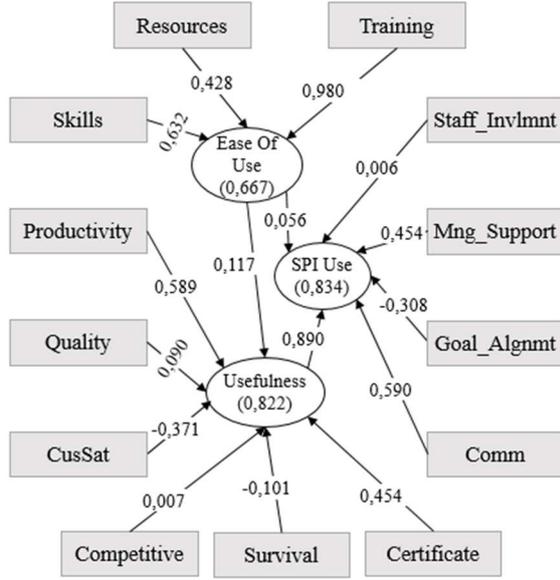
In the first step, instrument reliability analysis was conducted for this pilot study. Cronbach's Alpha and Composite Reliability values were calculated for internal consistency of the survey instrument. The reliability statistics of instrument are given in Table 3. The initial findings indicate that each construct's Cronbach's Alpha and Composite Reliability values are greater than 0.7 which means internal consistency of survey instrument exists.

Table 3. Reliability Statistics of Instrument (Enstrümanın Güvenilirlik İstatistikleri)

	Cronbach's Alpha	Composite Reliability
Obtaining SPI Certification	0,841	0,926
Communication	0,754	0,766
Competitiveness	1,000	1,000
Skills	1,000	1,000
Ease of Use	0,978	0,983
Goal Alignment	1,000	1,000
Training	1,000	1,000
Productivity	0,939	0,961
Quality	0,923	0,942
Resources	1,000	1,000
Use of SPI	1,000	1,000
Customer Satisfaction	1,000	1,000
Staff Involvement	1,000	1,000
Survival	1,000	1,000
Management Support	1,000	1,000
Usefulness	0,949	0,963

In the second step, we tested the hypotheses given in Method section. The Structural Equation Modeling (SEM) approach was employed along with partial least squares (PLS) algorithm to test the hypotheses which allows researchers to model and test complex theories with empirical data [22]. Additionally, the

model provides a path coefficient value to describe the causal relations among the variables with direct and indirect effects of its components [23]. The indirect effect is defined as “the pathway from the exogenous variable to the outcome through the mediator” [24]. SMART PLS program was used to perform the path analysis [22]. The results are represented in **Hata! Başvuru kaynağı bulunamadı.**



**Figure 5.** Path Analysis Result with PLS Algorithm  
(PLS Algorithmı ile Path Analizi Sonucu)

According to initial findings, path coefficients' results support H2, H4 and H5 hypotheses of this study. For example, Resources, Skills and Training positively influence the Ease of Use based on the path analysis results. Path coefficient values of Resources, Skills and Training between Ease of Use are significant. On the other hand, there are some insignificant path loadings for some constructs. For this reason, the initially set H1 and H3 hypotheses were not accepted. As seen in **Hata! Başvuru kaynağı bulunamadı.**, there are negative correlation values between variables in H1 and H3 hypotheses.

The PLS algorithm calculates standardized coefficients between -1 and +1 values. Path coefficients close to +1 value indicates that there is a strong positive relationship between two constructs and path coefficients close to -1 value indicates that there is negative relationship between two variables. According to our results, survival and customer satisfaction factors may not affected usefulness of SPI. In addition, goal alignment may not affected SPI Use.

#### 4. DISCUSSION AND CONCLUSIONS (TARTIŞMA VE SONUÇLAR)

In this study, we presented the initial version of the Software Process Improvement Acceptance Model and performed a pilot study to test the proposed hypotheses. The pilot study included 20 participants who work in as CMMI level 3 company. The study results indicate that different factors are effective in acceptance of SPI in SMEs. In the path analysis, direct and indirect effects of association were calculated. We examined the direct effects among variables in result set. Sixty-seven percent of the change in Ease of Use construct could be explained by three factors; Resources, Skills and Trainings. In order to get long-term benefits from implementing SPI models in organizations, proper allocation of the resources is necessary. Moreover, the results show that path coefficient value between Skills and Ease of Use is significant (0.632). The competencies of the people and their contribution to SPI program have positive impacts on Ease of Use. In addition, the path coefficient of Training factor (0.980) reveals that the Training variable has directly positive effect on Ease of Use variable.

The Usefulness variable is dependent on different factors. According to path coefficient results, perception of increasing Productivity has significant effect on Usefulness (0.589). There is also positive relations between obtaining Certification and Usefulness. Moreover, the participants think that SPI model usage positively affects the quality of software product. The SPI Use is the core factor of this model. The result of survey reveals that Communication variable has significant effect on SPI Use. In addition, Usefulness and Ease of Use factors have positive effect on SPI Use.

Path analysis results show that some of the path coefficient values are negative which indicates there is a negative influence between the factors. For example, the association between Customer Satisfaction and Usefulness is negative. The reason of this result might be due to the indirect effect of the small data set we used and the outlier responses.

As mentioned above, the path analysis includes indirect relations in which one factor affects a second factor through the mediator factor [24]. To illustrate, there is a significant indirect effect between Survival and SPI Use factors. According to results, positive relation between Survival factor and Usefulness indirectly affects the SPI Use factor. Training -> EaseOfUse -> Usefulness -> SPIUse, Skills -> EaseOfUse -> Usefulness and Certification ->

Usefulness -> SPIUse are the other examples of indirect effects.

In summary, this pilot study has examined factors for the adaptation of SPI models' usage in software organizations. We have analysed that there are relations between perceived consequences, facilitating conditions and SPI use with a limited sample size and in a single company.

The selected company has CMMI and ISO/IEC 9001 certificates. For this reason, the results should only be considered for these two models. The future work will include improving the model and performing survey studies with larger sample sizes to test the hypotheses.

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