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Identifying Factors Influencing on Agile Practices for Software Development

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Abstract

Agile practices are activities or actions that are utilized during software development to improve the quality and productivity of the resulting software. Those practices are influenced by a set of factors that affect the realization of their objectives. The purpose of this study is to determine the influence of organizational factors and the personnel working on the software development project to the agile practices. To this end, a model has been proposed that is composed of six critical success factors derived from the theories of administrative and human behavior and four groups of agile practices, and resulted in identifying 13 factor-practice relationships. The results from 146 questionnaires addressed to individuals involved in the software development process show that the factors of Confidence, Perception of Self-efficacy, Integrity and Availability of the Information and Experiences Learned, and Media Used all have a noteworthy positive influence on teamwork agile practices.

Keywords: agile practices, critical success factors, software quality, ASD, social theory.

1. Introduction

Although software is an essential element in all areas of the modern world, the development of the software has yet to become a perfect process. Despite efforts to employ software engineering methodologies in its creation, software development has not been consistently successful, which is demonstrated by the many software projects that are delayed, abandoned, or rejected. Several studies indicate that quality, as well as other factors such as cost, delivery time, and scope influence the success of a project [1].

Agile methodologies have been disseminated with the goal of improving software

quality to respond more easily to changes. According to [2], only 39% of the projects that have used agile methodologies have been successful, the remaining 61% have been dismissed as challenged or failed. Unfortunately, statistics show that the goal of improved software development has not yet been achieved and software quality is still a worrisome topic.

The principal objective of agile practices in the application of software development methodologies is to improve the quality of the software. Software quality is affected by a series of organizational, technical, project related, and personnel factors, just to name a few.

Consequently, many authors have conducted studies on critical success factors and agile practices. They have been organized into four specific scopes according to their contributions to the analyzed aspects related to the quality of the agile development process. They are presented in Table 1.

No.	Scope of the studies	Sources
1	Agile practices and their relationship with quality.	[3], [4], [5], [6]
2	Critical success factors and their influence on quality.	[1], [7], [8], [9], [10], [11]
3	Identification of critical success factors.	[1], [12], [2]
4	Identification of agile practices.	[13], [14], [15], [16], [5], [17]

Table 1. Scope of agile practices and critical success factors covered by the studies

Although the first two scopes analyze the relationships between the influence of agile practices on quality and the influence of critical success factors on quality, they do not focus on the relationship between agile practices and critical success factors and quality. A large number of studies in scopes 3 and 4 have helped identify practices and factors that influence agile development. However, no research has been found that analyzes the influence of critical success factors on the application of agile practices. On the other hand, many critical success factors are based on existing theories and there are factors that could be derived from these theories that can be studied and associated with the agile process. Consequently, this research addresses these issues with the objective of allowing companies and institutions that develop software to make better decisions regarding the application of agile practices and to control the factors that may affect the application of those practices.

These studies can be supported by an analysis of the influence of critical success factors on agile practices. It is through those critical success factors that the quality of the software can be improved, which is also the aim of agile principles. In spite of the above connection, this subject has been investigated very little.

In this study, a model is proposed that will identify the factors that have an influence, either positive or negative, on the application of agile practices and, consequently, on the quality of the software. The proposed model consists of 6 critical

success factors taken from the theories of human and organizational behavior, classified into two dimensions: *personnel* and *organization*. 17 agile practices were organized into the four categories of *teamwork, project management, engineering,* and *testing*. As a result, 13 hypotheses were validated through surveys administered to 146 people who use agile methodologies and are involved in the software development process in Ecuador.

The proposal found in this paper is the first part of a research study to determine the influence of agile practices on quality in the software development process. The results will allow researchers to determine the influence of organizational and teamwork factors on the application of agile practices. This will help designers to take actions to help improve the agility of a project and, as a consequence, improve the quality of the software.

The remainder of this paper is divided into four sections. Section 2 includes a theoretical framework about critical success factors, agile software development, and agile practices. It finishes by identifying the motivation for this work. Section 3 details the proposed conceptual model and its rationale. Section 4 describes the research methodology and includes the strategy applied to gathering the information and analyzing the results. Section 5 presents the results of the study. In Section 6, the results are discussed. Lastly, our conclusions are presented in Section 7.

2. Theoretical Framework

2.1 Critical success factors

In the literature discussing the topic of critical success factors, there is a wide variety of interpretations of the meaning of success in software development [18] which leads to a surprising diversity of descriptive variables for this phenomenon. The success of a software development project depends on a number of human factors. This detail is further evidenced in Agile Software Development (ASD). It prioritizes the work of individuals and interactions, collaboration with clients, and the response to changes suggested by clients [6]. The evaluation of the success of a project is assessed according to time, scope, cost and quality [1].

In addition, it can be stated that critical factors of success are the aspects that must be present for an agile project to be successful [1]. According to [14], in software projects, factors consist of several dimensions, such as the development life-cycle, estimation, the validation of executive management, project and resource management, and strategic level planning.

In the existing literature, several works have been identified that present factors that have an influence on the success of software development projects based on agile methodologies. Table 2 summarizes those factors as they are proposed by other authors and are grouped in the dimensions proposed as follows [1]: a) *Organizational* refers to factors related to the organizational structure and administrative climate of a company. b) *Personnel* includes factors related to the people who manage and execute the project. c) *Technical* groups together factors related to the engineering process of

the software under development. d) *Project* is comprised of factors related to the nature of the project during its development project. e) *Process* includes factors related to the software development process. Research work [19] recommends the addition of two dimensions seen as follows. *Iterative development* introduces factors related to the principle of iterations of agile methodologies. Finally, *Customer feedback* incorporates factors related to the interaction with the client and how to manage feedback. These dimensions have been appropriated because they are related to the agile development process.

Factor	Source
Dimension: Organizational	
Strong executive support	[1], [12]
Committed sponsor or manager	[1]
Cooperative organizational culture instead of hierarchal	[1]
Oral culture placing high value on face-to-face communication	[1]
Communication and negotiation	
Organizations where agile methodology is universally accepted	[1]
Collocation of the whole team	[1], [7]
Facility with proper agile-style work environment	[1], [12] [13]
Reward system appropriate for agile	[1],
Support for innovation	[9]
Clear business objectives	
Relationship with external partners	[12]
Staff turnover	[12], [13]
Maturity	[12]
Size	[12]
Stability	[12]
Organizational Structure	[12]
Payment Arrangements	[12]
Dimension: People	
Team members with high competence and expertise	[1], [7], [12]
Team members with great motivation	[1]
Managers knowledgeable in agile process	[1], [20]
Managers who have light-touch or adaptive management style	[1], [12]
Coherent, self-organizing teamwork	[1], [8] [12], [13]
Good customer relationship	[1], [20]
Personality	[8]
Interdependency and autonomy	[8]
Experience manager	[7]

Factor	Source
Moral	[7]
Participative safety	[9]
Vision and strategy	[9]
Goals and objectives	[9]
Culture	[12]
Commitment	[12]
Annual training	[13]
Continuously changing the Project Managers	[12], [13]
Following agile-oriented project management process	[1]
Following agile-oriented configuration management process	[1]
Following agile-oriented requirement management process	[1]
Honoring regular working schedule – no overtime	[1], [7]
Strong communication focus with daily face-to-face meetings	[1]
Strong customer commitment and presence	[1], [12]
Customer having full authority	[1]
Dimension: Technical	
Well-defined coding standards up front	[1], [12]
Simple design	[1], [20]
Rigorous refactoring activities	[1]
Right amount of documentation	[1]
Regular delivery of software	[1], [20]
Delivering most important features first	[1]
Correct integration testing	[1]
Tools and Infrastructure	[13]
Performance	[12]
Reusability	[12]
Deployment profile	[12]
Type, size, and connectivity of the application	[12], [20]
Modular design	[20]

Factor	Source
Portable design	[20]
Extensible design	[20]
Maintenance of documents and other resources	[13]
Software releases	[13]
Appropriate technical training to team	[1], [12], [7], [13]
Dimension: Project	
Project nature being non-life-critical	[1], [12]
Project type being of variable scope with emergent requirement	[1], [12] [13]
Projects with dynamic, accelerated Schedule	[1], [12]
Projects with small team	[1], [20], [12]
Projects with no multiple independent teams	[1]
Projects with up-front cost evaluation done	[1]
Projects with up-front risk analysis done	[1], [12]
Dimension: Iterative Development	
Time boxes releases	[20]
Operational releases	[20]
Small releases	[20]
Numerous releases	[20]
Dimension: Customer Feedback	
Feedback solicited	[20]
Feedback received	[20]
Feedback frequency	[20]
Feedback quality	[20]
Feedback incorporated	[20]

Table 2. Critical success factors found in the analyzed literature

2.2 Agile software development

Agile software development is an alternative software development methodology that originated to encourage collaboration between developers and users, to leverage rapid development cycles, and to respond to changes in a dynamic environment [21]. According to [22], agility involves both the ability to adapt to a variety of changes and to refine and fine-tune development processes as needed. Additionally, it indicates that agile approaches to software development provide flexibility within the method. On the other hand, [23] defines software development agility "as the software team's capability to efficiently and effectively respond to and incorporate user requirement changes during the project life cycle".

Agile methodologies and practices propose the values and principles that would allow teams to develop software quickly and respond to changes that may arise throughout a project [15]. The Agile Alliance is an organization dedicated to promoting concepts related to agile software development and helping organizations to adopt these concepts. The starting point was the Agile Manifesto [24], a document that summarizes the agile philosophy in twelve principles and four values. Although the creators and promoters of the most popular agile methodologies have subscribed to the agile manifesto and agree with its principles, each methodology has its own characteristics and emphasizes particular aspects. Some of the most representative methodologies are Extreme Programming (XP), SCRUM, Crystal Methodologies, the Dynamic Systems Development Method (DSDM), Adaptive Software Development (ASD), Feature-Driven Development (FDD), and Lean Development (LD) [25].

Table 3 shows a summary of the agile practices that have been found in the literature. Some authors have classified these practices into categories, [26] considers two categories in their study: Project Management and Software Development

Approach. Based on this classification, we have divided the practices of Software Development into two categories: Engineering and Testing Practices, we maintain the focus of Project Management and we increased the Teamwork category, considering it an important aspect within the agile development. Consequently, in our study, agile practices have been organized into four categories: a) The *Teamwork* category considers practices related to the behavior and working style of the people involved in the software development process. b) The *Project management* category includes practices related to the planning, execution, and monitoring of the software development project. c) The *Engineering* category considers practices related to the process of analysis, design, and coding of the software, and d) the *Testing* category indicates the practices related to the software testing process.

Agile methodologies base their process on the application of agile practices, that is, activities or actions oriented around the development of highly flexible projects. The methodologies XP and Scrum are the most frequently employed methodologies in the development of agile software. Scrum, XP, and a hybrid methodology between XP and Scrum are utilized by 69% of the organizations identified in [17]. These methodologies incorporate several agile practices. For example, [14] highlights the 12 agile practices employed by XP: the planning game, small release, metaphor, simple design, testing, refactoring, pair programming, collective ownership, continuous integration, 40-hour week, on-site customer, and coding standards . The main agile practices used by SCRUM according to [27] are iterative and incremental development, project planning, team empowerment, task-oriented project progress control, change management, retrospectives, post-mortem analyses at the end of each iteration, and the use of Timeboxing for all Scrum activities.

Agile Practices	**Source**
Category: Teamwork Practices	
Small teams	[28], [29]
Multifunctional teams	[30]
Multiple teams	[29]
Daily meeting	[18], [29], [30], [31]
Stand-up meeting	[6], [31], [32]
Client on-site	[14], [32]
Pair Programming	[6], [14], [19], [31], [32]
Agility in team communication	[14], [16], [19], [32]
People collaboration capabilities	[16], [33]
Team communication capabilities	[16], [30]
Competence of individuals	[16]
Confidence among team members	[16]
Participation of leaders	[16]

Agile Practices	**Source**
Leader recognition	[16], [33]
Daily cooperation between business people and developers	[6]
Frequency of interactions with customers	[16], [18], [19], [28], [30], [33], [34]
Customers motivations	[16]
Shift work	[31]
Self-organizing teams	[28], [32]
Training of professionals	[28]
Customer satisfaction with the projects	[16]
Interaction with partners in software development	[16]
Interaction with external partners	[16]
Organizational openness to talk	[16]
Agility in design decisions	[16], [32]
Team autonomy in projects	[16]
Multiple location teams	[29]
Customer training	[16]

Agile Practices	Source
Knowledge transfer	[30], [31]
Learning loop	[30]
Project charter	[19]
Useful documentation for the team	[16]
Useful documentation for the customer	[16]
Retrospective /feedback	[6], [14], [19], [31], [32], [34]
Collective ownership code	[14]
Category: Engineering Practices	
Zero Technical debts	[31]
Product Vision	[30]
Sprints	[6]
User story	[29], [31], [32]
Metaphor	[14]
CRC cards	[15], [31]
QA story card	[15]
Scenarios	[18], [34]
Coding standards	[14], [19], [31], [32], [33]
Simple design	[6], [14], [19], [28], [31], [33]
Flexibility to changes	[16], [19], [28], [32]
Environmental configuration	[16]
Requirements captured at high level	[32]
Quality check	[30]
Continuous specification analysis	[30]
Reduced documentation	[28]
Sprint Document	[19]
Review document	[19]
Design document	[19]
Business Case document	[19]
Automatic generation of documentation	[31]
Feasibility report	[19]
Small releases	[6], [18], [14], [19]
Refactoring	[14], [19], [28], [30], [32], [34]
Category: Management Project Practices	
Study of business objective	[32]

Agile Practices	Source
Burndown charts	[31], [32]
Kanban	[6]
Planning games	[18], [32], [14]
Velocity team	[31], [32]
Early Estimation	[19]
Iteration planning meeting	[6], [15], [18], [19], [29], [31], [32]
Outcome review	[32]
Review of requirements with product Owner and team	[6]
Risk Analysis	[19]
Code review	[19]
Project scope	[16]
Quality of projects	[16]
Term projects	[16]
Release Planning	[15], [29], [31], [32]
Incremental delivery	[19], [30]
Version Control	[19]
Prioritized Requirements	[19], [32], [34]
Risk reduction with external partners	[16]
Time boxing	[30]
Monitoring Progress	[30]
40-hour week	[14]
Category: Testing Practices	
Test early and often	[14], [32], [34]
Continuous integration	[6], [19], [30], [31], [34]
Screening bugs	[31]
Functional test	[6], [15]
System tests	[14], [19]
Integration tests	[19]
Test Driven Development	[19], [34], [15]
Unit tests	[31], [14], [19], [33], [15]
Acceptance tests	[18], [32], [19], [34]
Validation	[30]
Audits	[32]
Prioritizing Bugs	[15]

Table 3. Summary of agile practices found in the literature

3. Conceptual model

The proposed conceptual model is aimed at factors and their positive or negative influence on the application of agile practices in the software development process. The proposed model has the following components:

a. Critical success factors.
b. Agile practices in the agile development process.
c. The Hypotheses: 13 relationships between critical success factors and agile practices.

The structure of the proposed model is presented in Figure 1.

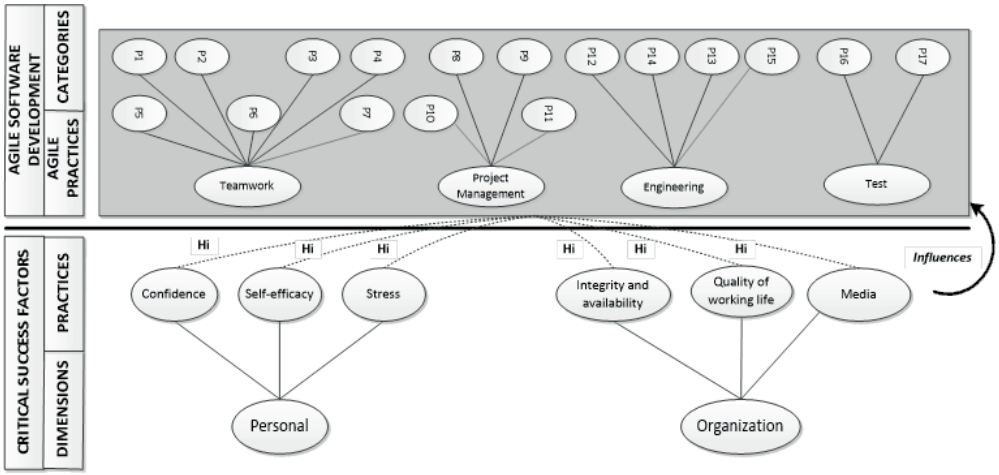

Figure 1. Conceptual Model

The description of these components is outlined below.

3.1 Component 1: Critical success factors

Any organizational transformation that involves many people will face challenges. In this context, research work [34] identified 35 challenges, organized into nine categories, many of which are related to organization and personnel, for example, change resistance, lack of investment, hierarchical management and organizational boundaries, and coordination challenges in a multi-team environment, among others. Based on this, the critical success factors presented here have been obtained from the review of theories focused on human and organizational behaviors. These theories were taken from [35], a database that provides researchers with summarized information on theories widely used in information systems (IS) research, from which the theories that relate to agile principles in the personnel and organizational fields were selected.

The critical success factors proposed here have been identified by considering the explicit and conceptual duplication of the factors from the literature and theories.

From that review, six important factors that influence the development of software using agile models have been ascertained. They have been classified in two dimensions. a) ***Personnel*** includes aspects related to the collective and individual behavior of the people who carry out the project and b) ***Organizational structure*** is related to the company's organizational operating style as it contributes to the achievement of its objectives and how the work environment and conditions affect and motivate the performance of the designers. Table 4 presents the factors considered in the proposed model, their definitions, and the theory on which they are based.

Id	Critical success factors	Definition	Theory that supports it
Dimension: Personnel			
FCO	Confidence	It is the favorable estimation that a person or group is able to act appropriately in a specific situation. Confidence is the trust that someone has in another person or thing.	Equity theory [36] Social capital theory [37]
FSE	Perceived Self-efficacy	It is the confidence in one's own capacity to carry out a task or achieve a certain goal.	Self-efficacy theory [38]
FSTR	Stress	State of mental fatigue caused by the demand for a much higher than normal performance. It often is the cause of a variety of physical and mental disorders.	Task closure theory [39]
Dimension: Organization			
FIAI	Integrity and availability of information and learned experiences	**Integrity:** Guarantee of the accuracy and completeness of the information and a confidence in its methods of processing. **Availability:** Assurance that authorized users have access to the information and its associated assets when required.	Information integration theory [40] Knowledge-based theory of the firm [41]
FWQL	Quality of working life	It refers to the positive or negative nature of a work environment. The primary objective is to create an excellent work environment for employees while contributing to the economic health of the organization.	Socio technical theory [42]
FCM	Media used	Technical system that serves to notify the members of a certain community. This refers directly to the instrument or form of content by which the communication process is carried out.	Media richness theory [43]

Table 4. Proposed critical success factors

3.1.1 Dimension: Personnel

In the Personal dimension, the factors that were identified were *confidence*, *perceived self-efficacy*, and *stress at work*. They are based on the Equity Theory, Social Capital Theory, Self-efficacy Theory, and Task Closure Theory [36]. The basis for each one of these factors and their relationship with agile practices are detailed as follows.

The Equity Theory is based on a structure of equity in the workplace and focuses on the relationship between input and output. One of the key inputs that this theory emphasizes is *confidence in the management team*. On the other hand, agile principle No. 4 indicates that *"Business people and developers must work together daily throughout the project."* [24]. According to this, a relationship of trust must be established between those in positions of responsibility in the company and the developers.

Similarly, the Social Capital Theory is defined as a set of characteristics of a social organization, which is present in the structures of interpersonal and intersectoral relations of a society represented by norms, networks of interpersonal relationships, and *confidence*. Principle No. 5 of agile development asserts: *"Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done."* For this reason, *confidence* has been considered one of the most significant factors to the success of a project that has been analyzed in this study.

The Self-efficacy Theory suggests that individuals program themselves for success or failure. If a person has a high level of self-efficacy, they will have a high percentage of accuracy in their solutions. Reflecting a similar thought, agile principle No. 12 states: *"At regular intervals, the team reflects on how to become more effective, then tunes and adjusts its behavior accordingly."* Therefore, perceived self-efficacy is an important factor that directly relates to agile practices.

The Task Closure Theory intimates that the division of tasks and the appropriate selection of communication media are very important to obtain a higher level of productivity. It suggests that human beings have an innate need for closure to allow them to feel that they have finalized a sequence of communications. In addition, selecting a means of communication that leads to closing operations will lead to lower levels of task fragmentation and *occupational stress*. The topic of *occupational stress* has been considered in this study to determine its influence on the application of agile practices as well.

3.1.2 Dimension: Organization

The group of factors related to organization are *Integrity and availability of the information and experiences learned, Quality of working life, and Media used*. They are based on the Information Integration Theory, Knowledge-based Theory of the Firm, Socio Technical Theory, and the Media Richness Theory [40].

The Information Integration Theory refers to two key postulates about the nature of consciousness: that an individual processes information from their own experiences and that those experiences are integrated as long as the different parts of the experiences build on each other. Likewise, the Transactive Memory Theory is based

on the idea that members are able to benefit from the knowledge and experience of others, especially in cases where a good understanding of the information is developed and then shared with the most knowledgeable members of the team. The Knowledge-based Theory of the firm (KBF) estimates knowledge as the most strategic resource of a company. Such knowledge is comprised of multiple entities including the organizational culture, policies, routines, documents, systems, and employees. In turn, the knowledge and experiences acquired by the work team must be shared in order to obtain greater productivity, product performance, and quality. Principle No. 4 of the agile development indicates similar theories by stating that *"Business people and developers must work together throughout the project".* Therefore, for the work to be productive, knowledge and acquired experiences must be shared. Based on these theories, the factor *Integrity and availability of the information and learned experiences* has been aggregated to this research study.

The Socio-technical Theory suggests that the technical subsystem and the social subsystem link together to compose an organization. The technical subsystem is comprised of the devices, tools, and techniques necessary to transform inputs into products in a way that improves the economic performance of an organization. The social subsystem is comprised of the employees at every level and the knowledge, skills, attitudes, values, and needs that they introduce to the work environment, as well as the reward system and authority structures that exist in an organization. The operations of the organization will only be able to maximize performance if the interdependence of these subsystems is explicitly recognized. According to this theory, the main responsibility of Chief Executive Officer is to improve the *Quality of working life*, which has been identified as a factor worthy of consideration in this study, and results in each employee's satisfaction with their work. At the same time, the achievement of these objectives will improve the productivity and the yield, adding value to the organization. This theory supports agile principle No. 5: *Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.*

The Task Closure Theory, mentioned above, promotes the appropriate selection of media to obtain a higher level of productivity. It assumes that human beings feel the need to bring closure to a communications sequence and will be highly motivated to choose the media that will allow them to sense that they have accomplished this. The Media Richness Theory classifies and values the richness of certain means of communication, such as telephone calls, video conferences, email, etc. and quantifies how rich and effective each personal communication media is for communicating. Likewise, Principle No. 6 of Agile Development establishes that *"The most efficient and effective method of conveying information to and within a development team is face-to-face conversation".* Therefore, the *Media used* factor has also been regarded in this study as a critical success factor worthy of analysis.

3.2 Component 2: Agile practices

The model consists of 17 practices or operations used in the software development process based on the most frequently used agile methodologies. Despite the

differences between the different agile methodologies, we have identified a set of practices that are common to most of them. The selected practices are based on the study [14], of which 11 practices have been recognized, The Planning Game, Small release, Simple design, Testing, Refactoring, Pair Programming, Collective ownership, Continuous integration, 40-hour week, On-site customer, and Coding standards. Xu, refers to these practices from the perspective of quality management in XP. According to the last five annual state of agile reports [17], they are considered as daily standup and retrospectives within the top 5 agile techniques. Therefore, these practices were included in our paper. In study [30], Timeboxing was considered the most frequently used agile practice, so it was also included. From this same study, the following practices were incorporated. *Monitoring progress* considers that all planning carried out in the projects must be controlled, and *Small Cross-functional Teams*, which we call *Multifunctional teams*, reflects the importance of teamwork in the methodology s agile. Based on the same criterion, the practice of *Self-Organizing Teams* was selected from study [28]. The selected categories and practices are presented in Table 5.

ID	Category	Agile Practices
PTW	Teamwork	P1 Pair programming
		P2 On-site customer
		P3 Stand up meetings
		P4 Self-Organizing teams
		P5 Multifunctional teams
		P6 Retrospectives
		P7 Collective code ownership
PMP	Project Management	P8 Planning games
		P9 Monitoring progress
		P10 40 hours per week
		P11 Timeboxing
PENG	Engineering	P12 Small releases
		P13 Simple design
		P14 Refactoring
		P15 Coding standards
PTEST	Testing	P16 Unit test
		P17 Continuous integration

Table 5. Agile practices studied

3.3 Hypotheses

This model represents the relationships between critical success factors and agile practices to determine the positive or negative influence that they impose. From the consideration of the six critical success factors and four categories of agile practices analyzed in the model, an *Analysis of standardized residuals* has been conducted for all the 24 relationships generated. The d' variable calculated by this analysis is a

measure of evidence against the null hypothesis, even though for some critical success factors and agile practice relationships, d' does not provide sufficient evidence to reject the null hypothesis, it does not indicate sufficient evidence to accept the null hypothesis, either. Consequently, 13 derived hypotheses have been generated which are revealed in Table 6 and supported in Sections 3.3.1 to 3.3.6. 11 relationships were discarded, since there is not sufficient logical basis to support their inclusion. These hypotheses have been coded as *Hi.j*, *i* being the factor analyzed and *j* the agile practice the factor influences. For example, hypothesis H2.3 corresponds to the relationship between the factor 2, *Self-efficacy* (FSE) and practice 3, *Engineering practices* (PENG).

Factors	Categories of Agile Practices			
	1. PTW	**2. PMP**	**3. PENG**	**4.PTEST**
1.FCO	H1.1		H1.3	H1.4
2.FSE	H2.1			H2.4
3.FSTR		H3.2	H3.3	H3.4
4.FIAI	H4.1			H4.4
5.FQWL				H5.4
6.FCM	H6.1	H6.2		

Table 6. Derived hypotheses

3.3.1 Set of hypotheses Factor 1: Confidence

Confidence (FCO) is a human factor that can exert influence on the organization of the work team and, by extension, on the practices of *Pair programming, Self-Organizing teams, Multifunctional teams, Retrospectives, and Collective code ownership*. The incorporation of this factor is imperative so that the group can act precisely, contribute to solving problems, and share information generated throughout the software development process. Consequently, H1.1 is generated: *"There is a significant influence that Confidence exerts on Teamwork practices."*

In addition, FCO is a factor that contributes to the fulfillment of practices such as *Simple design, Refactoring, and Coding Standards*. Success will depend on the trust that is given to each developer or designer in charge of these tasks. This brings us to H1.3: *"There is a significant influence that Confidence exerts on Engineering practices".*

As a result of the above-mentioned conclusions, it can be deduced that the complete and correct completion of *Unit Test and Continuous Integration* is based on the confidence that the tester will complete their work. Therefore, H1.4 states *"There is a significant influence that Confidence exerts on Testing practices".*

3.3.2 Set of hypotheses Factor 2: Perceived Self-Efficacy

Perceived Self-Efficacy (FSE), that is, each member of the work team's confidence in their own ability to correctly perform practices such as *Pair Programming, Stand-up*

meetings, Self-Organizing teams, Multifunctional teams, and Retrospectives. This factor is essential to allow each member to contribute to the organization of the work team and solve problems that may occur during the software development process. Hence, H2.1 can be generated: *"There is a significant influence that the Perceived Self-Efficacy exerts on Teamwork practices."*

On the other hand, the correct execution of *Unit test and Continuous integration* practices depends on the self-confidence of the testers that these tasks have been carried out completely and correctly, in such a way that it contributes to the delivery of a quality product. This brings us to H2.4: *"There is a significant influence that Perceived Self-Efficacy exerts on Testing practices."*

3.3.3 Set of hypotheses Factor 3: Stress

The Stress factor (FSTR) found in a work team is a factor caused by the demand for higher than normal performance, possibly due to not complying with the responsibilities such as those that are part of the practices *Planning game and Monitoring progress*. Those responsibilities may create the need for additional work days and, consequently, the non-compliance of the practice of 40 hours per week. Therefore, H3.2 is proposed: *"There is a significant influence that Stress exerts on Management Progress Practices."*

In addition, FSTR could result in the optimization of the source code through the *Refactoring Practice* not being carried out properly. Likewise, it could produce errors on the part the programmer if they neglected to consider *Coding Standards*, causing difficulties in the future maintenance of the software. This leads us to suppose H3.3: *"There is a significant influence that Stress exerts on Engineering Practices."*

Another aspect that may be affected by Stress is an incorrect or incomplete realization of the *Unit test and Continuous integration* practice. In other words, it would hinder the delivery of a quality product. Consequently, H3.4 states: *"There is a significant influence that Stress exerts on Testing practices."*

3.3.4 Set of hypotheses Factor 4: Integrity and availability of the information and experiences learned

All of the information generated in the development of a project must be correct, complete, and available to the entire work team. Likewise, it is essential to document all of the experiences acquired in such a way that it helps new team members or developers of other projects. This factor would contribute to practices such as *Pair programming, On-site customer, Self-Organizing teams, Multifunctional teams, Retrospectives,* and *Collective code ownership* being developed in an optimal way. Therefore, H4.1 can be proffered: *"There is a significant influence that Integrity and availability of the information and experiences learned exerts on Teamwork practices."*

Additionally, the source code of the software must be updated and available to all testers to perform *Unit test and Continuous integration* practices. This allows for the

recommendation of H4.4: *"There is a significant influence that Integrity and availability of the information and experiences learned exerts on Testing practices."*

3.3.5 Set of hypotheses Factor 5: Quality of working life

The *Quality of working life* is a factor that endeavors to create an optimal environment for a work team to formulate efficient and quality work, which will be reflected in the quality of the product delivered to the customer. One of the aspects that will determine the quality of the product is the correct and complete execution of *Unit test and Continuous integration practices*. Therefore, H5.4 is proposed: *"There is a significant influence that Quality of working life exerts on Testing practices."*

3.3.6 Set of hypotheses Factor 6: Media used

Media used (FCM) is an essential element that allows for the success of *Teamwork practices*. It contributes to the accomplishment of many tasks that do not necessarily require face-to-face interaction among its participants, such as *Pair programming, On-site customer, Stand meeting, Self-Organizing teams, Retrospectives,* and *Collective code ownership* practices. This rationale results in the proposal of H6.1: *"There is a significant influence that Quality of working life exerts on Teamwork practices."*

Additionally, FCM contributes to the correct management of the project. Its use can facilitate the practices of *Planning games, Monitoring progress, and Timeboxing*. Based on this, H6.2 can be included: *"There is a significant influence that Quality of working life exerts on Project Management practices."*

4. Research Method

4.1 Data collection

The research was drafted in an organizational context by using companies and institutions in Ecuador that develop software. This study used a survey conducted online using the Google Forms tool over four months, from October 2016 to January 2017. It was directed to 387 developers and others involved in the software development process that employ agile methodologies and work for companies and public and private institutions in Ecuador. Practitioners were selected from the databases of software development companies in this country, as well as the records of postgraduate graduates in Software Engineering and Applied Computing from the country's universities. 155 individuals responded to the survey. The objective of the survey was to ascertain the viewpoint of those involved towards the influence of critical success factors on the application of agile practices.

The survey was set up in three sections. Section 1: General Data (8 questions). Section 2: Perception of organizational and personnel factors that influence the application of agile practices (six questions), And Section 3: Other Related Aspects

(2 questions) to the user experience regarding quality and the application of agile practices. The questions in Section 1 were related to which agile methodologies are used and the role they play in software development projects. There were multiple responses since this information and the answers produced can vary according to the project to which the agile methodologies are applied. The questions in sections 2 were evaluated according to the Likert scale, a scale of 5 values: 1-No influence, 2-Low influence, 3-Medium influence, 4-High influence and 5-Complete influence. The survey was administered in the Spanish language. A translation into English is available in Appendix A.

Once the survey was prepared, a pilot test was carried out to a) ensure the validity of the survey, confirming that it measures what it should measure and is in accordance with the hypotheses proposed, b) analyze the wording of the questions to confirm that it was understandable for the respondents, c) detect unexpected values from the variables, flows of erroneous questions and other aspects, and d) determine if the duration of the questionnaire was adequate. For this, a group of 5 experts in the field, two teachers and three PhD's, were selected. As a result of the pilot test, some corrections were suggested to improve the survey, including concepts of the variables considered in the questions to avoid misinterpretation and including additional questions to ensure that the answers were consistent with the responders' experience with agile practices.

Once the information was obtained, the surveys were validated in order to eliminate inconsistencies and resolve, as far as possible, issues with the data collected. The main criterion of eligibility for the respondents to the answers was that the participants have indeed applied Agile Software Development Methodologies. Based on that criterion, the number of valid questionnaires was reduced to 146. The valid questionnaires were subjected to coding according to the variables under study.

4.2 Method for the analysis of the results

The approach to data analysis was quantitative. The results are arranged to statistically analyze the data collected in Sections 1 and 2 of the survey, which are related to the objective of this study and are applied to all values collected from the variables studied. The following analyses were performed:

a. *Descriptive Statistics* are elaborated to know the demographic characteristics of the respondents.
b. The *Reliability and Validity test* uses Cronbach's Alpha to determine the reliability of the internal consistency of the instrument to ensure that the items measured on the Likert scale measure the same construct and are highly correlated.
c. The *Examination of standardized residuals* is an analysis conducted of all the answers regarding factors and practices based on Section 2 of the survey.

To analyze the independent hypothesis of the variables representing the rows and columns of a table, it is necessary to identify the value of each cell of the table for each respondent, *r*, and define as a probability a standard normal deviate that exceeds the adjusted residual in a specific percentage.

The procedure suggested by [44] was adapted. It involves examination of standardized residuals e_{ij}, as follows,

$$e_{ij} = \frac{a_{ij} - \bar{a}}{\sqrt{\bar{a}}}$$

where a_{ij} is the value given for the respondent to each cell in the formed contingency table and $\bar{a}$ is the mean of all values given by the respondent (expected value). For each e_{ij}, the variance is estimated by:

$$v_{ij} = \left(1 - \frac{n_{i.}}{N}\right)\left(1 - \frac{n_{.j}}{N}\right)$$

where $n_{i.}$ and $n_{.j}$ are the sum of all the values a for row i and column j respectively, and N is the sum of all values a_{ij}. Thus, for each cell in the contingency table we are able to compute an adjusted residual, d_{ij}, where:

$$d_{ij} = \frac{e_{ij}}{\sqrt{v_{ij}}}$$

Finally for all respondents, the terms d_{ij} are normally adjusted as:

$$d_{ij}{}' = \frac{d_{ij}}{\sigma_r}$$

where σ_r, is the standard deviation of all d_{ij}

When the variables forming the contingency table are independent, the terms $d_{ij}{}'$ are normally distributed with mean of 0 and standard deviation of 1. We may then compare the absolute values of the entries with the standard normal deviate (z) using the Stanine method of scaling. The qualitative description used is related on Figure 2.

z	Scale		
	1	Negative Influence	High
-1.75			
	2		Moderate
-1,25			
	3		Low
-0,75			
	4	Average Influence	Slighty below
-0,25			
	5		Average
0,25			
	6		Slighty above
0,75			
	7	Positive Influence	Low
1,25			
	8		Moderate
1.75			
	9		High

Figure 2. Stanines defined descriptively

The basis for obtaining stanines is that a normal distribution is divided into nine intervals, each of which has a width of 0,5 standard deviation excluding the first and the last which are the remainder of the tails of the distribution. The mean value lies at the center of the fifth interval.

Finally, a test of the hypothesis was carried out to determine which relationships were accepted and rejected between critical success factors and agile practices.

5. Results

The approach to the data analysis was quantitative and based on closed-ended questions. On the basis of the survey data we obtained the summary as a percentage, which is presented in Appendix A.

5.1 Descriptive statistics

Information was collected from the 146 respondents, of whom 27,4% were women and 72,6% were men. Most of them, 76%, work in companies whose main activity is software development. Also, 6,8% of the respondents were working in institutions of higher education and another 6,4% of respondents belonged to financial institutions. The remaining percentage was distributed among the telecommunications, health, and tourism industries, and government institutions. The size of the companies where the majority of the respondents' work, 52,8%, corresponded to small businesses of less than 20 employees. 32,8% work in companies that have between 20 and 50 employees, and 14,4% work in companies with greater than 50 employees.

As shown in Figure 3a, 73,97% of respondents utilize the Scrum methodology, followed by XP and XP/Scrum hybrids with 28,77% and 13,01%, respectively. The remaining percentage belongs to responders who use other methodologies such as Agile UP or FDD, or proprietary methodologies adapted by their companies.

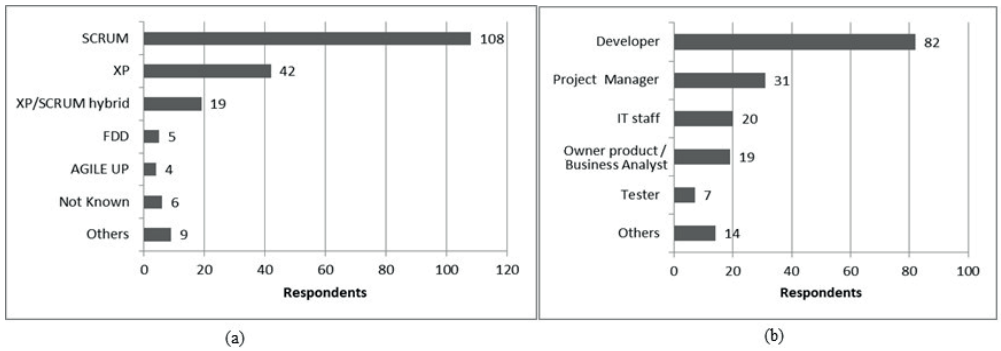

Figure 3. Agile Methodologies used and Profile of the respondents

Figure 3b reveals that 56,16% of the responders are software developers who have experience using agile methodologies, followed by Project Managers, IT staff, and Product Owners with 21,23%, 13,70 %, 13,01%, respectively. The respondents who

have a profile as testers only equals 4,79%. Others identified themselves as systems analysts, business analysts, and agile coaches and represent 9,59% of the respondents.

Figure 4 shows the statistics corresponding to the mean and standard deviation through a heat map of the 24 variables that relate the factors (columns) and the agile practices (rows). It can be seen that the FCM-PTW influence had the highest mean of 4,20, with a standard deviation of 0,973 (dark gray shade). That implies that most of the participants of this survey agree that *Media used factor* exerts a positive influence on the *Work team practice*. On the other hand, the FSTR-PTEST influence has the lowest mean of 3,41 and a standard deviation of 1,224 (dark gray dot-hatch), which indicates that the influence of the *Stress factor* on *Testing practices* is weak.

Factors	Agile Practices			
	PTW	PMP	PENG	PTEST
FCO	4,05 ± 1,013	3,84 ± 1,010	3,61 ± 1,085	3,69 ± 1,061
FSE	4,08 ± 0,965	3,79 ± 1,090	3,75 ± 1,138	3,79 ± 1,032
FSTR	3,69 ± 1,224	3,55 ± 1,221	3,47 ± 1,146	3,41 ± 1,224
FIAI	4,04 ± 0,901	3,92 ± 0,965	3,92 ± 1,000	3,95 ± 0,992
FQL	3,96 ± 0,989	3,81 ± 1,059	3,65 ± 1,087	3,62 ± 1,013
FCM	4,20 ± 0,973	4,12 ± 0,979	3,86 ± 1,070	3,87 ± 1,032

Figure 4. Heat map of mean and standard deviation of the relationship between factors and agile practices

Table 7 shows a summary of the statistics of the study variables. The mean value of the items is 3,818, with a range of 0,788 between 3,411 and 4,199 from a total of 24 items considered (using a contingency table of 6 x 4). The average variance of the items is 1,123 and has a range of 0,687 between the minimum and maximum of 0,812 and 1,499. ±

	Mean	Minimum	Maximum	Range	Variance	Items
Media of the items	3,818	3,411	4,199	0,788	0,042	24
Variance of the items	1,123	0,812	1,499	0,687	0,035	24

Table 7. Summary of the statistics

5.2 Reliability and validity test

To test the reliability of the internal consistency of the collected data, we used Cronbach's Alpha, which uses values between 0 (a consistent variance cannot be

defined) and 1 (the variance is consistent). A higher value of the Cronbach's Alpha would indicate a greater reliability or accuracy of the statistical inferences of the data. An acceptable value using Cronbach's Alpha ranges from 0,70 [45]. In Table 8, we can see that the Cronbach's Alpha value for the 24 variables analyzed was 0,958. This indicates that the internal consistency of the data is highly reliable.

Cronbach´s Alpha	Cronbach´s Alpha based on standardized items	N. of items
0,95	0,95	24

Table 8. Reliability statistics for the 24 variables analyzed

5.3 Analysis of adjusted residuals

Figure 5 shows the adjusted residuals in the form of a heat map. The darker gray shade area corresponds to the highest ratings from the respondents (positive influence); the darker dot-hatched area corresponds to the lowest ratings from the respondents (negative influence). The significance is represented by the stanines in brackets, on a scale of 1-9, as seen in Figure 2.

Factors	Agile Practices			
	PTW	PMP	PENG	PTEST
FCO	**1,11 (7)**	0,09 (5)	**-1,02 (3)**	**-0,61 (4)**
FSE	**1,27 (8)**	-0,12 (5)	**-0,41 (4)**	-0,16 (5)
FSTR	**-0,59 (4)**	**-1,29 (2)**	**-1,67 (2)**	**-1,99 (1)**
FIAI	**1,12 (7)**	**0,50 (6)**	**0,48 (6)**	**0,67 (6)**
FQL	**0,67 (6)**	-0,07 (5)	**-0,80 (3)**	**-0,94 (3)**
FCM	**1,85 (9)**	**1,44 (8)**	0,18 (5)	**0,27 (6)**

Figure 5. Heat map of adjusted residuals between factors and agile practices

The results show that the influence that the *Media used factor (FCM)* exerts on the *teamwork practice (PTW)* is high, z = 1,85, where the z value is produced by d', indicating a probability of cases greater than the value, or a possible positive influence, of 3%. In addition, this factor has a moderate influence on *Project management practices (PMP),* z = 1,44, a probability of cases greater than the value of 7%. The influence of the *Perceived Self-Efficacy factor (FSE)* on the *teamwork*

practice (PTW) is rated as Moderate, z = 1,27, a probability of cases greater than the value 10%.

Another important result indicates that the negative impact the *stress factor (FSTR)* has on *testing practices (PTEST)* is extremely high, z = -1,99, a probability of cases less than the value of 2%. It exercises a moderately negative influence on *engineering practices (PENG)* and *Project management practices (PMP)* z = -1,67 and z = -1,29, 5% and 10% probabilities of cases less than the value or a possible negative influence, respectively.

5.4 Test of hypothesis

Table 9 summarizes the results detailed in this section. Of the 13 hypotheses proposed, 3 null hypotheses, H1.4, H2.4, and H4.4 were accepted, because the d' value is between -0,75 and 0,75, values that are inconsequential, implying an insufficient average positive or negative influence to reject the null hypothesis. The other 10 hypothesis can be confirmed as true, meaning the influence on factors and practices is adequate to reject the null hypothesis. Hypotheses H1.1, H2.1, H4.1, H6.2.1, and H6.2.2 exert a positive influence, while hypotheses H1.3, H3.2, H3.3, H3.4 and H5.4 exert a negative influence.

Factors	**Agile Practices**			
	PTW	PMP	PENG	PTEST
FCO	**H1.1 √+**		**H1.3 √-**	H1.4 X
FSE	**H2.1√+**			H2.4 X
FSTR		**H3.2 √-**	**H3.3 √-**	**H3.4 √-**
FIAI	**H4.1 √+**			H4.4 X
FWQL				**H5.4 √-**
FCM	**H6.2.1√+**	**H6.2.2√+**		

Table 9. Results of the test of the hypothesis

The critical success factors and categories of agile practices that have a significant influence, whether positive or negative, are presented in Figure 6. As can be seen, all the factors have a significant influence on one or more categories of agile practices.

6. Discussion

6.1 Agile methodologies used

The descriptive study carried out shows that, in Ecuador, the ranking of the use of agile methodologies is similar to other countries (see Table 10). The four studies place Scrum as the most used agile methodology, while XP and a hybrid methodology between Scrum and XP occupy the second and third places respectively.

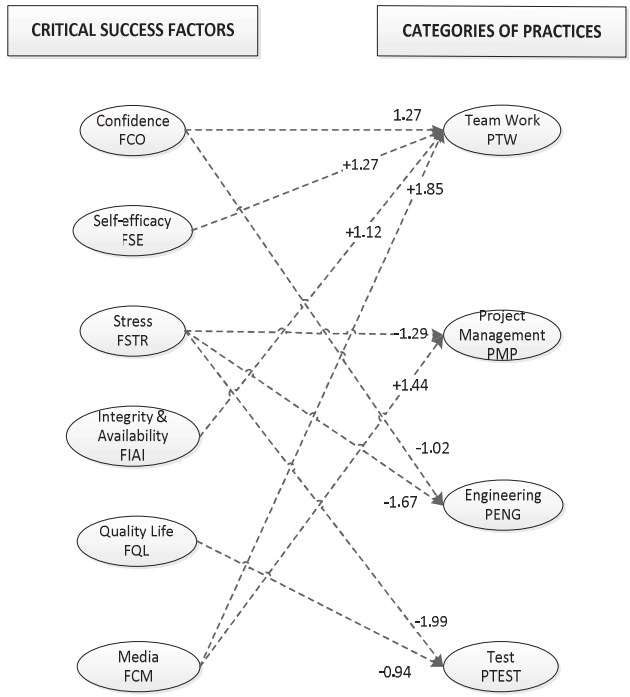

Figure 6. Final model of critical success factors and their influence on agile practices

Order	This Study	Diebold [30]	Ahmed [28]	Versionone [17]	Vallon et al. [46]
1	Scrum	Scrum	Scrum	Scrum	Scrum
2	XP	Scrum/XP	Agile MSF	Scrum/ XP	Scrum/XP
3	Scrum/ XP	XP	XP	Custom Hybrid	Unclear
4	FDD	Scrum/XP/Lean	FDD	Scrumban	Kanban

Table 10. Ranking of the most used agile methodologies

6.2 Influence of factors on agile practices

From the quantitative data obtained in our study, it can be observed that all the classified factors have a positive or negative influence on agile practices.

The factors *Confidence (FCO), Perceived Self-Efficacy (FSE), Integrity and availability of the information and experiences learned (FIAI)* have a positive influence on the agile practice of *Teamwork (PTW).* This substantiates the conclusion made in Subsection 3.3, since these factors directly influence the practices connected to people.

Media Used (FCM) is the factor that most positively influences the agile practices of *Teamwork (PTW)* and *Project Management (PMP).* These results reflect that the communication chosen by the project leader and its members affects the effectiveness

of their actions such as the coordination of work, meetings, solving problems, and monitoring the completion of planned activities. All of these pursuits are influenced by the means of communication used. In accordance with what is established in agile methodologies, face-to-face communication is the most suitable form of communication. However, there may be other forms of communication utilized, such as video conferences, emails, etc.

The *Stress* factor (FSTR) exerts a negative influence on agile *engineering practices (PENG), project management (PMP),* and *testing (PTEST).* Stress is commonly viewed as an imbalance between the expectations and demands of the environment on one side and the individual's own capabilities and needs on the other. Likewise, the team leader's stress can be transmitted to the work team by increasing the expectations placed on the development and monitoring of activities. The *Stress* factor is the one factor that most negatively influences the application of agile practices. This result is expected. However, a positive result that has been derived from this research is the determination of which categories are most affected by this factor.

Other factors that negatively affect the agile practices of *Engineering (PENG)* and *Testing (PTEST)* are the factors of *Confidence (FCO)* and *Quality of working life (FQWL)* respectively. These results are unexpected, since it is expected that a team with good working conditions would correctly perform its work consistently. However, the results reflect the opposite. These aspects must be controlled with proper *Project Management*.

Although the other factors analyzed also have a level of positive or negative influence on agile practices, the values obtained were not significant enough to be acknowledged. This implies that whether these factors are managed correctly or incorrectly, their influence on agile practices will not change appreciably. For example, according to the results obtained, *FSTR* was shown to have a negative influence on *Engineering, Project management,* and *Testing* practices. However, even if there were an adjustment in the control of this factor, no significant change would be seen in these practices.

The results also demonstrated that the *Quality of working life* factor has a positive influence on *Teamwork* practices. This corroborates what is established in the Socio-Technical Theory, which states that an improvement in the quality of a worker's working life increases their performance and productivity. Again, however, its influence, despite being positive, is not noteworthy.

The statistical tests confirm ten of the thirteen hypotheses presented. The three unsupported hypotheses (H1.4, H2.4, and H4.4) are related to the practice of *Testing*. Initially, these hypotheses had been established on the assumption that the factors *Confidence (FCO)* and *Self-efficacy (FSE)* would impact the *Testing* practice *(PTEST).* However, the results show that these do not significantly influence the correct execution of *PTEST*, since the professionalism of the team is independent of the trust placed in the work team, and it does not affect the complete and correct execution of the testing practices. *FIAI* does not significantly influence testing either. This can be understood by the fact that there will always be basic information for the realization of tests, either documented in the code or externally. If the standard coding is respected, the testing will not be influenced by the factor *FIAI*.

6.3 Limitations of the study

This study uses the survey technique to obtain its results. Therefore, it is subject to the following limitations.

a. The type and size of the projects were not considered. These aspects could modify the results of this study. The level of application of agile practices will be different depending on the type and size of the project.
b. As Table 3b reports, 16,44% of responders use agile methodologies different from Scrum and XP, which may cause the results to indicate a bias towards the practices employed by these methodologies.
c. According to a study conducted by the Ecuadorian Software Association, up to 2015, 22% of all software development companies have more than 50 employees. Only 14,4% of the responders belong to this classification of companies. It cannot be confirmed if this sample covers 65% of the existing companies. There may be a gap in the results.
d. The sample was limited to those involved in the software development process in Ecuador. It could be supposed that the sample is small, although all possible responders were contacted through social networks and email. In addition, we must take into account that the agile community in this country has more than 700 followers. A larger sample size could provide a more robust statistical calculation and more accurate analysis.
e. The specific practices corresponding to each practice category were not analyzed. However, the questionnaire indicated which practices were considered as a part of each category. This aspect may not have been recognized correctly by the responders, which would affect the results.

7. Conclusions

In this work, six factors have been introduced that exert an influence on agile practices. They were divided into two dimensions. The *Personnel Dimension* includes the factors of *Confidence, Perceived self-efficacy,* and *Stress* at work, and are based on the Equity Theory, Social capital Theory, Self-efficacy Theory, and Task Closure Theory. The *Organization Dimension* includes the factors of *Integrity and availability of the information and experiences learned, Quality of working life,* and *Media used*, and are based on the Information integration Theory, the Transactive Memory Theory, the Knowledge-based Theory of the firm, the Socio-Technical Theory, and the Media Richness Theory.

The agile practices have been cataloged in four categories: *Teamwork, Project Management, Engineering,* and *Testing*. Of the 93 practices identified in this cutting-edge study, 17 practices related to the Scrum and XP methodologies were chosen because they are the methodologies most utilized.

This work has shown that 10 of the 13 proposed agile hypotheses reflect a significant influence on agile practices.

The results obtained from a survey administered to 146 responders involved in the software development process in Ecuador identified the following factors as having

an influence on Agile practices. *Confidence (FCO), Perceived Self-efficacy (FSE), Integrity and availability of the information and experiences learned (FIAI),* and *Media used (FCM)* have a significant positive influence on agile practices. On the other hand, *Stress (FSTR)* has a negative influence on nearly all agile practices and the *Quality of working life* factor *(FQWL)* negatively affects the *Testing practices*.

The model proposed in this study contains six critical success factors, four categories of agile practices, and ten recognized relationships between them. This model can be validated, fortified, and put into practice in additional environments in order to ratify or refute the results obtained in this work.

Future studies could implement strategies to mitigate negative factors and strengthen positive factors in software projects and therefore contribute to ratify or refute the results obtained through this research. In addition, it would be important to analyze the proposed model in different conditions, such as universities, private companies, public companies, or in global software development environments in order to know if the influence of different factors on agile practices varies according to the environment. Likewise, the model could be analyzed considering the profiles of those involved in the software development process to ascertain their viewpoint regarding the influence of factors in agile practices. As indicated above, agile practices have been grouped into only four categories, which is why this study has left out some of specific practices involved in each of the categories. Therefore, the information obtained in this analysis can serve as a basis for future studies considering more specific practices.

Appendix A: Survey

This is a survey to determine the factors that influence the quality of the software development process that applies agile methodologies.
This survey is aimed at software development teams that apply agile methodologies.
Your answers are anonymous and will be used strictly for investigative purposes.
The Survey is divided into 3 sections. Section 1 is related to the characterization of the company and the people who complete the questionnaire. Section 2 helps to determine the influence of critical success factors on the application of agile practices, meanwhile, Section 3 contains questions that complement the study.
Thank you for your cooperation!

Section 1: General Data.

1.1 Does the company you work for use agile methodologies for software development? If your answer is NO, do not fill out this questionnaire.
Yes; No
1.2 Which agile methodologies does the company use?
Scrum; XP; FDD; Agile UP; Hybrid XP/Scrum; Do not know; Other.
1.3 What is your position in the company?
Project Chief; Software developer; Owner; IT Personal; Tester; Other.
1.4 Gender
Male; Female.
1.5 How many people make up the development team in your company?
<10; 10-19; 20-29; 30-39; 40-49; >50

1.6 What is the company's core business?
Software development; Financial services; Professional services; Health; Public Institution; Education; Telecommunication; Insurance; Other.
1.7 Where is the company's head office located?
(open answer)
1.8 Where are you currently working?
(open answer)

Section 2. Relationships between critical success factors and agile practices.

Agile practices are techniques which are applied in the agile development process. They have been grouped in four categories:
TEAMWORK: Pair programming, on-site customer, multi-functional teams, self-organizing teams, stand-up meetings, collective code ownership, and retrospectives.
PROJECT MANAGEMENT: Planning games, 40 hours per week, Timeboxing, monitoring progress.
ENGINEERING: Small releases, simple design, refactoring, coding standards.
TESTING: Unit test, Continuous integration
Evaluate according to 1 to 5 scale (1: No influence or negative influence, 5: Complete positive influence)

Personnel
2.1 What influence does CONFIDENCE have on the following agile practices:
Teamwork: *1; 2; 3; 4; 5*
Project Management *1; 2; 3; 4; 5*
Engineering *1; 2; 3; 4; 5*
Testing *1; 2; 3; 4; 5*
2.2 What influence does PERCIVED SELF-EFFICACY have on the following agile practices:
Teamwork: *1; 2; 3; 4; 5*
Project Management *1; 2; 3; 4; 5*
Engineering *1; 2; 3; 4; 5*
Testing *1; 2; 3; 4; 5*
2.3 What influence does STRESS have on the following agile practices:
Teamwork: *1; 2; 3; 4; 5*
Project Management *1; 2; 3; 4; 5*
Engineering *1; 2; 3; 4; 5*
Testing *1; 2; 3; 4; 5*

Organization
2.1 What influence does INTEGRITY AND AVAILABILITY OF INFORMATION AND LEARNING EXPERINCES have on the following agile practices:
Teamwork: *1; 2; 3; 4; 5*
Project Management *1; 2; 3; 4; 5*
Engineering *1; 2; 3; 4; 5*
Testing *1; 2; 3; 4; 5*
2.2 What influence does QUALITY OF WORKING LIFE have on the following agile practices:
Teamwork: *1; 2; 3; 4; 5*
Project Management *1; 2; 3; 4; 5*
Engineering *1; 2; 3; 4; 5*

Testing *1; 2; 3; 4; 5*
2.3 What influence does MEDIA USED have on the following agile practices …
Teamwork: *1; 2; 3; 4; 5*
Project Management *1; 2; 3; 4; 5*
Engineering *1; 2; 3; 4; 5*
Testing *1; 2; 3; 4; 5*

Section 3. Other related aspects.

3.1 Choose one or more agile practices you apply to software development.
Pair programming; on-site costumer; stand up meetings; multifunctional teams; self-organizing teams; retrospectives; collective code ownership; planning games; monitoring progress; 40 hours per week; Timeboxing; simple design; small releases; refactoring; coding standards; testing, continuous integration

3.2 Does the company apply quality control to the software development process?
Yes; No; Partially

Appendix B. Summary obtained from survey data

Factor	Practice	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)
FSE	PDİS	5	12	16	38	29
	PMP	4	10	16	41	28
	PTW	1	8	12	40	39
	PTEST	3	10	21	40	27
Mean FSE		*3,3*	*9,8*	*16,3*	*40,1*	*30,7*
FCO	PDİS	5	9	26	38	21
	PMP	3	7	23	38	29
	PTW	2	6	18	33	41
	PTEST	3	8	31	31	27
Mean FCO		*3,4*	*7,5*	*24,5*	*35,1*	*29,5*
FQWL	PDİS	4	14	16	45	21
	PMP	1	14	18	37	30
	PTW	2	8	16	42	33
	PTEST	5	11	20	43	21
Mean FQWL		*3,3*	*11,5*	*17,5*	*41,6*	*26,2*
FIAI	PDİS	3	5	23	36	33
	PMP	2	6	20	42	30
	PTW	1	6	16	43	34
	PTEST	3	3	25	34	35
Mean FDİSP		*2,1*	*5,1*	*20,9*	*38,9*	*33,0*
FSTR	PENG	5	14	29	29	22

Factor	Practice	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)
	PMP	8	11	28	25	28
	PTW	5	13	23	25	34
	PTEST	8	15	27	27	23
Mean FSTR		*6,7*	*13,4*	*26,7*	*26,5*	*26,7*
FCM	PDİS	3	9	22	33	34
	PMP	1	6	16	33	44
	PTW	1	5	18	24	51
	PTEST	3	7	23	35	32
Mean FCM		*1,9*	*6,8*	*19,9*	*31,2*	*40,2*

References

[1] T. Chow and D. B. Cao, "A survey study of critical success factors in agile software projects," *J. Syst. Softw.*, vol. 81, no. 6, pp. 961–971, Jun. 2008.

[2] Standish Group, "Chaos Report 2015." 2015.

[3] M. de A. Santos, "Agile Practices: An Assessment of Perception of Value of Professionals on the Quality Criteria in Performance of Projects," *J. Softw. Eng. Appl.*, vol. 04, no. 12, pp. 700–709, 2011.

[4] K. Curcio, A. Malucelli, S. Reinehr, and M. A. Paludo, "An analysis of the factors determining software product quality: A comparative study," *Comput. Stand. Interfaces*, vol. 48, pp. 10–18, Nov. 2016.

[5] N. Gorla and S. C. Lin, "Determinants of software quality: A survey of information systems project managers," *Inf. Softw. Technol.*, vol. 52, no. 6, pp. 602–610, Jun. 2010.

[6] Z. Bougroun, A. Zeaaraoui, and T. Bouchentouf, "The projection of the specific practices of the third level of CMMI model in agile methods: Scrum, XP and Kanban," in *Information Science and Technology (CIST), 2014 Third IEEE International Colloquium in*, 2014, pp. 174–179.

[7] L. Fernández-Sanz and S. Misra, "Influence of human factors in software quality and productivity," in *Computational Science and Its Applications-ICCSA 2011*, Springer, 2011, pp. 257–269.

[8] S. T. Acuña, M. Gómez, and N. Juristo, "How do personality, team processes and task characteristics relate to job satisfaction and software quality?" *Inf. Softw. Technol.*, vol. 51, no. 3, pp. 627–639, Mar. 2009.

[9] S. T. Acuña, M. Gómez, and N. Juristo, "Towards understanding the relationship between team climate and software quality—a quasi-

experimental study," *Empir. Softw. Eng.*, vol. 13, no. 4, pp. 401–434, Aug. 2008.

[10] B. Begier, "Users' involvement may help respect social and ethical values and improve software quality," *Inf. Syst. Front.*, vol. 12, no. 4, pp. 389–397, Sep. 2010.

[11] M. N. Mirza, Z. Pourzolfaghar, and M. Shahnazari, "Significance of Scope in Project Success," *Procedia Technol.*, vol. 9, pp. 722–729, Jan. 2013.

[12] P. Clarke and R. V. O'Connor, "The situational factors that affect the software development process: Towards a comprehensive reference framework," *Inf. Softw. Technol.*, vol. 54, no. 5, pp. 433–447, May 2012.

[13] V. Subramanyam and C. G. Prasad, "Organizational practices that effects Software Quality In Software Engineering process," *International Journal of Engineering Trends and Technology*, vol. 2, no. 3, pp. 25–30, 2013.

[14] B. Xu, "Towards High Quality Software Development with Extreme Programming Methodology: Practices from Real Software Projects," in *International Conference on Management and Service Science, 2009. MASS '09*, 2009, pp. 1–4.

[15] K. Opelt and T. Beeson, "Agile Teams Require Agile QA: How to Make it Work, An Experience Report," in *Agile, 2008. AGILE '08. Conference*, 2008, pp. 229–232.

[16] P. H. de S. Bermejo, A. L. Zambalde, A. O. Tonelli, S. A. Souza, L. A. Zuppo, and P. L. Rosa, "Agile Principles and Achievement of Success in Software Development: A Quantitative Study in Brazilian Organizations," *Procedia Technol.*, vol. 16, pp. 718–727, 2014.

[17] Versionone, "11th Annual State of Agile Report." 2017.

[18] K. Mirnalini and V. R. Raya, "Agile - A software development approach for quality software," in *2010 International Conference on Educational and Information Technology (ICEIT)*, 2010, vol. 1, pp. V1-242-V1-244.

[19] S. Sultana, Y. H. Motla, S. Asghar, M. Jamal, and R. Azad, "A hybrid model by integrating agile practices for Pakistani software industry," in *2014 International Conference on Electronics, Communications and Computers (CONIELECOMP)*, 2014, pp. 256–262.

[20] D. F. Rico, "Effects of Agile Methods on Website Quality for Electronic Commerce," in *Hawaii International Conference on System Sciences, Proceedings of the 41st Annual*, 2008, pp. 463–463.

[21] X. Yu and S. Petter, "Understanding agile software development practices using shared mental models' theory," *Inf. Softw. Technol.*, vol. 56, no. 8, pp. 911–921, Aug. 2014.

[22] B. Henderson-Sellers and M. Serour, "Creating a Dual-Agility Method: The Value of Method Engineering - ProQuest," *Journal of Database Management*, vol. 16, no. 4, pp. 1–23, 2005.

[23] G. Lee and W. Xia, "Toward Agile: An Integrated Analysis of Quantitative and Qualitative Field Data on Software Development Agility," *MIS Q.*, vol. 34, no. 1, pp. 87–114, 2010.

[24] Agile Alliance, "12 Principles Behind the Agile Manifesto," *Agile Alliance*, 04-Nov-2015.

[25] G. A. García-Mireles, M. Á. Moraga, F. García, and M. Piattini, "Approaches to promote product quality within software process improvement initiatives: A mapping study," *J. Syst. Softw.*, vol. 103, pp. 150–166, May 2015.

[26] J. F. Tripp and D. J. Armstrong, "Agile Methodologies: Organizational Adoption Motives, Tailoring, and Performance," *J. Comput. Inf. Syst.*, vol. 58, no. 2, pp. 170–179, 2016.

[27] K. Schwaber and Jeff Sutherland, *La Guía de Scrum*. 2013.

[28] A. Ahmed, S. Ahmad, N. Ehsan, E. Mirza, and S. Z. Sarwar, "Agile software development: Impact on productivity and quality," in *2010 IEEE International Conference on Management of Innovation and Technology (ICMIT)*, 2010, pp. 287–291.

[29] A. Mundra, S. Misra, and C. Dhawale, "Practical Scrum-Scrum Team: Way to Produce Successful and Quality Software," in *2013 13th International Conference on Computational Science and Its Applications (ICCSA)*, 2013, pp. 119–123.

[30] P. Diebold and M. Dahlem, "Agile Practices in Practice: A Mapping Study," in *Proceedings of the 18th International Conference on Evaluation and Assessment in Software Engineering*, New York, NY, USA, 2014, pp. 30:1–30:10.

[31] K. N. Manjunath, J. Jagadeesh, and M. Yogeesh, "Achieving quality product in a long term software product development in healthcare application using Lean and Agile principles: Software engineering and software development," in *2013 International Multi-Conference on Automation, Computing, Communication, Control and Compressed Sensing (iMac4s)*, 2013, pp. 26–34.

[32] C. Scharff, "Guiding global software development projects using Scrum and Agile with quality assurance," in *2011 24th IEEE-CS Conference on Software Engineering Education and Training (CSEE T)*, 2011, pp. 274–283.

[33] A. Marrington, J. M. Hogan, and R. Thomas, "Quality assurance in a student-based agile software engineering process," in *Software*

Engineering Conference, 2005. Proceedings. 2005 Australian, 2005, pp. 324–331.

[34] S. Bhasin, "Quality Assurance in Agile: A Study towards Achieving Excellence," in *AGILE India (AGILE INDIA), 2012*, 2012, pp. 64–67.

[35] K. R. Larsen and D. Eargle, "Theories Used in IS Research," *Theories Used in IS Research Wiki*, 2017. [Online]. Available: https://is.theorizeit.org/wiki/Main_Page. [Accessed: 17-Apr-2018].

[36] J. S. Adams and S. Freedman, "Equity Theory Revisited: Comments and Annotated Bibliography," in *Advances in Experimental Social Psychology*, vol. 9, L. B. and E. Walster, Ed. Academic Press, 1976, pp. 43–90.

[37] J. S. Coleman, "Social Capital in the Creation of Human Capital. 94, | socialcapitalgateway.org," *The American Journal of Sociology*, vol. 94, pp. S95–S120, 2005.

[38] A. Bandura, "Self-efficacy: Toward a Unifying Theory of Behavioral Change," *Psychological Review*, vol. 84, no. 2, pp. 191–215, 1977.

[39] D. Straub and E. Karahanna, "Knowledge Worker Communications and Recipient Availability: Toward a Task Closure Explanation of Media Choice," *Organ. Sci.*, vol. 9, no. 2, pp. 160–175, Feb. 1998.

[40] J. S. Carroll, "Review of Foundations of Information Integration Theory," *Am. J. Psychol.*, vol. 95, no. 4, pp. 708–711, 1982.

[41] R. M. Grant, "Toward a knowledge-based theory of the firm," *Strateg. Manag. J.*, vol. 17, no. S2, pp. 109–122, Dec. 1996.

[42] R. P. Bostrom and J. S. Heinen, "MIS Problems and Failures: A Socio-Technical Perspective, Part II: The Application of Socio-Technical Theory," *MIS Q.*, vol. 1, no. 4, pp. 11–28, 1977.

[43] R. L. Daft and R. H. Lengel, "Information richness: A new approach to managerial behavior and organizational design," *Res. Organ. Behav.*, vol. 6, pp. 191–233, 1984.

[44] S. J. Haberman, "The Analysis of Residuals in Cross-Classified Tables," *Biometrics*, vol. 29, no. 1, p. 205, Mar. 1973.

[45] J. Nunnally and L. Bernstein, *Psychometric theory*. NewYork: McGraw-Hill Higher, INC, 1994.

[46] R. Vallon, B. J. da Silva Estácio, R. Prikladnicki, and T. Grechenig, "Systematic literature review on agile practices in global software development," *Inf. Softw. Technol.*, vol. 96, pp. 161–180, Apr. 2018.