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What Works When?
Exploring Contingency in Software Development Methodology

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ABSTRACT

In project management 'one size does not fit all'. Matching the methodology to the needs of a particular project is essential in managing cost, quality and schedule. Because project personnel tend to favour the methodology they are most experienced in, and numerous methodologies are available on the market, objective guidance is required to select a methodology that leads to project success. This research engaged with members of the PRINCE2, PMI and Agile communities via local interviews and an international survey. Factors in the project and project environment (organisation, industry, etc) were identified that predicted the software development methodology that fits. The results also reveal that methodology fit, experience level and market uncertainty are significant predictors of project success.

Keywords: Information systems; information technology, knowledge management, lean production, process innovation, technology innovation

INTRODUCTION

In software development, one size does not fit all. Contingencies shape the alignment between the project and its environment, and between software development practices and project success. Software development practices must align with management methodologies employed at different hierarchical levels (development team, project, programme, etc). A project management hierarchy and associated methodologies adapted from APM, 2006, p.7; Charvat, 2003, p.7; Dalcher & Brodie, 2007, p.10; OGC, 2009, p.219 is illustrated in Figure 1. The conditions favouring a particular software development methodology (e.g., Waterfall, RUP or Scrum) are not well understood. Because numerous project management methodologies (e.g., Prince2, PMI or Agile) are available on the market it can be difficult to identify what works when. Moreover people tend to stick with what they are good at and favour the project management methods with which they have had most experience (Boehm & Turner, 2004). Thus to increase the overall chances of success (and to reduce the risk of project failure), we need objective guidance to identify the most appropriate software development methodology (SDM) and then to tailor it as necessary to match the needs of a given project. The current research aims to answer two questions: RQ1: What are the important project environment and project factors' that fit in software development methodology? RQ2: What is the role of SDM fit in project success? The remainder of this section explores the issues via the literature, local interviews and an international survey. Findings are presented and discussed in the final two sections.

PROJECT MANAGEMENT METHODOLOGY SELECTION - TWO APPROACHES

Many researchers distinguish *traditional* (heavy) and agile (light) approaches to project management (Boehm & Turner, 2003; Charvat, 2003; Highsmith, 2010; Wysocki, 2009). Traditional approaches rely on a linear or incremental lifecycle. These methods are *plan-driven* and are characterized by a requirement/design/build approach to development (Boehm & Turner, 2004). In this kind of project, the requirements are clearly specified and little change is expected. Thus, the environment is predictable and planning tools can be used to optimise the management of the project. These approaches are usually change-resistant and focus on compliance to plan as a measure of success (Wysocki, 2009). Consequently, they are somewhat prescriptive, and heavy on process and documentation. According to Wysocki (2009), no more than 20 percent of all projects have the characteristics of traditional projects, but project managers continue to apply these traditional methods on projects for which they are not suited (Figure 2).

On the other hand, *agile* methods have been developed to respond to the dynamic aspects of the environment. Organisations need short delivery cycles to cope with uncertainty and rapid change in requirements (Wysocki, 2009). Agile approaches are based on an iterative or adaptive lifecycle and are designed to accept and embrace change (Figure 3). They are value-driven rather than plan-driven and use tacit knowledge between team members in place of heavy documentation. This principle is enshrined in the Manifesto for Agile Software Development (Figure 4). In agile methods, the major, upfront, one-time planning task is replaced by an iterative and adaptive series of just-in-time tasks each of which is executed only when needed. This provides flexibility and adaptability to the project, enabling it to cope more readily with change requests. Table 1 contrasts traditional and agile software methodologies.

SDM FIT AND PROJECT SUCCESS

SDM Fit is about methodological success, that is, the choice of the SDM that best helps the successful completion of the project (Cockburn, 2007; Perrin, 2008). For the purposes of the current research, *SDM Fit* is defined as the choice of a SDM that delivers Project Success in the context of relevant factors associated with the Project and Project Environment. The literature on SDM Fit does not provide a definitive account of the relevant factors. Cockburn (2007) discusses many criteria related to methodological success, but some of the criteria are difficult to measure and the significance of each has not been tested. In addition the concepts and priorities associated with project success are hard to define and measure because these vary according to project type and industry (Highsmith, 2010; Shenhar, Tishler, Dvir, Lipovetsky, & Lechler, 2002). Table 2 summarizes a total of 19 contingencies in SDM Fit sourced from the methodology fit literature. The last column provides an initial classification into two broad categories: *Project (P)* or *Project Environment (PE)*. There is neither agreement about the relative importance of these 19 contingencies nor clarity about how to operationalize them for the purpose of researching SDM Fit.

Boehm & Turner (2003) describe how to reduce the risk associated with an inappropriate choice of SDM. Five Project Factors are assessed to ascertain how well the project fits with either the Agile or the Plan-driven method. These Project Factors are as follows: *need for personnel* *supervision, project criticality, project size, control culture, and requirements stability*. Each is considered critical and each is measured on a scale from pure plan-driven to pure agile. The collective match on all five Project Factors, typically illustrated by a radar plot, determines the profile of the project (Figure 5). Boehm & Turner (2003) support their model by describing projects where the project factors do not favour a pure methodology, and where risks are reduced by including practices associated with the opposite (complementary) methodology. In summary, the use of 'critical' factors and a risk-based approach offers insightful guidelines for the majority of us who approach systems development from within the confines of a single favourite methodology, and who may therefore lack an appreciation of how to achieve a 'methodologically successful project' (Cockburn, 2007).

RESEARCH PHILOSOPHY AND DESIGN

This is a positivist study based on the ontological assumption that reality is external and objective (Easterby-Smith, Thorpe & Jackson, 2008; O'Leary, 2010). The purpose is to answer research questions 1 and 2 by exploring the contingencies associated with the research model constructed for each (Figure 6 and 7, respectively). The hypotheses are as follows:

RQ1: SDM Fit Research Model (Figure 6)

H1: *Project Environment factors influence the choice of the SDM that Fits*

H2: *Project factors influence the choice of the SDM that Fits*

RQ2: Project Success Research Model (Figure 7)

H3: *Project Environment factors influence Project Success*

H4: The degree of *SDM Fit influences Project Success*

H5: *Project factors influence Project Success.*

Two research methods were employed. Conceptual and empirical uncertainty about the two research models was first reduced by semi-structured interviews conducted with practitioners in Wellington, New Zealand. Semi-structured interviews were conducted with eight project workers. A card sort procedure was employed (Faiks & Hyland, 2000; Rugg & McGeorge, 1997; Spencer & Warfel, 2004). The primary aim was to select the most important constructs for the two independent variable clusters (Figure 6). It was anticipated that a successful card sort process would enable a more focussed survey to be employed so that the exploratory research might also develop some testable hypotheses and, perhaps, useful predictions. Twenty eight cards were employed each containing a measure related to the 19 contingencies summarized in Table 2. The participants were asked, firstly, if each candidate measure was important to methodological success (SDM Fit) and, secondly, to rank in importance those candidate measures that were important. As participants sorted the cards, the researcher asked them to comment on their choices in order to get a better understanding of the reality of methodology selection. This procedure was first executed with the project environment measures and then with the project measures (Table 2). By the end of the interviews new perspectives had emerged and a consensus had formed that some of the original measures were unimportant. The card sort technique delivered a rank ordered list of both project environment and project measures. This initial exploration of contingencies in software development enabled 28 measures to be reduced to 16 measures. To ensure the clarity of the survey, a pilot test was also conducted among five practitioners. Their feedback contributed to the improvement of the layout of the questionnaire and its wording.

An international survey was conducted in May 2010. The target population was the Prince2, PMI and Agile communities of SDM practice. Their characteristics are summarised in Table 3 (Sheffield and Lemetayer, 2010). Members of these communities were contacted at a PMI conference and via websites and the authors' professional networks. Because each community is equally important to answering the research question an equal number of survey requests were sent to each community. A total of 106 responses were received from 501 requests for a response rate of 21%. Within each community members were selected on the basis of researcher convenience. There was a higher response rate from the Agile community and a lower response rate from the Prince2 community. While replies were received from 22 countries, almost 70% were drawn from just 3 countries – USA (38 responses), New Zealand (19 responses), and Australia (16 responses).

The survey was web-based and short, taking only five to eight minutes to complete. It aimed to answer the research questions via gathering data on the 16 measures of contingencies in the project and its environment that the literature review *and* the interviews had found to be important. The survey questions were distributed as follows: demographic (4 questions), project environment (6 questions), project (10 questions), SDM (5 questions), project success (9 questions), and feedback on the survey (1 question). The measure of project success included 'the iron triangle' (time, budget, functionality). Nearly all questions were answered on 5-point Likert scales. Where possible the measures in the literature (Table 2) were reused. It was intended that all

35 questions could be answered with relative ease by the intended audience – experienced project workers. In summary the hypotheses were tested via 35 measures provided by each of 106 respondents drawn from three worldwide communities of SDM practice – Prince2, PMI and Agile.

FINDINGS

Exploratory Factor Analysis

Descriptive Statistics

The descriptive statistics in Table 4 identify that the majority of the respondents (66%) have more than 10 years of experience in software development and 43% were project managers (either agile or traditional). The smallest project cost USD 2,500 (2 man months) and the biggest cost USD 840 million (1,260 man years). As suggested by one of the pilot testers, not all respondents knew the total cost of the project they worked on. This question was answered by only 54% of the respondents. The modal respondent was one with more than 10 years experience (DEM1) who worked for an organization with more than 5,000 employees (DEM2) in the finance/insurance industry (DEM3) and whose role was that of a traditional project manager (DEM4).

Descriptive statistics for measures of the independent variables (Project Environment and Project) and dependent variables (SDM and Project Success) are reported in Table 5 and Table 6, respectively. Most variables have a mean value close to 3, a minimum of 1 and maximum of 5. Power distance has the lowest mean, which can be explained by the fact that the most represented countries (i.e. USA, New Zealand and Australia) have a low power distance index (Hofstede & Hofstede, 2005).

Test of Reliability

Cronbach's alpha was calculated to evaluate the internal consistency of the three variables measured via the aggregation of multiple questions/measures. The test gave a value well above .8 for all three variables, which indicates that there is no problem with their internal consistency (Table 7).

Exploratory Factor Analysis of Project Environment, Project and Project Success Data

Exploratory factor analysis of responses to the project environment questions produced three factors - named *organizational culture (measured from conservative to entrepreneurial), market uncertainty*, and *low power distance* – that collectively explain 76.4% of the variability (Table 8). Exploratory factor analysis of responses to the project questions produced three factors – named *empowerment of the project team, low complexity of the project, and experience level of the team* – that collectively explained 56.6% of the variability (Table 9). As expected for a dependent variable with a Cronbach's alpha measure of .88, exploratory factor analysis of responses to the Software Development Methodology questions revealed a single component – named *agility* – that explained 68.3% of the variability (Table 10). As expected for a dependent variable with a Cronbach's alpha measure of .87, exploratory factor analysis of responses to the Project Success questions also revealed a single component – named *project success* - which explained 61% of the variability (Table 11).

FINDINGS ON RESEARCH QUESTION 1

Correlation Analysis of the SDM Fit Research Model

For the purposes of the current research, the SDM that Fits was defined as the choice of a SDM that delivers Project Success in the context of relevant factors associated with the Project and Project Environment. While the card sort has sharpened up the contingency factors identified in the literature (Table 2), the nature of the research remains exploratory. As a consequence structural equation modelling (SEM), which entails confirmatory factor analysis, was not employed to support the simultaneous or dynamic analysis of a single model incorporating both Figure 6 (Q1) and Figure 7 (Q2). An alternative approach to analysis was employed, in which the SDM that Fits was defined as the choice of a SDM that delivers Project Success *higher than the mean* in the context of relevant factors associated with the Project and Project Environment (Figure 6). It transpired that 46 of the 106 projects had measures of Project Success that were higher than the mean. These were defined as 'successful' projects and analysis proceeded with them. Research Question 1 (hypothesis 1 and 2) were tested by analysis of the correlation between the factors which emerged from the relevant exploratory factor analysis of 'successful' projects. By definition, the SDM employed in these 'successful' projects is the SDM that Fits.

Table 12 identifies two factors that significantly correlate with the SDM that Fits. *Organizational culture* (measured from conservative to entrepreneurial) is positively correlated with the SDM that Fits (r=.51, p< .001) hence supporting Hypothesis H1: Project Environment factors influence the choice of an SDM that Fits. *Empowerment of the project team* is positively correlated with the choice of an agile SDM that Fits (r=.80, p<.001) hence supporting Hypothesis H2: Project factors influence the choice of Software Development Methodology that Fits.

Multiple Regression Analysis of the SDM Fit Research Model

To determine the best predictors of the SDM that Fits, a step-wise regression analysis was conducted using factors from the exploratory factor analysis that were significantly correlated with SDM that Fits. *Empowerment of the project team* (b=.51, t=6.11, p<.001) and *organizational culture*, (b=.32, t=3.78, p<.001) predict Project Success (Table 13), and explain 50% of the variance in Project Success (Adj.R-square=.50, p<.001) (Table 14). A unit increase in *empowerment of the project team* produces a .51 increase in the SDM that Fits. Similarly, a unit increase in *organizational culture* (measured from conservative to entrepreneurial) produces a .32 increase in the SDM that Fits. This regression model also supports Research Question 1. The regression equation can be applied to all 106 projects and the absolute value of the residual employed as a single direct measure of (lack of) SDM Fit.

FINDINGS ON RESEARCH QUESTION 2

Correlation Analysis of the Project Success Model

Research Question 2 hypothesis 4 is tested via the residual measure of SDM Fit described above. RQ2 hypotheses 3 and 5 were tested by analysis of the correlation between the factors which emerged from the exploratory factor analysis. Table 15 identifies three factors that significantly correlate with Project Success. *SDM Fit* is positively correlated with Project Success (r=.20, p<.05) hence supporting Hypothesis H4: The degree of SDM Fit influences Project Success. *Market uncertainty* is negatively correlated with Project Success (r=-.22, p<.05) hence supporting Hypothesis H3: Project Environment factors influence Project Success. *Experience level of the team* is positively correlated with Project Success (r=.38, p <.01) hence supporting Hypothesis H5: Project factors influence Project Success.

Multiple Regression Analysis of the Project Success Research Model

To determine the best predictors of SDM that Fits, a step-wise regression analysis was then conducted using the factors from the exploratory factor analysis that were significantly correlated with Project Success. *Experience level of the project team* (b=.38, t=3.93, p<.001), *Market Uncertainty* (b=-.22, t=-2.25, p<.05), and *SDM Fit* (b=.20, t=2.14, p<.05) predict Project Success (Table 16), and explain 21% of the variance in Project Success (Adj.R-square=.21, p<.001) (Table 17). This regression model also supports Research Question 2.

Finally, a correlation analysis was conducted between SDM (not the SDM that Fits or the degree of SDM Fit) and Project Success to evaluate if one approach delivers more project success than the other in all situations. In other words, it tested whether one size fits all. No correlation was found between these two factors (r =.165, p =.110), which confirms that one size does not fit all. The use of one particular approach regardless of the project and its environment will not increase project success.

DISCUSSION

The Research Questions Revisited

RQ1: Critical Factors in SDM Fit

Two critical factors in SDM Fit are organisational culture and empowerment of the project team (Figure 8). The finding that organisational culture is significant is consistent with Strode et al. (2009) who found a relationship between low formality organizations and the use of agile methodologies. It is also consistent with Iivari and Huisman (2007), who found a positive relationship between the hierarchical rational organizations and the deployment of traditional methodologies. Exploratory factor analysis revealed that organisational culture encapsulates measures of the *project environment* such as methodology supported by top management, level of entrepreneurship and level of risk taking willingness. Other project environment variables such as project management methodology, economic sector and firm size directly influence project success but not SDM Fit. There is clearly a need to consider the findings based on both the RQ1 and RQ2 research models in understanding how to obtain project success.

The second factor critical in SDM Fit, *empowerment of the project team*, has more influence than the first. Exploratory factor analysis revealed that empowerment of the project team encapsulates measures of the *project* such as methodology supported by the customer, customer commitment and requirements uncertainty. The finding that empowerment of the project team and requirements uncertainty are significant indicators of SDM Fit supports the 'control culture' and 'requirements stability' factors in the Boehm and Turner (2003) model. The card sort procedure employed in the interviews revealed that the remaining three factors in the Boehm and Turner (2003) model (need for personnel supervision, project criticality and project size) were not considered important. However, measures of these factors were included in the survey and each measure was subject to correlation analysis that found no statistical support for their influence on SDM Fit (Figure 10).

RQ2: Project Success

Three critical factors in project success are market uncertainty, SDM Fit and experience level of the project team (Figure 9). While the PMBOK (PMI, 2008) mentions dozens of factors that influence project success, these three factors collectively explain more than one fifth of the variance. No previous study was identified that measured the impact of *SDM Fit* on Project Success. This study also confirms that one size does not fit all, as there is no relationship between SDM and Project Success. In other words, the use of a particular SDM regardless of the characteristics of the project or its environment does not improve Project Success. Tiwana and Keil (2004) also found that the use of a potentially inappropriate methodology (i.e., one chosen without consideration of the project context) was a major risk driver. The one-size-fits-all approach is clearly demonstrated to be inappropriate in the current study. This mentality can lead to bad methodology choices that threaten the chances of project success.

This study demonstrates that two other factors have an impact on project success: *experience level of the team* and *market uncertainty*. A more experienced team will therefore increase the success of the project regardless of the methodology chosen. Similarly, increased market uncertainty will reduce project success. The more stable the market is, the more likely the project will be successful. These two factors do not influence SDM Fit, but directly impact project success.

IMPLICATIONS

The current study has at least four implications for practitioners. *Firstly*, to obtain better results, practitioners have to ensure that their allegiance to a particular community of project management methodology practice does not blind them to the need to select the most appropriate SDM. *Secondly*, the current study demonstrates that when top management, the project management, project team and customer fail to agree on SDM, project success will suffer. *Thirdly*, the findings demonstrate that project managers and, more generally, top management and organizations should adopt a more project-specific approach to project management and software development. The study provides the beginnings of a metric for evaluating SDM Fit based, for example, on the variables identified in Figure 10. The higher the project score is on these variables, the more appropriate an agile approach is. *Fourthly*, practitioners will have to think about how to tailor the methodology selected to best fit their needs. This is particularly true when these factors do not lead to a clear choice of methodology. A willingness to adopt hybrid methodologies that combine the features of plan-driven and agile methodologies may be needed.

Contribution

The current research contributes to the SDM fit literature, a contingency model that includes the impact of factors associated with the project *and* the project environment, on SDM Fit *and* project success. The contingencies identified and evaluated by this research may assist practitioners to select the most appropriate methodology and to achieve higher project success rates.

DELIMITATIONS

This study has some limitations. Firstly, due to the lack of literature in SDM Fit and particularly the lack of suitable quantitative instruments, this research is exploratory. Secondly, a survey was used to find statistical evidence for the contingency factors. However, the survey instrument has its limitations. Thirdly, the constructs used are not all based on theoretically sound conceptualizations and tested instruments. These do not exist within the context of research on SDM Fit. The way SDM is evaluated on a spectrum from traditional to agile is not based on any existing instrument, which limits the validity of the findings. Improvements are possible by including more questions about beliefs (e.g., about project management methodologies) and methods. Even though Agile methodologies, for example, share the same underlying philosophies, they do not all use the same methods, techniques and tools. New measures had to be devised to measure this construct. Questions on the usage by the project team of techniques and practices within the same category could have provided more accurate measures of software development methodologies. Likewise questions could have been included about the relative weighting of aspects of project success as the weights may vary with SDM. Schedule may be more important in Agile, for example. However, each of these additions would have increased the length of the survey. Interviewees remarked that methodologies attract strong, almost religious beliefs that colour responses. For example, it was suggested that agile people would say that project success is high and that the customer is satisfied because they believe that this is what agile methodologies are intended to bring. While the questions used to measure project success addressed a broad spectrum of project success dimensions, other measures may have given different findings.

In this study the sample is not entirely random which may limit the generalizability of the findings. Although a large variety of projects was represented in the database, and the collective project experience of respondents exceeds 1,000 years, a survey of different projects in different countries and environments may have produced slightly different outcomes. Also the sample size remains relatively low. A larger sample size could have provided more accurate statistical evidence. Nevertheless the goal of this exploratory study was not the generalization of the findings. Finally this research assumes that different respondent roles do not influence the data collected. It would have been interesting to see if there are any significant differences according to the respondent's position in the project management hierarchy sketched in Figure 1. Programme managers, for example, may have insights that differ from those of project managers and customers.

Future Research

Further research is required in order to produce more robust use-friendly metrics on contingencies in software development. Confirmation of the results reported here could proceed via qualitative research employing semi-structured *interviews* that looked more carefully at issues such as the impact of *organizational culture, role* and *requirements uncertainty* on SDM Fit and Project Success. A *refined survey* instrument could be devised that included additional measures of the beliefs and practices associated with project management methodology and SDM (Figure 6), as well as the weighting of various aspects of *project success* (Figure 7). More careful *theoretical sampling* and confirmatory factor analysis would deliver a succinct theoretical model with enhanced predictive power (Figure 11).

The factors identified in the current research provide conceptual and empirical foundations for multiple additional studies. Refinement of the current findings would provide project managers with a robust framework and associated metrics to justify to their executives or customers the most appropriate approach. Case study research could then test the applicability and usefulness of the framework in particular instances. Clearly, one size does not fit all. The software development methodology contingency factors explored in this study provide practitioners with initial assistance in understanding what works when.

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FIGURES AND TABLES

FIGURE 1: Project Management Hierarchy and Associated Methodologies

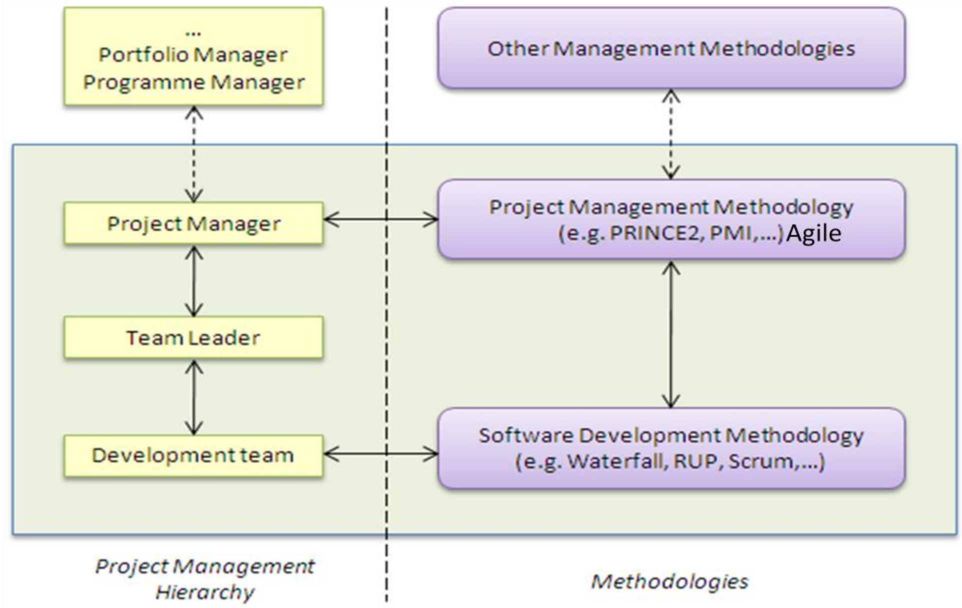

FIGURE 2: THE TRADITIONAL WATERFALL DEVELOPMENT MODEL (ADAPTED FROM LEFFINGWELL, 2007)

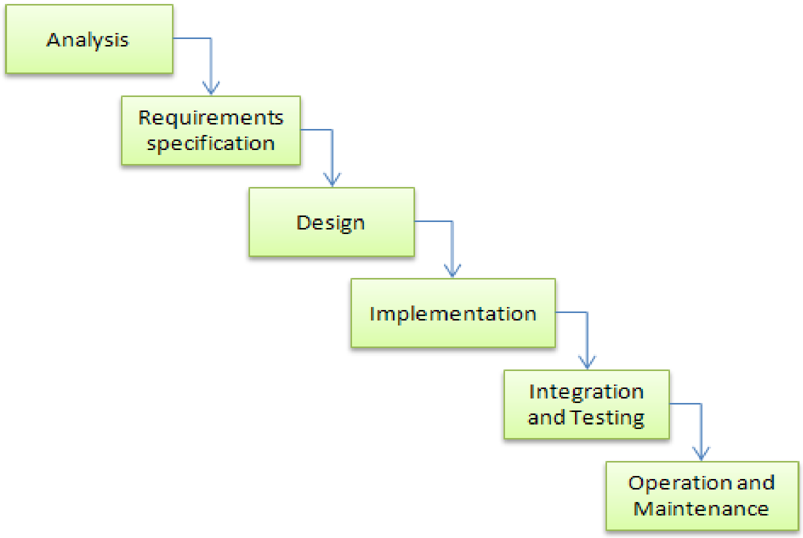

FIGURE 3: THE AGILE SCRUM PROCESS (ADAPTED FROM BOEHM & TURNER, 2005)

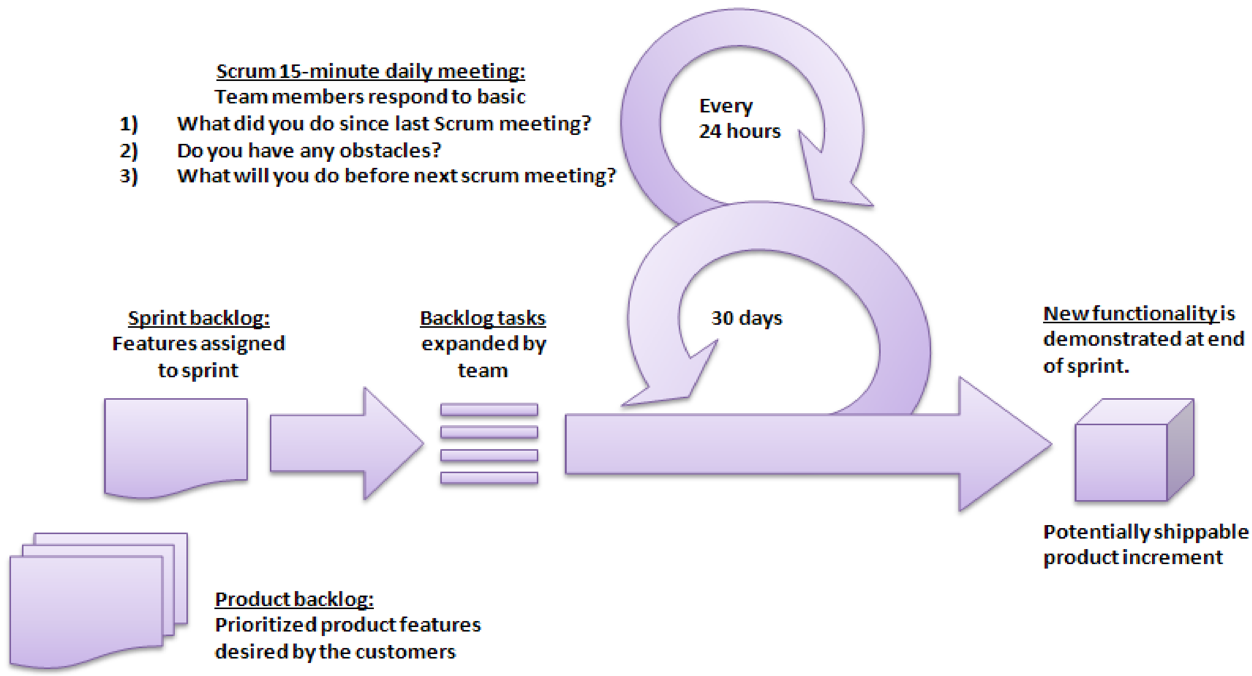

FIGURE 4: THE AGILE MANIFESTO

Manifesto for Agile Software Development

We are uncovering better ways of developing software by doing it and helping others do it. Through this work we have come to value:

Individuals and interactions over processes and tools
Working software over comprehensive documentation
Customer collaboration over contract negotiation
Responding to change over following a plan

That is, while there is value in the items on the right, we value the items on the left more.

Kent Beck, Mike Beedle, Arie van Bennekum, Alistair Cockburn, Ward Cunningham, Martin Fowler, James Grenning, Jim Highsmith, Andrew Hunt, Ron Jeffries, Jon Kern, Brian Marick, Robert C. Martin, Steve Mellor, Ken Schwaber, Jeff Sutherland, and Dave Thomas.

FIGURE 5: PROJECT FACTORS IN SDM FIT (BOEHM & TURNER, 2003, P. 59)

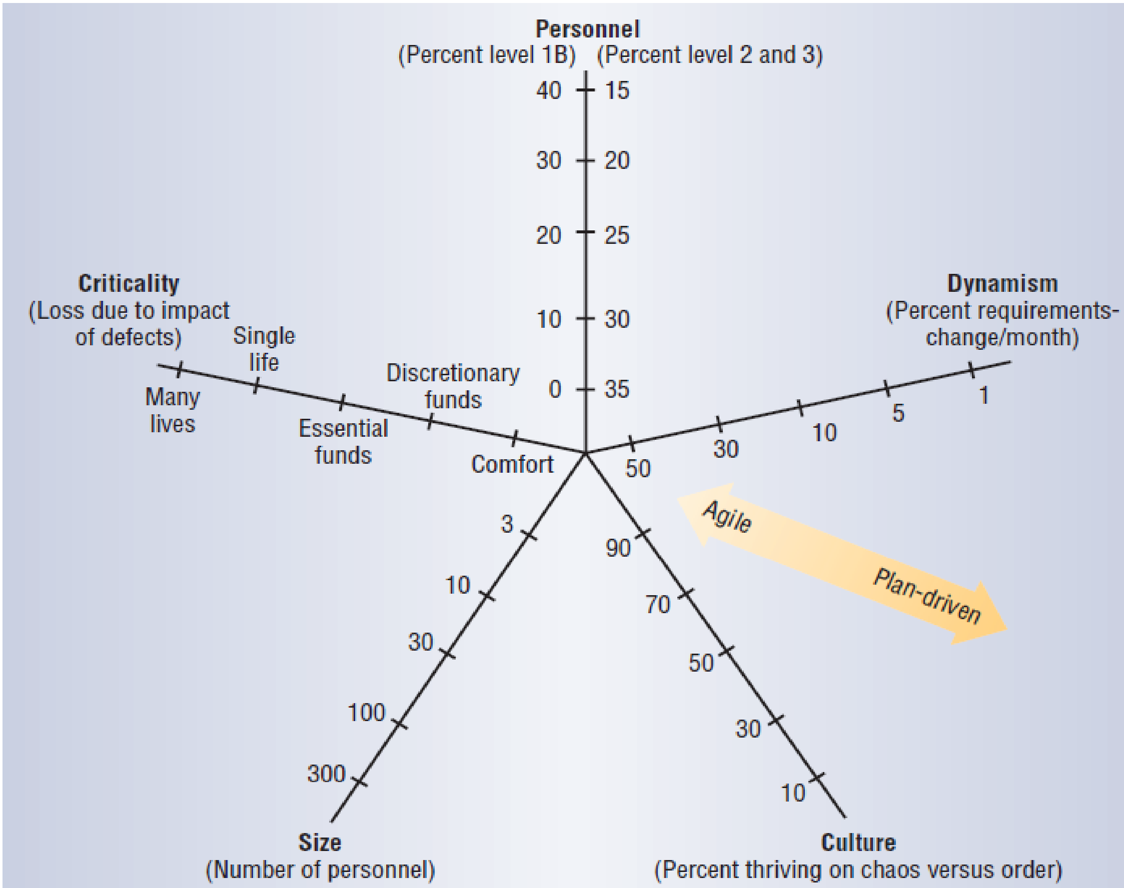

FIGURE 6: SDM FIT RESEARCH MODEL (RQ1)

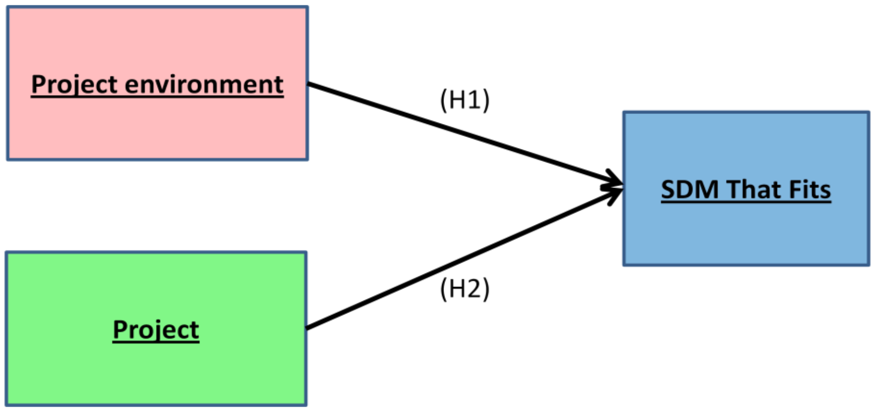

Figure 7: Project Success Research Model (RQ2)

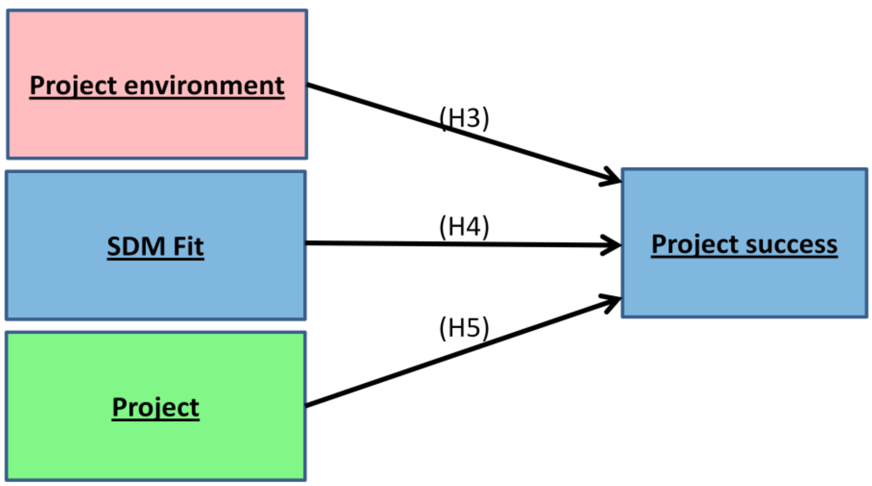

FIGURE 8: REGRESSION ANALYSIS SUMMARY FOR SDM FIT RESEARCH MODEL (RQ1)

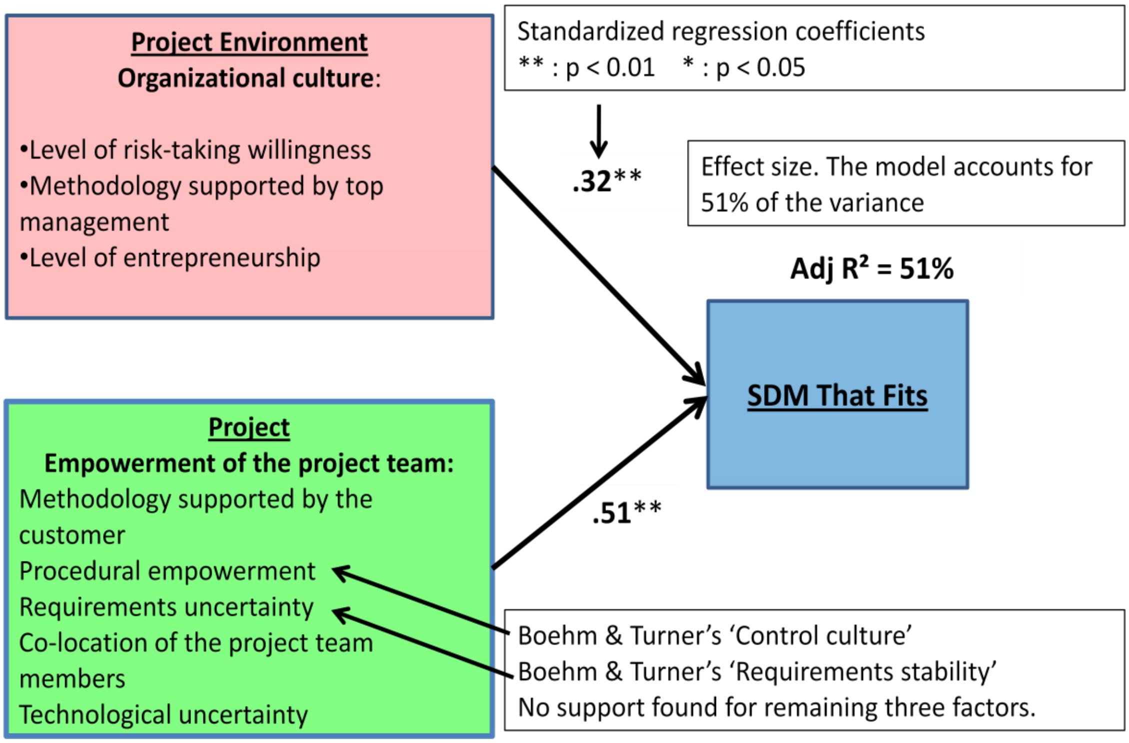

FIGURE 9: REGRESSION ANALYSIS SUMMARY FOR PROJECT SUCCESS RESEARCH MODEL (RQ2)

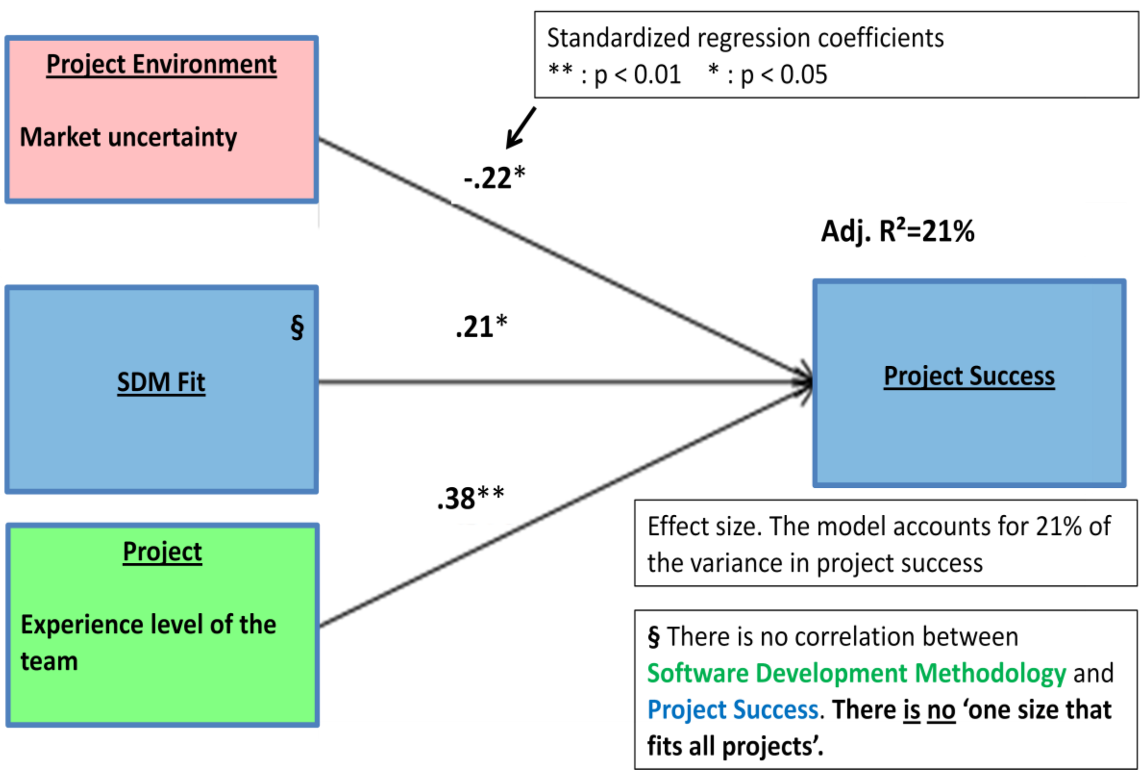

FIGURE 10: PROJECT FACTORS IN SDM FIT

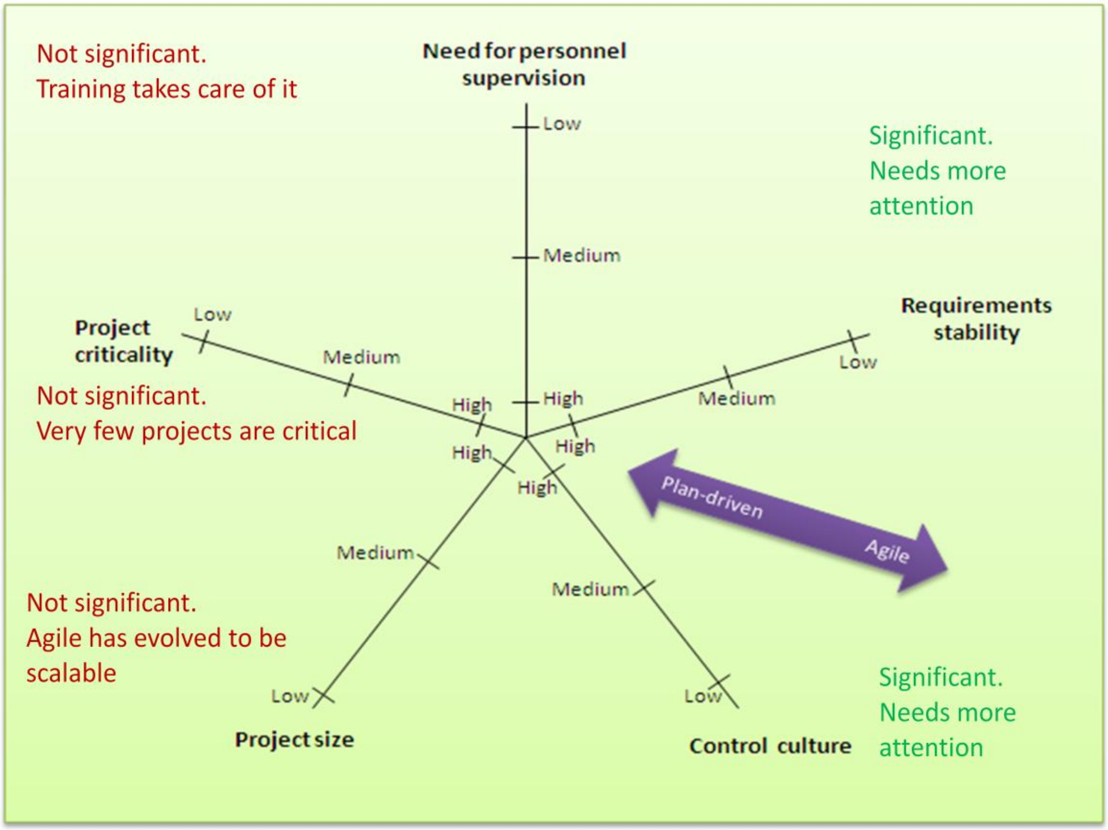

FIGURE 11: AREAS FOR FUTURE RESEARCH

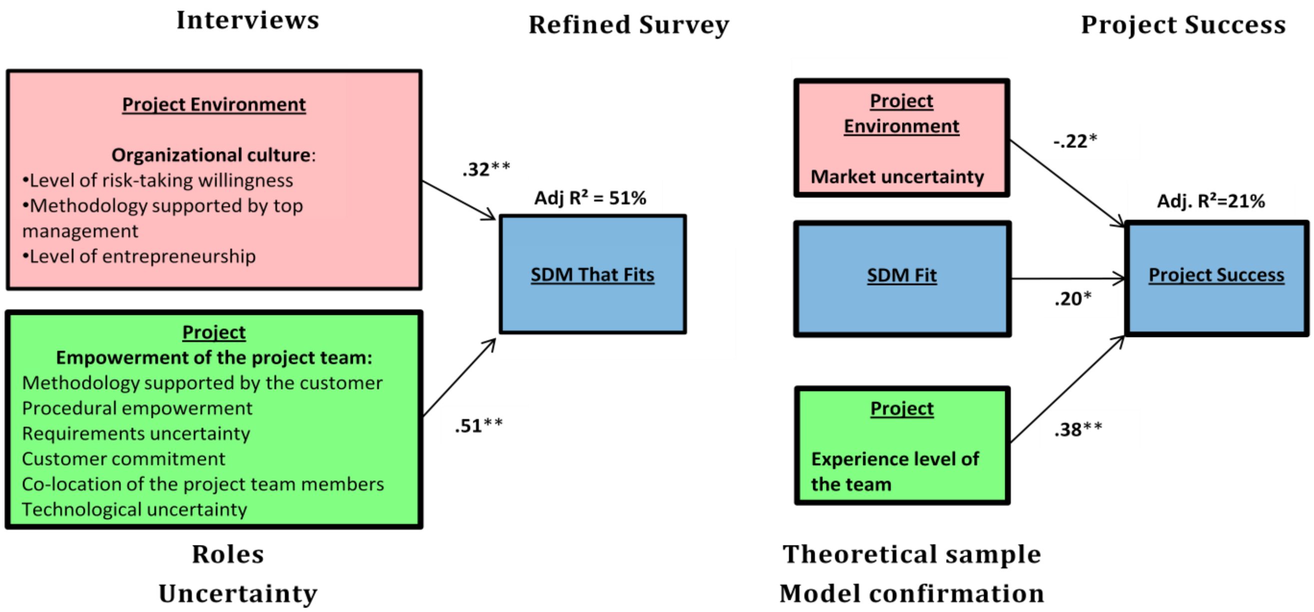

Table 1: Traditional and Agile Software Perspectives on SDM

Issue	Traditional Approach	Agile Approach
Development life cycle	Linear or incremental	Iterative or Adaptive
Style of development	Anticipatory	Adaptive
Requirements	Clearly defined and documented	Emergent – Discovered during the project
Architecture	Heavyweight architecture for current and future requirements	YAGNI precept ("You aren't going to need it")
Management	Controlling	Facilitating
Documentation	Heavy / detailed	Light (replaced by face to face communication)
	Explicit knowledge	Tacit knowledge
Focus	Process	People
Goal	Predictability and optimization	Exploration or adaptation
Change	Tends to be change averse	Embraces change
Team members	Distributed teams of specialists	Co-location of generalist senior technical staff
Team organization	Pre-structured teams	Self-organizing teams
Client involvement	Low involvement	Client onsite and considered as a team member
	Passive	Active/proactive
Organization culture	Command and control	Leadership and collaboration
Market	Mature/Main Street market	Dynamic/Early market
Product features	All included	Most important first
Testing	End of development cycle	Iterative and/or drives development process
Measure of success	Conformance to plan	Business value delivered

TABLE 2: COMPREHENSIVE SUMMARY OF CONTINGENCY FACTORS IDENTIFIED IN THE SDM FIT LITERATURE

Factor	Literature	Category
Co-location of the project team members	Cockburn (2000); Highsmith (2010); Koch (2005); Pixton et al. (2009); Wysocki (2009)	P
Compliance and governance factors	Highsmith (2010)	PE
Culture of the project team / Procedural empowerment	Boehm and Turner (2003); Highsmith (2010); Koch (2005); Misra et al. (2009); Strode, Huff, and Tretiakov (2009)	P
Customer commitment, collaboration and involvement	Ceschi, Sillitti, Succi, and De Panfilis (2005); Chow and Cao (2008); Koch (2005); Misra et al. (2009); Wysocki (2009)	P
Market uncertainty	Highsmith (2010); Pixton et al. (2009); Wysocki (2009)	PE
National culture	Misra et al. (2009)	PE
Nature of the contract	Koch (2005)	PE
Personnel skills and team maturity	Boehm and Turner (2003); Chow and Cao (2008); Koch (2005); Misra et al. (2009); Pixton et al. (2009); Ratbe et al. (2000); Wysocki (2009)	P
Project cost	Charvat (2003); Ratbe et al. (2000); Wysocki (2009)	P
Project criticality	Boehm and Turner (2003); Charvat (2003); Cockburn (2000, 2007); Highsmith (2010); Koch (2005); Pixton et al. (2009)	P
Project duration	Highsmith (2010); Pixton et al. (2009); Ratbe et al. (2000); Wysocki (2009)	P
Project size (man hours)	Burns and Dennis (1985)	P
Requirements uncertainty / Requirements stability	Boehm and Turner (2003); Burns and Dennis (1985); Highsmith (2010); Koch (2005); Pixton et al. (2009); Ratbe et al. (2000); Shenhar (2001); Wysocki (2009)	P

Factor	Literature	Category
Proportion of the organization affected	Ratbe et al. (2000); Wysocki (2009)	P
Team Size	Boehm and Turner (2003); Charvat (2003); Cockburn (2000, 2007); Highsmith (2010); Koch (2005); Pixton et al. (2009)	P
Technological uncertainty	Charvat (2003); Ratbe et al. (2000); Wysocki (2009)	P
Top management support for one approach	Ratbe et al. (2000)	PE
Training	Charvat (2003); Livermore (2008); Misra et al. (2009);	PE
Urgency	Highsmith (2000); Ratbe et al. (2000)	P

TABLE 3: THREE COMMUNITIES OF SDM PRACTICE

Communities of practice / Characteristics	PRINCE2 (Prescriptive)	PMI (PMBOK guide) (Descriptive)	Agile (Appreciative/Value-driven)
Values/Principles	Seven principles defined in the PRINCE2 manual	Processes should be structured	Defined by the Agile Manifesto
Main documents	*Managing Successful Projects with PRINCE2* (2009) *Directing Successful Projects with PRINCE2* (2009)	*A Guide to the Project Management Body of Knowledge (Pmbok Guide)* 4th edition (2008)	*Agile manifesto* (2001) *Declaration of Interdependence* (2005) *Personal statements of signatories*
Selected activities / certifications	PRINCE2 accreditation by passing two exams: Foundation and Practitioner Experience required: none	PMP (Project Management Professional) certification Experience required: 3 to 5 years of project management experience	'The position of Agile Alliance remains firmly that employers should not require certification of employees and that skill needs to be acquired by practice on agile projects not by training alone.'
Size of the community	250,000+	'more than half a million members and credential holders in 185 countries'	6,000+ signatories Number of practitioners is unknown

TABLE 4: SAMPLE SURVEY

DEM1: Experience of the respondent	N=106
Less than 1 year	0
1 to 2 years	4
2 to 5 years	9
5 to 10 years	23
more than 10 years	70

DEM3: Industry	N=106
Finance/Insurance	18
Manufacturing	9
Education	7
Pharmaceutical/Healthcare	6
Computer related	7
Construction/Utilities/Engineering	4
Marketing/Retail	4
Government	11
IT Services/Vendors	13
Transportation	3
Real Estate/Legal Services	7
Aerospace	4
Media/Publishing	5
Other (includes Mining, Research, Telecommunication, Energy & Non-profit)	8

DEM2: Organization size (Number of employees)	N=106
1 to 10	7
11 to 50	19
51 to 100	10
101 to 500	21
501 to 1,000	5
1,001 to 5,000	19
More than 5,000	25

DEM4: Position of the	N=106
respondent	29
Traditional Project Manager	17
Agile Project Manager	12
Traditional Team Leader	9
Agile Team Leader	21
Team member:	4
Developer/tester	14
Architect	
Other (includes delivery, development or testing manager and CTO)	

PE6: Project Management Methodology	N=106
PRINCE2	10

P8.1: Project cost (USD)	N=57	PMI (PMBOK)	15
Less than 100,000	8	Agile Project Management	56
100,000 to 1M	18	None	8
1M to 10M	21	Don’t Know	8
10M to 100M	7	Other (includes mainly in-house methodology)	9
More than 100M	3		

TABLE 5: SUMMARIZED DESCRIPTIVE STATISTICS FOR THE INDEPENDENT VARIABLES

Variable (From 1- very low to 5- very high, except otherwise stated)	N	Mean	Standard Deviation	Minimum	Maximum
PROJECT ENVIRONMENT					
PE1: Methodology supported by top management *(from 1-plan-driven to 5- agile)*	104	2.62	1.33	1	5
PE2: Level of entrepreneurship	106	3.27	1.26	1	5
PE3: Level of risk-taking willingness	105	3.46	1.14	1	5
PE4: Market uncertainty	106	3.32	1.31	1	5
PE5: Power distance*	106	2.34	0.52	1.57	4.46
PROJECT					
P1: Project criticality*	106	2.75	1.07	1	5
P2: Experience level of the team	106	3.62	1.28	1	5
P3: Technological uncertainty	106	2.28	1.14	1	5
P4: Requirements uncertainty	106	3.45	1.24	1	5
P5: Procedural Empowerment	106	2.48	1.03	1	5
P6: Customer commitment	106	3.45	1.20	1	5
P7: Methodology supported by the customer *(from 1-plan-driven to 5- agile)*	103	2.89	1.15	1	5
P8: Project size*	100	2.66	1.04	1	5
P9: Co-location of the project team members	106	3.33	1.46	1	5

** These scales were reversed for data analysis*

TABLE 6: SUMMARIZED DESCRIPTIVE STATISTICS FOR THE DEPENDENT VARIABLES

Variable	N	Mean	Standard Deviation	Minimum	Maximum
SOFTWARE DEVELOPMENT METHODOLOGY (1- plan-driven, 5- agile)					
SDM1.1: Individuals over Processes	106	3.31	1.13	1	5
SDM1.2: Working code over documentation	106	3.58	1.19	1	5
SDM1.3: Collaboration over contract	106	3.42	1.26	1	5
SDM1.4: Change over plan	106	3.40	1.28	1	5
SDM2: Development life cycle	106	3.75	1.60	1	5
PROJECT SUCCESS (1- unsuccessful, 5- successful)					
PS1.1: Time	105	3.36	1.20	1	5
PS1.2: Budget	99	3.34	1.22	1	5
PS1.3: Functionality	105	4.13	1.02	1	5
PS1.4: Quality	106	4.26	0.89	1	5
PS2.1: Addresses a need	105	4.37	0.71	2	5
PS2.2: Product is used	103	4.50	0.74	1	5
PS2.3: Customer is satisfied	103	4.17	0.87	2	5
PS3.1: Team is satisfied	106	3.73	1.06	1	5
PS3.2: Team would work the same way again	102	3.75	1.24	1	5

Table 7: Test of Reliability

Variable	Number of items	Cronbach's alpha
Project Success (PS1.1 to PS3.2)	9	.91
Software Development Methodology (SDM1.1 to SDM2)	5	.88
Project Size (P8.1 and P8.2)	2	.87

Table 8: Factor Analysis of the Project Environment Variables

Variables \ Factors	PE_FAC1 Organizational culture *(from conservative to entrepreneurial)*	PE_FAC2 Market uncertainty	PE_FAC3 Low power distance
PE1: Methodology supported by top management *(from plan-driven to agile)*	**.75**	.25	.05
PE2: Level of entrepreneurship	**.75**	-.18	-.10
PE3: Level of risk-taking willingness	**.80**	.01	.22
PE4: Market uncertainty	-.03	**.95**	-.23
PE5: Power distance*	-.16	.20	**.95**

** This scale was reversed for data analysis.*

TABLE 9: FACTOR ANALYSIS OF THE PROJECT VARIABLES

Variables \ Factors	**P_FAC1** Empowerment of the project team	**P_FAC2** Low project complexity	**P_FAC3** Experience level of the project team
P1: Project criticality*	.20	**.79**	.06
P2: Experience level of the team	.07	-.23	**.70**
P3: Technological uncertainty	**.46**	-.35	-.40
P4: Requirements uncertainty	**.58**	-.05	-.40
P5: Procedural Empowerment	**.77**	-.05	.02
P6: Customer commitment	**.56**	.02	.52
P7: Methodology supported by the customer *(from plan-driven to agile)*	**.77**	.02	.09
P8: Project size*	.14	**.75**	-.18
P9: Co-location of the project team members	**.48**	.12	.01

** These scales were reversed for data analysis*

TABLE 10: FACTOR ANALYSIS OF THE SDM VARIABLES

Variables \ Factors	**SDM_FAC1** Agility
SDM1.1: Individuals over processes	.78
SDM1.2: Working code over documentation	.81
SDM1.3: Collaboration over contract	.89
SDM1.4: Change over plan	.89
SDM2: Development life cycle	.76

TABLE 11: FACTOR ANALYSIS OF THE PROJECT SUCCESS VARIABLES

Factors / **Variables**	**PS_FAC1** Project Success
PS1.1: Time	.70
PS1.2: Budget	.75
PS1.3: Functionality	.82
PS1.4: Quality	.89
PS2.1: Address a need	.80
PS2.2: Product is used	.82
PS2.3: Customer is satisfied	.85
PS3.1: Team satisfaction	.76
PS3.2: Team would work the same way	.60

TABLE 12: CORRELATIONS OF THE INDEPENDENT FACTORS WITH SDM THAT FITS (SDM FIT RESEARCH MODEL)

Variables	Correlation coefficients	Significance (1-tailed)
PE_FAC1: Organizational culture *(from conservative to entrepreneurial)*	.51**	.00
PE_FAC2: Market uncertainty	.24	.06
PE_FAC3: Low power distance	.03	.42
P_FAC1: Empowerment of the project team	.80**	.00
P_FAC2: Low project complexity	.12	.22
P_FAC3: Experience level of the team	.12	.22

***. Correlation is significant at the .01 level (1-tailed).*

TABLE 13: REGRESSION COEFFICIENTS (SDM FIT RESEARCH MODEL)

	Unstandardized Coefficients		*Standardized Coefficients*		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
Constant	.00	.07		.02	.98
P_FAC1: empowerment of the project team	.52	.08	.51	6.11	.00
PE_FAC1: organizational culture	.31	.08	.32	3.78	.00

TABLE 14: REGRESSION MODEL SUMMARY (SDM FIT RESEARCH MODEL)

R	R Square	Adjusted R Square	Std. Error of the Estimate
.72	.51	.50	.67

Predictors: Constant, P_FAC1. Dependent Variable: SDM_FAC1

TABLE 15: CORRELATIONS OF THE INDEPENDENT FACTORS WITH PROJECT SUCCESS (PROJECT SUCCESS RESEARCH MODEL)

	Correlation coefficients	Significance (2-tailed)
PE_FAC1: Organizational culture *(from conservative to entrepreneurial)*	.09	.38
PE_FAC2: Market uncertainty	-.22*	.02
PE_FAC3: Low Power distance	.14	.19
FIT: SDM Fit	.20*	.04
P_FAC1: Empowerment of the project team	-.04	.73
P_FAC2: Low complexity	.12	.27
P_FAC3: Experience level of the team	.38**	.00

**. Correlation is significant at the .05 level (2-tailed). **. Correlation is significant at the .01 level (2-tailed).*

TABLE 16: REGRESSION COEFFICIENTS (PROJECT SUCCESS RESEARCH MODEL)

	Unstandardized Coefficients		***Standardized Coefficients***		
	B	**Std. Error**	**Beta**	**t**	**Sig.**
Constant	.24	.17		1.44	.15
P_FAC3: Experience level of the team	.39	.10	.38	3.93	.00
PE_FAC2: Market uncertainty	-.22	-.96	-.22	-2.25	.03
FIT: SDM fit	.30	-.14	.20	-2.14	.04

TABLE 17: REGRESSION MODEL SUMMARY (PROJECT SUCCESS RESEARCH MODEL)

R	R Square	Adjusted R Square	Std. Error of the Estimate
.49	.24	.21	.90

Predictors: Constant, P_FAC3, PE_FAC2, and FIT. Dependent Variable: PS_FAC1