Association for Information Systems
AIS Electronic Library (AISeL)

PACIS 2018 Proceedings

Pacific Asia Conference on Information Systems (PACIS)

6-26-2018

A Contingency Theory Motivated Framework to Select Information System Development Methods

Altti Lagstedt
Haaga-Helia University of Applied Sciences, Helsinki and Turku School of Economics at the University of Turku, aaelag@utu.fi

Tomi Dahlberg
Turku School of Economics at the University of Turku, tomi.dahlberg@utu.fi

A Contingency Theory Motivated Framework to Select Information System Development Methods

Completed Research Paper

Lagstedt, Altti
Turku School of Economics at the University of Turku,
Haaga-Helia University of Applied Sciences
Helsinki, Finland
altti.lagstedt@haaga-helia.fi

Dahlberg, Tomi
Turku School of Economics at the University of Turku
Turku, Finland
tomi.dahlberg@utu.fi

Abstract

Several change-driven (agile) information systems development (ISD) methods have been launched during the recent years. In addition to agile ISD methods it is still possible to succeed also with plan-driven ISD methods. To facilitate ISD method selections that maximize the probability of ISD project success we crafted and evaluated an ISD method selection framework based on the idea of matching the properties of ISD methods and the characteristics of the business contexts where ISD methods are used. We conducted a systematic literature search to evaluate whether the proposed framework is also able to capture the findings of prior ISD method selection research and to guide future empirical research. From over 1000 potential articles we identified 42 articles that address ISD method selection. We discovered that the proposed framework was able to explain the findings of prior research.

Keywords: Information Systems Development Method Selection

Introduction

During the last 60+ years an astonishing number of information system development (ISD) methods have been published. The removal of known limitations of previous method(s) is a typical motive for the launch of a new method (e.g. Boehm 1988; Royce 1970; Vidgen and Wang 2009). Prior research has classified ISD methods in a myriad ways (Mahmood 1987). In this study, we follow the classification based on the control concept of IS development. Plan-driven (traditional, waterfall) and change-driven (agile) ISD methods are the two main categories of this classification. Both have over 60-year history (Benington 1983; Larman and Basili 2003). We regard this classification theoretically sound and descriptive for ISD work both as an academic concept and as an ISD practice descriptor.

Given the history one might expect that ISD projects deliver all the time better results. That has not happened. For example, Standish Group has disclosed the success rate of ISD projects annually since mid-1980s. They have reported that the success rate of IS projects has improved only by 5-10 % in 35 years, from the 20-25 % level during the 1980s and 1990s to the 30-35 % level during the 2010s (Hastie and Wojewoda 2015; MacManus and Wood-Harper 2007; Verner et al. 2008). Plan-driven methods dominated ISD work during the 1970s, 1980s and 1990s, and still have a strong position in ISD method development and standardization, for example, among the roughly 150 international standards developed under the ISO/IEC JTC1 SC7. During the recent years, the popularity of agile ISD methods, such as SCRUM, XP and DEVOPS, has increased. Agile ISD methods are marketed as the solution to the limitations of plan-driven methods (Theocharis et al. 2015), and this claim receives some support

from Standish Group's Chaos reports. For example, in 2015, the success rate of change-driven projects was 39% whereas only 11% of plan-driven projects succeeded (Hastie and Wojewoda 2015). Standish Group claims that the use of change-driven methods is the main reason for the recent 5-10 % increase in IS project success rate (Hastie and Wojewoda 2015).

Yet, over 60 % of change-driven ISD projects were troubled or failed entirely in 2015 (Hastie and Wojewoda 2015). It seems possible to succeed, deliver an IS after troubles, or fail entirely with any ISD method. Thus there appears to be no ISD method that "fits to all needs" (Brooks 1986; Cusumano et al. 2009; Hall and Rapanotti 2015). Dahlberg and Lagstedt (2018) investigated two ISD failure projects, one executed with a plan-driven and the other with a change-driven ISD method. Obviously most failure reasons of these projects differed for this reason. The two projects, however, had one common failure reason. The characteristics of the chosen ISD method matched poorly with the characteristics of business (process) context for which the IS was developed (Dahlberg and Lagstedt 2018). The evident conclusion is that better guidelines for ISD method selection are needed to improve the success rate of ISD projects (Cusumano et al. 2009; Gupta and Dwivedi 2015; Howell et al. 2010; MacCormack and Verganti 2003; Mitchell and Seaman 2009; Vessey and Glass 1998).

Against this backdrop, we were surprised that only 42 articles addressed ISD method selection (criteria) between alternative ISD methods among the over 1000 articles collected with the systematic literature search method of (Kitchenham 2004; Webster and Watson 2002). Our surprise grew when we discovered that the characteristics of the organizational / business development contexts were even less considered as the criteria of ISD method selection. The purpose of this article is to fill this research gap by crafting and evaluating an ISD selection framework, in which the characteristics of the organizational / business development contexts are matched with ISD method characteristics.

We do not know, why organizational / business context characteristics appear to have received little attention in prior ISD method selection research. The strong influence of the plan-driven waterfall (Royce 1970) and stage-gate based methods is one possible reason (Avison and Fitzgerald 2006). In these ISD methods, business requirements are specified and agreed prior to the start of technical ISD work, an ISD project is re-planned should business requirements change, and the results of previous project phase(s) are accepted at a decision gate prior to the start of the next phase. Contrary to this, change-driven ISD methods build on continuous dialogue between IS and business professionals. Business requirements specification and continuous dialogue are ISD methods' means to capture business needs and contexts. This still differs from our research objective, which is to provide guidelines to select ISD methods that fit to the characteristics of organizational / business contexts and business development (methods). Our idea is to address the organizational / business context characteristics as contingent factors in order to guide ISD method selection (Ahimbisibwe et al. 2015). Contingency theory (e.g. Burns and Stalker 1994) states that contingent factors are such environmental factors of an organization - for example, an ISD project - which influence strongly the organization but cannot be changed or controlled by the organization. Contingency theory offers two empirically thoroughly tested propositions. An organization needs to adapt to contingent factors, and the organization should develop alternative strategies to respond to identified contingent factors (Burrell and Morgan 1979; Howell et al. 2010). The selection of alternative ISD methods to different business contexts is an example of alternative strategies. Our proposed ISD selection framework is contingency theory motivated since it builds on these two propositions of the contingency theory.

The generic research problem of the present research is: how to take the organizational/business development context into account in the selection of ISD methods so that the probabilities of ISD project success and successful ISD method usage is increased? Our objective is to answer that problem by crafting and evaluating an ISD selection framework that matches the characteristics of business contexts and ISD methods. We also formulated two more specific research questions:

RQ1: *Is the proposed framework able to capture the results of prior ISD method selection research?*

RQ2: *What other criteria could be considered and how they should be taken into account in the proposed framework?*

To answer these research questions we present the framework and its theoretical background in the next section. The third section explicates the methodology of the systematic literature research conducted to probe and evaluate the proposed framework. In section four, the results of the systematic literature review are disclosed as the means to validate the framework and to answer our research questions. The article ends with a discussion and conclusions section. The proposed framework with its testing and validation against the results of prior research are our main contributions to research.

The Proposed Contingency Theory Motivated Framework

We regard ISD an integral part of organizational development. The rationale of ISD is that an information system is developed to support and enable the execution of an organization's strategy and business within a specific business (processes) context. The definitions of IS reflect this rationale. For example, Avison and Fitzgerald (2006) specify: "an information system in an organization provides processes and information useful to its members and clients". Lyytinen and Hirschheim (1988) proposed that in addition to being mechanisms of sociological and managerial control ISs are also means of discourse. From their perspective IS development is a way for people to make sense of their environment. Consequently, a (successfully developed) IS is the true representation of the organizational reality for its users within a specific use context. When an IS is developed, that always impacts the organizational / business contexts of the development, that is, supports and/or enables business development. (R)evolving changes and uncertainties related to changes characterize organizational / business development (Nutt 2010; Thompson 2003). Changes with their uncertainties may be related to the execution of business (processes), the outcomes of changed business execution, or both. From the perspective of the approach proposed here, we conclude that it is necessary to describe how plan-driven and change-driven ISD methods approach these two types of uncertainties, and how organizational development addresses the same issues. We further propose that on the basis of such understanding, it is possible to craft an ISD method selection framework with the underlying principle of matching the characteristics of ISD methods and organizational / business contexts.

Characteristics of IS Development

The change-driven "code and fix model" was probably the first "ISD method" (Boehm 1988). Please, note that we use systematically the ISD method term although it was launched several decades after the code and fix model term. The need for more formal coding / ISD practices was advocated strongly early on. Bennington presented one of the first plan-driven ISD methods in 1956 (Benington 1983). As new plan-driven ISD methods were launched, such as the notorious waterfall model in 1970 (Royce 1970), they often borrowed, and still borrow, concepts and practices from the plan-driven project management and systems engineering realm (McCracken and Jackson 1982). Plan-driven ISD development builds on the premise that the business requirements of an IS to be developed as well as the tasks, resources, responsibilities and the timeline of an ISD project can - and need to - be planned in detail before the ISD work and project execution start. ISD will start immediately after the planning phase is completed and accepted. Critique claims that plan-driven ISD development results too often in mechanistic and inflexible development activities, and in failures (McCracken and Jackson 1982; Sommerville 1996). We conclude that plan-driven ISD methods appear to suit to stable business contexts with high certainty regarding both the execution of the business (processes) and business outcomes. The early specification and freezing of business requirements and IS functionalities match to these contexts. Correspondingly, if business (process) execution and its expected outcomes change continuously and/or are highly immature, plan-driven ISD methods should not be selected.

First change-driven ISD methods emerged in the early 1960s. Larman and Basili (2003) describe NASA's Mercury project, where iterative and incremental ISD methods were used. During the 1980s Boehm's iterative prototyping (Boehm et al. 1984) and spiral models (Boehm 1988) received a lot of attention. The roots of agile methods, for example SCRUM, XP and DEVOPS, are in iterative and incremental ISD methods. The underlying assumption is that it is impossible to specify business requirements and project execution in detail prior to the actual development due to business context uncertainties and complexities. ISD work and projects should be executed in small iterative steps (sprints) guided by a generic master plan and step specific prioritized user stories. An IS is thus built

piece by piece in small increments. Feedback is continuously collected from ISD project stakeholders and by evaluating the results of the previous step(s) (Boehm 1988; Boehm et al. 1984). Change-driven ISD development typically leads to "snake-trail" (zigzag) type development paths, where each step could be seen as a small project. Continuous adaptations to business execution and outcome uncertainties are inherent in change-driven ISD methods. We conclude that these methods suit well to changing and uncertain business contexts. Correspondingly, change-driven ISD methods may lead to inefficiencies in stable and mature business contexts with incremental business/IS development needs.

Entrepreneurial Opportunities

From organizational and business perspective the development of a new IS offers entrepreneurial opportunities, in other words new business opportunities. Alvarez and Barney (2007) classified entrepreneurial opportunities into opportunity discovery and opportunity creation. According to them opportunity discovery means the possibility to evaluate business opportunity costs, profits, risks, necessary activities and other key development issues in advance. We conclude that plan-driven ISD methods suit well to opportunity discovery type contexts. Experimenting and learning by doing characterize opportunity creation. Costs, profits, risks and other business opportunity specifics are created and evaluated during and/or after development work. Our conclusion is that change-driven ISD methods suit well to opportunity creation type contexts.

Contingent Factors of Organizational Development

The environments of organizations change all the time. Contingency theory was developed so that an organization is able to respond to the uncertainties of its environment. Contingent factors have two key features. They influence the organization significantly and the organization is to a large extent unable to influence or control the outcomes of contingent factors. According to contingency theory, different organizational principles or strategies are appropriate responses to different environmental circumstances (Burrell and Morgan 1979). If IS development is considered as an inherent part of organizational development, as we do, then the contingency theory approach is a theoretically justified choice to deal with the uncertainties of organizational business development contexts.

		Preferences regarding possible outcomes	
		Certainty	Uncertainty
Beliefs about cause / effect relations	Certain	**computational strategy**	**compromise strategy**
	Uncertain	**judgmental strategy**	**inspirational strategy**

Figure 1. Thompson's (1967) decision making strategies (Thompson 2003)

(Burns and Stalker 1994) discovered that in stable and predictable environments mechanical (=plan-driven) structures are efficient whereas organic (=change-driven) structures fit better to uncertain and changing environments. Thompson (2003) crafted his two-dimensional strategy model shown in Figure 1. The vertical dimension of the model depicts certainty-uncertainty in relation to the cause-effect relationships of the organizational development, and the horizontal dimension the certainty-uncertainty of development outcomes. The model identifies four distinct strategies: 1) Computational strategy, where activities and outcomes are possible to "count" (=specify) in advance. 2) Judgmental strategy, where outcomes are possible to specify in advance, whereas activities need "judgment" between alternatives. 3) Compromise strategy, where activities are possible to specify in advance but outcomes need to be negotiated for a "compromise". 4) Inspirational strategy, where "inspiration" needs to be used to find a way forward (Thompson 2003, pp. 132–143). In our opinion, Thompson's model describes a useful way to match the characteristics of ISD methods and their business development contexts. Computational strategy resembles plan-driven methods, inspirational strategy change-driven methods. The two other alternatives are in between, and either plan-driven or change-driven methods could be used depending on the amount on certainty-uncertainty (see also Nutt 2010).

Business Processes Maturity

A business process maturity assessment is a useful tool to guide organizational development with the related ISD. The origins of maturity models are in product quality management. Paulk et al. (1993) introduced the CMM (capability maturity model) model for IS process quality assessments in 1993. The CMM model reflects and builds on the ideas of Shewart, Deming, Juran and Crosby. The CMM model aims to assess the maturity of IS processes only, whereas the CMMI (CMM Integrated) model introduced later, is a generalized model for the assessment of any process (Harmon 2010). The five levels of maturity - initial, repeatable, defined, managed, optimized – are widely known and applied in various business process maturity models (Röglinger et al. 2012). Maturity level assessments capture both process execution maturity and process metrics (=outcome) maturity. Business process and process metrics maturity are low when the business process and/or its metrics change all the time, bear significant uncertainties, and/or are poorly understood / defined. We conclude that change-driven ISD methods suit to the development of these business process contexts. Correspondingly, high maturity level processes are developed systematically on the basis of established metrics that are comparable to those of other organizations. We conclude that plan-driven ISD methods suit well to the development of such business process contexts (unless the purpose is to execute a radical change).

The Contingency Theory Motivated Framework for ISD Method Selection

Figure 2 shows our proposed contingency theory motivated framework for ISD method selection. The framework is crafted by combining the two theoretical dimensions and the concepts discussed above. The vertical dimension of the framework depicts and matches the certainties (=characteristics) of current and future business development and IS development, that is, how the characteristics of ISD match with those of the related business / organizational development context. The horizontal dimension does the same in order to match the certainties (=characteristics) of business development outcomes and ISD. For theoretical clarity we classified both dimensions of the framework only into two classes. In reality, both dimensions may have multiple values between the two ends of the scales.

High business execution certainty (and high objectives predefinition certainty on how ISD supports business development)	Leans to plan-driven ISDMs Leans to change- driven ISDMs	**Plan-driven ISDMs should be selected and used**
Low business execution certainty (and low objectives predefinition certainty on how ISD supports business development)	**Change-driven ISDMs should be selected and used**	Leans to plan- driven ISDMs Leans to change-driven ISDMs
	Low business development outcomes certainty (and low certainty on how ISD supports outcomes achievement)	**High business development outcomes certainty** (and high certainty on how ISD supports outcomes achievement)

Figure 2. The proposed contingency theory based framework for ISDM selection

The framework describes four distinct business contexts and proposes how the two main categories of ISD methods fit to each context. Contexts, where both certainties are either low or high, provide clear guidelines for ISD method selection. The other two are borderline contexts, where either type of ISD methods could be used. High uncertainties of business execution cause-effects, low business maturity and business creation together with high uncertainties of business development outcomes, e.g. balanced scorecard metrics, describe business development contexts, where change-driven ISD methods should be selected and used to support and enable business development. The characteristics of change-driven

ISD methods are similar as the characteristics of these business contexts. So-called greenfield development of a new business is a descriptive example. However, should the uncertainties of a business context be extreme, then it could become impossible to make any meaningful ISD method decisions (Thompson 2003, p. 135). The brake down of the development situation into constituent parts and problem structuring are recommended for these situations (Howell et al. 2010).

The opposite corner of the framework proposes that plan-driven ISD methods should be selected and used. High certainty of business execution (Thompson 2003), high business maturity (Röglinger et al. 2012) and business discovery (Alvarez and Barney 2007) describe these business development contexts, to which the characteristics of plan-driven ISDMs fit well. Further development of a well-functioning business and its processes with no need for disruptive changes is a descriptive example.

Business process re-engineering with challenging well-defined objectives and high uncertainties regarding how business processes could be changed and developed to achieve such objectives is a descriptive example of the framework's right-low corner business context. New business opportunity seeking for a well-functioning business, for example, by enlarging the business into a new market, is a descriptive example of the framework's left-high corner business context. In these two contexts the selection of change-driven ISD methods is probably always a safe bet. However, if the uncertainty is low or can be reduced, then plan-driven ISD methods probably become preferable. It might also be possible to start with one type ISD method and then switch to another ISD method as the prototyping method suggested already in the 1980s (Boehm et al. 1984). A lot of empirical research would be needed to define clearer ISD method selection guidelines.

Systematic Literature Review

We used the systematic literature review method of Kitchenham (2004) to select and analyze prior research. Our objectives were to verify the existence of the proposed research gap, to summarize existing knowledge on ISD method selection, and to analyze whether or not the proposed framework captures the findings of previous ISD method selection research. Based on the ideas of MacDonell et al. (2010) we deemed the systematic literature review a robust and sufficient research method to answer our research questions. Literature review results will also be used as the theoretical background and basis in our future research activities.

Research Protocol: Preliminary Search and Search String Formulation

We followed the advice of Kithchenham (2004) and formulated a written research protocol to guide the literature review. During conceptualization, we read selected seminal textbooks (e.g. Avison and Fitzgerald 2006; Boehm and Turner 2004) and scanned top information systems science (ISS) and computer science (CS) journals. Next we conducted a preliminary search in Proquest and Google Scholar databases to estimate publication volumes, the types of publications, and to design useful search term strings and limitations. ISS and CS are interdisciplinary and thus research findings on ISD method selection are found from the outlets of various academic disciplines. We decided to search literature from all disciplines including conference proceedings and so called "grey literature" as (Kitchenham 2004; Webster and Watson 2002) advice instead of limiting the search to the top journals only. We used three types of databases: ISS and CS specific (ACM Digital Library, IEEE / IEEE Xplore Digital Library), multidisciplinary (ProQuest, ScienceDirect and Academic Search Premier EBSCO), and reference databases (Web of Science, Scopus and Google Scholar).

The preliminary search indicated that only a handful of articles address ISD method selection. The unexpectedly low number of ISD method selection articles confirmed that the research gap discussed in the Introduction section does, indeed, exist. We also discovered several poorly designed, conducted and documented studies. For these two reasons we decided to include into the final search all peer-reviewed articles regardless of their quality or the scientific impact of a conference or a journal.

Literature search was then conducted database by database since databases had different search practices, for example, what search operators and operator combinations were allowed. Instead of one long search string we had to formulate four search strings to deal with the limitations of the databases.

Search strings used are shown in Table 1. We conducted 32 (8 databases, 4 search strings) individual searches. This resulted in 1419 initial and approximately 1000 unique articles after duplicate removal. We conducted literature searches from abstracts with the NEAR operator. If the NEAR operator produced less than 20 publications or was unavailable in a database, then we executed a wider search with the AND operator. We conducted 32 (4 search strings in 8 databases) individual searches. Google Scholar does not support searches from abstracts only, truncations are not allowed and the search field is too short for long search strings. For these reasons those searches were limited to titles, and shorter search strings were used. We deemed the resulting wider search acceptable since Google Scholar was used as a complementary database. Patents and citations were excluded. We did not set any time limitations since the history of ISD methods goes back 60+ years (Larman and Basili 2003). Webster and Watson (2002) recommended the use backward and forward searches to supplement search results. Consequently, we performed backward and forward searches by reviewing the citations of articles that passed the three first phases of filtering.

Table 1. Search Strings Used

	Search strings (with the NEAR operator)
First search	*(("ISD" OR "system* development" OR "application development" OR "software engineering" OR "system* engineering" OR "application engineering" OR "software production" OR "system* production" OR "application production" OR "software project*" OR "system* project*" OR "application project*") NEAR (method*)) NEAR (select* OR choos* OR choice))*
Second search	*(("ISD process" OR "ISD life cycle" OR "system* development process" OR "system* development life cycle") NEAR (select* OR choos* OR choice))*
Third search	*("Software Process Model*" OR "Software Life Cycle*" OR "software process paradigm") NEAR (select* OR choos* OR choice)*
Fourth search	*(("situational factor*" OR "contingency factor*" OR "contingency model*") NEAR (software OR "information system*")*
Limitations:	Title/abstract, conference papers, journal articles, language English, peer-reviewed

Filtering of the Discovered Publications

The literature search produced 1419 initial and approximately 1000 unique articles after duplicate removal. We filtered the unique articles in four phases. The first filtering was done on the basis of article title and the second by reading abstracts. During the third filtering, we skimmed (fast read) articles. In the final filtering, we read the remaining 33 articles. Twenty-nine additional articles were identified in backward and forward searches. This resulted in 9 additions. Thus 42 articles constitute the material from which the evaluative results of the literature review are drawn.

During the filtering a positive drop policy was applied. In each filtering phase, only those articles were dropped that were clearly out of scope. Unsure cases were moved to the next phase. We used the following inclusion criteria: 1) the article addresses ISD method selection; 2) is available at least in one of the selected scientific databases; 3) is peer-reviewed; 4) full text is available and 5) is in the English language. Correspondingly, the exclusion criteria were: 1) the article is out of scope (does not address ISD method selection. Excluded articles could, for example, investigate ISD method engineering or method tailoring but not ISD selection); 2) investigates only one ISD method category (for example compares various plan-driven methods only); 3) shows unsubstantiated subjectivism (for example the superiority of a particular method is presumed without evidence). We followed the advice of (Webster and Watson 2002) and formulated and grouped key concepts iteratively.

Results

The criteria of ISD method selection discovered in the 42 articles were initially classified into three categories: people, project and environment, see Table 2. After the classification of the discovered ISD

selection criteria, we evaluated whether of not our proposed framework shown in Figure 2 captures these ISD selection criteria. Tables 3, 4 and 5 show the results of this analysis. As the final literature analysis step, we compared our proposed ISD method selection framework to the ISD selection frameworks that we found in the 42 articles.

ISD Method Selection Criteria

In the reviewed 42 articles, the number of ISD method selection criteria varied from two criteria (Burns and Dennis 1985) to a sophisticated model with 8 classes, 40 criteria and 170 sub-criteria (Clarke and O'Connor 2012). We agree with Benediktsson et al. (2006) that highly detailed, that is, atomized ISD method selection models are difficult to use conceptually and also in practice. We classified the ISD method selection criteria of the reviewed articles into three categories: people, project and environment. The number of most often mentioned ISD method selection criteria were calculated to compose Table 2. The people, project and environment categories each have six subclasses, i.e. 18 selection factors. The high numbers of entries in each subclass indicate the explanatory power of this classification. Please, note that the applied classification of ISD selection criteria shows – as expected by RQ2 in the Introduction section - that other issues in addition to the characteristics of ISD methods and business development contexts have been investigated in prior research.

The allocations of most, but not all, ISD method selection subclasses into the three categories were self-explanatory. The 'size of the development team' was allocated into the People category instead of the Project category, since prior research has typically discussed how team size impacts the behavior of team members. The 'uncertainty of results' was allocated into the Environment category, whereas the 'complexity' and 'quality objectives' into the Project. In prior research, complexity refers to the complexity of the development (project), whereas the 'uncertainty of results' describes business environment related uncertainties. Please, note that the classification of Table 2 is inductive. The classification describes our best understanding about the nature of the ISD method selection criteria in the reviewed articles in a situation, where we were unable to find any established prior classification.

Table 2. ISD method selection criteria classes in prior research

People, # of articles		Project, # of articles		Environment, # of articles	
Developer acquirements,	30	Complexity,	32	Uncertainty of results,	34
Size of a development team,	15	Size of the system,	23	Criticality of the developed IS,	22
Communication,	15	Resources (time),	19	Uncertainty of current situation,	20
End-user acquirements,	15	Resources (money),	18	Stakeholder involvement,	15
End-user involvement,	12	Quality objectives,	15	Control practices,	12
Developer involvement,	10	Systems history,	7	Business satisfaction,	5

Does the Proposed Framework Cover The Findings of Prior Research?

After we had completed the classification shown in Table 2, we evaluated for each subclass does our proposed ISD method selection framework include that subclass or not. A positive answer means that the proposed framework covered the particular subclass and that the particular subclass supported the suggestion that the proposed framework is a useful description of ISD method selection. As expected, the proposed framework covered some criteria well, some indirectly, and a few not at all. It was a (pleasant) surprise to us that, in our opinion, none of subclasses argued against the proposed framework, which matches the characteristic of ISD method and business development contexts.

Table 3 shows those subclasses (criteria) of prior research that the proposed ISD method selection framework covered well according to the data analysis done by us. Table 4 lists subclasses (criteria) that were covered indirectly and Table 5 subclasses (criteria) that were not at all covered. System history and control practices describe events up to a current situation. Both subclasses impact future business execution and outcome uncertainties either directly (known, open) or indirectly (hidden, disguised). Therefore we have placed these two subclasses into both Table 3 and Table 4.

Table 3. Criteria well covered by the framework

Criterion	Description
End-user involvement	Prerequisites for a mature business processes, impacts positively business execution and outcome uncertainties
End-user acquirements	
Complexity	A key reason for business execution and outcome uncertainties
Uncertainty of results	Synonym with the uncertainty of outcomes
Business satisfaction	Related to opportunity discovery, process maturity and uncertainties
Uncertainty of current situation	Synonym with present business execution and outcome uncertainties
System history	Depicts business maturity, business execution and outcome uncertainties
Control practices	
Stakeholder involvement	Extension of end-user involvement and acquirements. See above

Table 4. Criteria indirectly covered by the framework

Criterion	Description
Developer acquirements	Skilled and capable developers should be selected or educated. If this is done it impacts business execution and outcome uncertainties positively
Developer involvement	
Size of the development team	A large team with skill differences may impact negatively business execution and outcome uncertainties
Quality objectives	Quality objectives and criticality could increase or decrease business execution and outcome uncertainties
Criticality of the developed IS	
System history	See Table 3. The impacts could be direct (Table 3), indirect (hidden, this Table) or both
Control practices	

Table 5. Criteria not covered by the framework

Criterion	Description
Communication	Communication is needed independent of whatever ISD method is selected. Communication practices, however, differ between ISD methods. High quality communication impact business execution and outcome uncertainties positively.
Size of the system	Typical success criteria of plan-driven ISD projects that do not suit to situations where ISD method selection is done between plan-driven and change-driven ISD methods.
Resources (money)	
Resources (time)	

Of the subclasses listed in Table 5 it might have been possible to place communication into Table 4. The amount and style of communication impact perceptions about business execution and outcome uncertainties. Still, we placed communication into Table 5 since ISD methods follow different communication practices. This makes communication ISD method specific. Finally, we compared the proposed ISD method selection framework to the frameworks and models of previous research.

Comparisons to the ISD Method Selection Models of Prior Research

When ISD projects are regarded as "organizations within organizations" and when ISD projects are deemed a part of business development, then it is clear that ISD projects cannot be executed in "vacuum". Rather the organizational / business context has to be taken into account in ISD method selection (and in ISD work). This approach does, however, not describe the ISD selection models of prior literature. They consider only or primarily ISD project characteristics as the selection criteria. Furthermore, the majority of the 42 reviewed articles discussed only a few ISD characteristics as the selection criteria of ISD method selection and did not present or advocate any ISD method selection model. A few articles proposed more or less rigid guidelines and/or models for ISD method selection.

The most typical approach was to suggest that ISD methods should be selected on the basis of ISD project complexity and uncertainty. Figure 3 is a descriptive example for this approach. In our opinion, such guidelines and models consider inadequately the characteristics of the organizational / business context. Business context characteristics are considered as if they are static or given (contingent-type) factors with no impact on ISD work. In our opinion, ISD project complexity and uncertainty based guidelines and models do not consider thoroughly the impact of the business development context on ISD methods selection and usage. In addition to the limitation on ISD work and ISD project characteristics only, the ISD project complexity and uncertainty approach has been criticized as conceptually problematic. For example, Mathiassen and Stage (1990) asked, are ISD project uncertainty and complexity independent or elements of the same factor. Howell et al. (2010) stated that, in general, complexity could be seen as one element of uncertainty. In summary, in our opinion, ISD method selection models that focus primarily or entirely on the complexity and uncertainty of ISD work are unable to provide sch guidance for ISD method selection that creates match with the characteristics of business development (and related business development methods).

Project Complexity			
	High	System Life Cycle	Mixed Method
	Low	Prototyping	Prototyping
		Low	High
		Project Uncertainty	

Figure 3. The ISD method selection model of Burns and Dennis (1985)

Howell et al. (2010) identified five environmental themes associated with the selection of development approach within generic project contexts. These themes are: complexity, uncertainty, team empowerment, criticality and urgency. Howell et al. (2010) argued that urgency and complexity are the two elements of uncertainty, and that criticality and team empowerment are the two elements of consequence (Howell et al. 2010). With this argumentation they reduced the number of development method selection criteria dimensions to two, namely uncertainty and consequence of a project (Howell et al. 2010). To us it appears that uncertainty resembles "beliefs about cause/effect relations" and that consequence resembles "preferences regarding possible outcomes", which are the two dimensions of the Thompson contingency theory model (Thompson 2003). Howell et al. (2010) also suggested that plan-driven approach is better in low uncertainty contexts, and that change-driven (agile) approach is preferable for contexts with high uncertainty. However, in their model only project specific factors are discussed. So, even though the underlying approach of Howell et al. (2010) framework is rather similar to our framework, the absence of organizational / business context factors is the substantial difference between the Howell et al. model and our framework.

Maybe the best known ISD selection model is Boehm's and Turner's (2004) five-dimensional Home Ground Polar Chart Model. Their model proposes that the selection between agile and plan-driven methods should be based on dynamism, culture, size, criticality and personnel. Their idea is that if IS requirements are fixed (dynamism), work needed is well organized (culture), number of personnel involved is high (over one hundred), the results of ISD are critical, and personnel involved are lowly skilled, then plan-driven methods should be used. At the other end of the scales, agile (change-driven) methods should be used. Their model, although being rather comprehensive, includes only (technical) IS/IT project characteristics and builds on the assumption that development teams are "fixed". This

might have been true in the internal ISD projects conducted prior to this millennium but seldom describes current outsourced ISD work, where a different ISD vendor could be selected for each ISD project. Moreover, in the model of Boehm and Turner (2004), the uncertainties of ISD development outcomes are measured with the dynamism of requirements, that is, changes/month. It is possible to use this metrics only after the start of an ISD project, when ISDM(s) have already been selected. References to the impacts of business development context characteristics are not included explicitly, whereas the other factors mentioned provide potential answers to the RQ2 outlined in the Introduction section. In future (empirical) studies, it could be possible to investigate would the combination of our framework and the Boehm and Turner model provide better results than either model alone.

Ahimbisibwe et al. (Ahimbisibwe et al. 2015) crafted a large "home ground polar chart" with 28 selection factors to guide ISD method selection. They picked the selection factors from literature and classified them into four categories: organizational, team, customer, and project. In practice, having to pay attention to 28 factors makes any IDS method selection model conceptually and operationally difficult, especially since some of the factors are conceptually inconsistent and overlapping. We regard this model (Ahimbisibwe et al. 2015) as an extended version of the Boehm and Turner (Boehm and Turner 2004) model. The discussion in the paragraph above could be repeated with one added remark. The Ahimbisibwe et al. (2015) model includes organizational culture as one of the 28 factors. They suggest that if mechanistic and bureaucratic structures characterize an organization then plan-driven ISD methods are preferable. Change-driven ISD methods are preferable for organic and flexible structure organizations. We recognize that organizational structure may resemble with business context maturity since high maturity typically requires rigid organizational structures. Investigating the impact of organizational structures offer another potential venue for future research.

Some other ISD method selection models have also been proposed. De Weger and Franken (1997) proposed a two-dimensional model, where the reductions of efficiency risk (and the neglecting of future situational risks) guides the selection towards plan-driven ISD methods. Correspondingly, the reductions of future situational risks guides the selection towards change-driven ISD methods (should efficiency risks be unimportant) (De Weger and Franken 1997). If "future situational risks" are seen as opportunity creation and "efficiency risks" as business uncertainty then this model could be considered a subset of our framework. Tang and van Vliet (2012) in turn suggested that the developer team experience is one of the key determinants of complexity together with the size and the difficulty of the developed IS. According to them high experience supports the selection of solution-driven (=plan-driven) ISD methods and low experience problem-driven (=change-driven) ISD methods. We conclude that low experience of IS professionals, business developers, end-users or other stakeholder, increases the uncertainties inherent in the ISD method selection. A few articles, not included in the 42 articles, attempted to formulate the ISD method selection problem into a mathematical model. These studies did, however, not include any additional ISD method selection criteria or models.

Discussion and Conclusions

As an answer to the research question one we developed a contingency theory motivated ISD method selection framework with two dimensions: business execution certainty and development outcome certainty. The underlying idea of the proposed framework is that the characteristics of ISD methods and their organizational / business development use contexts need to match. We then probed the framework with the ISD method criteria and ISD method selection models discovered in the systematic literature review we did. The proposed ISD method selection framework was able to capture 14 out of the 18 ISD selection factors of previous research. We also found that ISD method selection discussion is quite uncommon, only 42 articles included criteria and/or models on how to make the selection between alternative ISD methods. Even fewer articles had considered how the characteristics of organizational and business contexts are related to ISD method selection.

In answering research question 2, we found that 18 ISD method selection criteria were suggested in the reviewed 42 articles. The proposed framework did not capture four of them. Three of these four ISD selection criteria (time, money and size of the system) are actually typical success criteria of plan-driven ISD projects and do not suit to the selection between plan-driven and change-driven ISD methods. The

remaining criterion is communication. Communication is executed in a method specific way within any ISD method and is therefore more an ISD method property than an ISD method selection criterion. However, it is possible that our framework (=select an ISD method that matches with the business development context) and the Boehm and Turner (2004) model (=refine the selection by considering the key properties of ISD practice) could complement each other.

On the basis of our findings we claim that the proposed framework offers a novel perspective to ISD selection and captures both organizational / business development contexts factors and the selection factors found from prior literature. Next the framework should be probed empirically. We already conducted a study where 31 IS development consultants and professionals working in the borderline between IS suppliers and clients were interviewed. The interviewees listed 23 different ISD method selection criteria. All the 18 criteria covered by the 42 articles were among them. The additional factors found in the interviews were: trend, plausibility of a method, size of user and IS supplier organization, and industry type. The comparison of these two sources of evidence is a very potential topic of a future article.

Future studies could test and validate the proposed framework also with other types of empirical studies. Such studies could result in clearer empiria-based guidelines for the selection of change-driven and plan-driven ISD methods. Some other potential venues for future research include:

1. What are the influences of organizations' work, ISD and business development culture on ISD method selection? For example, how much do existing control practices or the legacy of ISD methods usage affect ISD method selection? Is it advisable and/or possible to try to change and/or ignore these kinds of organizational culture factors?

2. How does IS legacy influence ISD method selection and business development? For example, do legacy ISs influence what ISD methods can be used in various business development situations?

We discovered that astonishingly few ISD method selection models have empirically validated the criteria and/or guidelines of ISD method selection. There are clearly more articles that give unsubstantiated subjective recommendations for ISD method selection without any theory backed and/or empirical evidence, i.e. the effects and the soundness of the proposed criteria are difficult to evaluate. The lack of attention paid to the business use contexts of ISD methods is also striking. We regard future theoretical and empirical research on these topics important. This is also our recommendation to researchers, and we offer our study as a contribution to such future efforts.

Our advice to practitioners is to pay attention to the match between ISD methods selected and the characteristics of the business development contexts, where the selected ISD methods are to be used. There appears to be no single ISD method that suit to all kinds of business development contexts.

References

Ahimbisibwe, A., Cavana, R. Y., and Daellenbach, U. 2015. "A Contingency Fit Model of Critical Success Factors for Software Development Projects A Comparison of Agile and Traditional Plan-Based Methodologies," *Journal of Enterprise Information Management* (28:1), pp. 7–33. (https://doi.org/10.1108/JEIM-08-2013-0060).

Alvarez, S. A., and Barney, J. B. 2007. "Discovery and Creation: Alternative Theories of Entrepreneurial Action," *Strategic Entrepreneurship Journal* (1:1–2), pp. 11–26.

Avison, D. B. E., and Fitzgerald, G. 2006. *Information Systems Development*, (4th ed.), Maidenhead: McGraw-Hill.

Benediktsson, O., Dalcher, D., and Thorbergsson, H. 2006. "Comparison of Software Development Life Cycles: A Multiproject Experiment," *IEE Proceedings - Software* (153:3), pp. 87–101. (https://doi.org/10.1049/ip-sen:20050061).

Benington, H. D. 1983. "Production of Large Computer Programs," *Annals of the History of Computing* (5:4), pp. 350–361. (https://doi.org/10.1109/MAHC.1983.10102).

Boehm, B. W. 1988. "Spiral Model of Software Development and Enhancement.," *Computer*, pp. 61–72. (https://doi.org/10.1109/2.59).

Boehm, B. W., Gray, T. E., and Seewaldt, T. 1984. "Prototyping Vs. Specifying," *IEEE Software* (May),

pp. 473–484.
Boehm, B. W., and Turner, R. 2004. *Balancing Agility and Discipline: A Guide for the Perplexed*, Addison-Wesley Professional.
Brooks, F. P. J. 1986. "No Silver Bullet-Essence and Accidents of Software Engineering," in *Proceedings of the IFIP Tenth World Computing Conference*, pp. 1069–1076. (https://doi.org/10.1109/MC.1987.1663532).
Burns, R. N., and Dennis, A. R. 1985. "Selecting the Appropriate Application Development Methodology," *ACM Sigmis Database* (613).
Burns, T., and Stalker, G. M. 1994. *The Management of Innovation*, (3rd ed.), Oxford: Oxford University Press. (https://doi.org/10.1093/acprof:oso/9780198288787.001.0001).
Burrell, G., and Morgan, G. 1979. *Sosiological Paradigms and Organisational Analysis*, Farnham, Surrey, England: Ashgate Publishing Limited.
Clarke, P., and O'Connor, R. V. 2012. "The Situational Factors That Affect the Software Development Process: Towards a Comprehensive Reference Framework," *Information and Software Technology* (54:5), Elsevier B.V., pp. 433–447. (https://doi.org/10.1016/j.infsof.2011.12.003).
Cusumano, M. A., MacCormack, A., Kemerer, C. F., and Crandall, W. 2009. "Critical Decisions in Software Development: Updating the State of the Practice," *IEEE Software* (26:5), pp. 84–87.
Dahlberg, T., and Lagstedt, A. 2018. "There Is Still No ' Fit for All ' IS Development Method : Business Development Context and IS Development Characteristics Need to Match," in *Proceedings of the 51st Hawaii International Conference on System Sciences* (Vol. 9).
Gupta, D., and Dwivedi, R. 2015. "A Framework To Support Evaluation of Project In-Hand and Selection of Software Development Method," *Journal of Theoretical and Applied Information Technology* (73:1), pp. 137–149.
Hall, J. G., and Rapanotti, L. 2015. "Towards a Design-Theoretic Characterisation of Software Development Process Models," in *GTSE '15: Proceedings of the Fourth SEMAT Workshop on General Theory of Software Engineering*, IEEE Press Piscataway, NJ, USA ©2015, pp. 3–14. (https://doi.org/10.1109/GTSE.2015.8).
Harmon, P. 2010. "The Scope and Evolution of Business Process Management," in *Handbook on Business Process Management 1*, J. vom Brocke and M. Rosemann (eds.), Springer Berlin Heidelberg, pp. 37–82.
Hastie, S., and Wojewoda, S. 2015. "Standish Group 2015 Chaos Report - Q&A with Jennifer Lynch," *InfoQ, Blog*. (https://www.infoq.com/articles/standish-chaos-2015, accessed February 22, 2018).
Howell, D., Windahl, C., and Seidel, R. 2010. "A Project Contingency Framework Based on Uncertainty and Its Consequences," *International Journal of Project Management* (28:3), Elsevier Ltd and IPMA, pp. 256–264. (https://doi.org/10.1016/j.ijproman.2009.06.002).
Kitchenham, B. 2004. "Procedures for Performing Systematic Reviews," Keele, UK.
Larman, C., and Basili, V. R. 2003. "Iterative and Incremental Development: A Brief History," *Computer* (36:6), pp. 47–56. (https://doi.org/10.1109/MC.2003.1204375).
Lyytinen, K., and Hirschheim, R. 1988. "Information Systems as Rational Discourse: An Application of Habermas' Theory of Communicative Action," *Scandinavian Journal of Management Studies* (4:1–2), pp. 19–30.
MacCormack, A., and Verganti, R. 2003. "Managing the Sources of Uncertainty: Matching Process and Context in Software Development," *Journal of Product Innovation Management* (20:3), pp. 217–232. (https://doi.org/10.1111/1540-5885.2003004).
MacDonell, S., Shepperd, M., Kitchenham, B., and Mendes, E. 2010. "How Reliable Are Systematic Reviews in Empirical Software Engineering?," *Software Engineering, IEEE Transactions On* (36:5), pp. 676–687. (https://doi.org/10.1109/TSE.2010.28).
MacManus, J., and Wood-Harper, T. 2007. "Understanding the Sources of Information Systems Project Failure," *Management Services* (51:3), pp. 38–43.
Mahmood, M. a. 1987. "System Development Methods - A Comparative Investigation," *MIS Quarterly: Management Information Systems* (11:3), pp. 293–307.
Mathiassen, L., and Stage, J. 1990. "Complexity and Uncertainty in Software Design," *COMPEURO'90: Proceedings of the 1990 IEEE International Conference on Computer Systems and Software Engineering@m_Systems Engineering Aspects of Complex Computerized Systems*, pp. 482–489. (https://doi.org/10.1109/CMPEUR.1990.113661).

McCracken, D. D., and Jackson, M. A. 1982. "Life Cycle Concept Considered Harmful," *SIGSOFT Softw. Eng. Notes* (7:2), pp. 29–32. (https://doi.org/10.1145/1005937.1005943).

Mitchell, S. M., and Seaman, C. B. 2009. "A Comparison of Software Cost , Duration , and Quality for Waterfall vs. Iterative and Incremental Development : A Systematic Review," in *Third International Symposiumm on Empirical Software Engineering and Measurement*, pp. 511–515. (https://doi.org/10.1109/ESEM.2009.5314228).

Nutt, P. C. 2010. "An Empirical Test of Thompson ' s Model of Strategic Choice," *International Journal of Business* (15:2), pp. 159–183.

Paulk, M. C., Curtis, B., Chrissis, M. B., and Weber, C. V. 1993. "Capability Maturity Model for Software, Version 1.1," Pittsburgh, Pennsylvania.

Röglinger, M., Pöppelbuß, J., and Becker, J. 2012. "Maturity Models in Business Process Management," *Process Management* (18), pp. 1–18.

Royce, D. W. W. 1970. "Managing the Development of Large Software Systems," *Ieee Wescon* (August), pp. 1–9.

Sommerville, I. 1996. "Software Process Models," *ACM Computing Surveys* (28:1), pp. 269–271.

Tang, A., and van Vliet, H. 2012. "Design Strategy and Software Design Effectiveness," *IEEE Software* (29:1), pp. 51–55. (https://doi.org/10.1109/MS.2011.130).

Theocharis, G., Kuhrmann, M., Münch, J., and Diebold, P. 2015. "Is Water-Scrum-Fall Reality? On the Use of Agile and Traditional Development Practices," in *International Conference on Product-Focused Software Process Improvement* (Vol. 9459), Springer International Publishing, pp. 149–166. (https://doi.org/10.1007/978-3-319-26844-6_11).

Thompson, J. D. 2003. *Organizations in Action: Social Science Bases of Administrative Theory*, Transaction Publishers.

Verner, J., Sampson, J., and Cerpa, N. 2008. "What Factors Lead to Software Project Failure?," in *Proceedings of the 2nd International Conference on Research Challenges in Information Science, RCIS 2008*, pp. 71–79. (https://doi.org/10.1109/RCIS.2008.4632095).

Vessey, I., and Glass, R. 1998. "Strong vs. Weak Approaches to Systems Development," *Communications of the ACM* (41:4), pp. 99–102.

Vidgen, R., and Wang, X. 2009. "Coevolving Systems and the Organization of Agile Software Development," *Information Systems Research* (20:3), pp. 355–376. (https://doi.org/10.1287/isre.1090.0237).

Webster, J., and Watson, R. T. 2002. "Analyzing the Past to Prepare for the Future: Writing a Literature Review," *MISQ Quarterly* (26:2), Xiii–Xxiii.

De Weger, M. K., and Franken, H. M. 1997. "A Situational Approach to Design Strategies," *Software Quality Journal* (6:3), pp. 181–194.