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DevOps: Walking the Shadowy Bridge from Development Success to Information Systems Success

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Short Paper

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Abstract

In recent years enterprises have observed that a holistic approach to agile information systems development and a closer integration of information systems development with information systems operations is essential to maximize the probability of success, leading to the emerging DevOps phenomenon. While past research delivers insights about success criteria in information systems development as well as information systems operations, conceptual inclusion of DevOps is missing. We propose a multi-staged qualitative research design including literature review and multiple-case study to explore and identify origins of critical success criteria used to measure success by the two major IT-related enterprises functions IT development and IT operations. Based on that, we aim to contribute a "DevOps model", from a success criteria perspective, and reconcile information systems development with the Information Systems Success Model. In addition, our research significantly fosters understanding of the DevOps phenomenon and identifies paths for future research.

Keywords: DevOps, Information Systems Development Success, Information Systems Success, Success Criteria, Success Factors, Information Systems Success Model

Introduction

In today's industrial practice, applying agile methods such as Scrum (Beck 1999) or Extreme Programming (Schwaber and Beedle 2002) to *information systems development (ISD)* is increasingly one promising way for enterprises to maximize the probability of *ISD success* (Dybå and Dingsøyr 2009). These approaches, collectively labelled under the umbrella of *agile information systems development (AISD)* (Conboy 2009), currently are the dominant way to ISD in industry (VersionOne 2018). AISD approaches-in-use within companies are often characterized as a combination of specific *agile practices* (e.g., daily stand-up meeting, pair programming, etc.) taken from different methods, which team members can choose to enact as a methodology-in-use (Recker et al. 2017).

Although a lot of ISD research has investigated specific facets of AISD such as the use and effects of selected agile practices (e.g., Balijepally 2009; Holmqvist and Pessi 2006; van Oorschot et al. 2018) or the implementation and adoption of AISD methods to teams (e.g., Cao et al. 2009; Mangalaraj et al. 2009), there is still a dearth of research that tries to link AISD in general to ISD success. On the one hand, we lack insights about how to measure and evaluate AISD and ISD success (Conboy 2009). On the other hand, most extant AISD research has focused solely on developmental factors, the ISD process itself, and the developers' perspective, with little attention being paid to operational factors, the resulting IS product, or its long-term operation and use (Diegmann et al. 2018).

In industry, the simultaneous consideration of both developmental and operational factors is central to the emerging phenomenon of *DevOps* (Wiedemann et al. 2019). DevOps is a portmanteau word of "development" and "operations". Proponents of the concept argue that the two major IT-related enterprise functions *IT development* and *IT operations* increasingly apply shared goals and use shared practices across both functions, bringing together team members from both development and operations, in order to implement AISD in a comprehensive way (Lwakatare et al. 2016; Qumer Gill et al. 2018; Wiedemann 2017). In essence, DevOps appears as a logical extension of AISD, aiming to bridge development to its resulting IS product and its systems' operation (Lwakatare et al. 2016; Qumer Gill et al. 2018). Thus, companies applying DevOps streamline their IT development and IT operations to overcome classic barriers and friction points between those two often siloed IT functions.

Since DevOps is a very recent phenomenon, only few studies up to now exist. Extant work so far has investigated various disparate aspects of DevOps, for example, the continuous software-engineering pipeline of approaches such as DevOps (Fitzgerald and Stol 2017), the different roles for knowledge sharing within systems management, characteristics of support tools for systems maintenance (Forsgren et al. 2016), adoption challenges for DevOps (Lwakatare, Karvonen, et al. 2016), or necessary skill sets of team members for DevOps (Wiedemann and Wiesche 2018). The lack of formal definition for DevOps and various different theoretical conceptualizations among these studies, however, prevent a thorough understanding of what DevOps entails and signifies.

As a starting point for building such an understanding and conceptualization, the *Theory of Information Systems Success* (DeLone and McLean 1992, 2003) and its resulting *IS Success Model (ISSM)* is one of the most important contributions to comprehensively measure information systems (IS) success on the operational side. By responding to the call to further refine the ISSM as well as to explore its relationships with ISD (DeLone and McLean 2016, p. 93), we aim to reconcile the emerging DevOps phenomenon and the issue of evaluating ISD success with an updated version of the model. In doing so, we aim to deliver a theoretically and empirically grounded conceptualization and definition of DevOps, stemming from an IS success perspective, and thus foster our understanding of the emerging DevOps phenomenon.

In essence, to gain understanding about what DevOps is, we want to explore and find out whether the use of DevOps is (a) a way to optimize a dimension of the ISSM (e.g., service quality), (b) whether it is a success factor and driver of the ISSM itself, (c) whether it is a means that influences IS success (i.e., a cause and effect factor), and (d) what role the application of agile practices plays. Therefore, we aim to answer the following research questions:

RQ1. What are the origins of success criteria enterprises use for their DevOps initiatives?

RQ2. What is a suitable conceptualization and definition of DevOps from an ISSM perspective, and how does current practice-in-use match to this?

For answering the first question, we aim to empirically explore which success criteria used in industrial practice have their origins mainly in IT development, which ones have their origins mainly in IT operations, and which ones have their origins in both entities. Subsequently and closely related to this, we aim to develop and conceptualize a "DevOps model" based on an updated ISSM (integrating developmental and operational success measures) and empirical studies for answering the second question.

Section 2 of this paper summarizes related work and discusses the theoretical background. Section 3 describes the preliminary research model and research design. In Section 4, the expected contribution is discussed and an outlook is provided.

Related Work and Theoretical Background

DevOps and its Measurement: Bridging Development and Operations

DevOps as one way of applying agile approaches across IT functions (Hüttermann 2012) has gained increasing attention from IS research (Sharp and Babb 2018). Due to lack of specific research, models, and definitions, DevOps can describe different things, including team structure, success criteria/factors as well as concepts and tooling (Qumer Gill et al. 2018). In this study, we focus on the success aspect, since increasing the probability of success is the underlying motivation to implement DevOps, shared incentives between development and operations are crucial for success (Hüttermann 2012), and metrics and measures are often an essential, grounding part of existing DevOps initiatives (Google 2019; Wiedemann et al. 2019).

Accordingly, *measurement* is a major characteristic of DevOps and *useful metrics* is a pattern of DevOps practice (Lwakatare et al. 2016), suggesting that both development teams and operations teams should be incentivized and rewarded by the same metrics, and that one function should use feedback from the other (e.g., progress in development is measured in terms of having a working system in the production environment). DevOps and its focus on measuring addresses major management concerns, including business productivity and cost reduction, IT and business alignment, and business agility and speed to market (Luftman et al. 2013). DevOps accepts that functions do often have different or even conflicting success criteria; nonetheless, it tries to align the success criteria of the two major IT functions found in enterprises, IT development and IT operations, with each other, in order to reduce friction points, and widening the scope of agility from traditional ISD teams in order to prevent micro-optimized silos (Hüttermann 2012).

What remains unclear, however, is how DevOps is applied and utilized from a success criteria perspective, which measures typically *are* used in emerging DevOps initiatives, and which measures *should* be used. First, we *lack insights about and measurement of success criteria*. For example, "software functionality" is typically used as an ISD success respectively IT development measure (Recker et al. 2017), and "mean time between failures" is typically used as an IS success respectively IT operations measure (Dekleva 1992). Applying DevOps, it is unclear how both relate to each other, if both should be used, if one should be prioritized above the other, or if both are useful at all. This makes it difficult to understand the motivation of, and, in practice, to improve on those criteria.

Second, it also remains unclear to which extend previously identified AISD success criteria, for instance, *simplicity*, *adding value*, and *learn through change* (Conboy 2009), are commonly utilized and incorporated in measurement in industry, and how these ISD measures do relate to the resulting IS (e.g., in terms of product quality or customer satisfaction). In practice, such success criteria identified by research could be a good starting point for DevOps initiatives, however, often they appear as neither measurable nor actionable, and information about metrics are still fuzzy. There is a need for developing a set of metrics to evaluate actual performance outcomes under each component of AISD (Conboy 2009). Similarly, we need more detailed knowledge about specific success criteria and their link to the related DevOps phenomenon.

Third, *most measures lack a convincing rationale and theoretical grounding*. Behind any good concept or theory should be a strong underlying logic and rationale (Whetten 1989). Although existing research shaped our understanding of AISD, a parsimonious theory is still missing (Abrahamsson et al. 2009; Conboy 2009; Whetten 1989), particularly about the role of DevOps. Although AISD may not be the best solution for all given setups, and in practice often a blend of AISD practices is used (e.g., Fitzgerald et al. 2006), it is widely recognized that AISD is strongly accepted and adopted in industry (VersionOne 2018). However, AISD approaches are not adopted nor enacted "by-the-book" in most enterprises, and often a blend of practices is used. Meanwhile, extant research on AISD mainly has focused on the developers' perspective (Diegmann et al. 2018), with little research focusing on holistic approaches such as DevOps or end users' responses to AISD, or on factors related to the enterprise function of IT operations.

Information Systems Development Success and Information Systems Success

What many of the approaches both on ISD success and on IS success have in common is that they conceptualize *success* as a dependent variable, and identify multiple success sub-concepts and concepts closely related to success.

ISD success is often related to individual aspects such as staying within scope, time, and cost requirements (Chow and Cao 2008), rapid change (Lee and Xia 2010), or delivering high quality (Siau et al. 2010). It has been discussed from different social-technical perspectives, either from an organizational and team perspective such as diversity (Ramasubbu et al. 2015), or from a behavioral and methodological perspective such as communication (Hummel et al. 2013) or learning (Conboy 2009). Additionally, enterprises often tailor their respective AISD initiatives to also adapt *lean* approaches (Poppendieck and Poppendieck 2003) to manage and improve measures of flow time and cycle time (Anderson and Reinertsen 2010; Wang et al. 2012; Wetherbe and Frolick 2000), which in turn also relate to ISD process-based success criteria. In sum, a diverse and varied set of ISD success conceptualizations and measures have been proposed.

IS success similarly can be defined in multiple ways. There are nearly as many success measures as there are studies (DeLone and McLean 1992). Starting with the data processing era in early 1950s, IS have continuously evolved, reaching the customer-focused era in the new millennium (DeLone and McLean 2016). For research, measurement of IS success was always crucial. For example, early studies discussed the User Information Satisfaction instrument (Ives et al. 1983). The Technology Acceptance Model (TAM) focused on comprehensive measure of IS success as well (Davis 1989). Complementary contributions include, amongst others, SERVQUAL, ITIL, or the Balanced Scorecard (DeLone and McLean 2016).

One of the most adopted and influential contributions (Urbach et al. 2009) in this domain is the *IS Success Model (ISSM)*, tackling success as a blend of six dimensions. According to the ISSM, the inter-related variables of IS success are: system quality (the desirable characteristics of an IS), information quality (the desirable characteristics of the IS outputs), service quality (the quality of the support that system users receive), use (the degree and manner in which employees and customers utilize the capabilities of the IS), user satisfaction (users' level of satisfaction with reports, web sites, support services etc.), and net impact (the extent to which the system is contributing to the success of individuals, groups, or organizations) (DeLone and McLean 2016). The model serves as a base for other work, for example, summarizing the measures of the ISSM applied to the evaluation of IS success and by examining the relationships that comprise the ISSM (Petter et al. 2008). Later work focuses on independent variables as success factors and identifying their relationships to the ISSM, for example, project characteristics such as project management and developer skills (Petter et al. 2013).

In essence, the ISSM attempts to reconcile the plethora of approaches trying to measure IS success, and results in a multi-dimensional framework for understanding the multi-dimensionality of IS success, giving a combined view on existing process and variance models. Its six interdependent variables must all be measured and/or controlled to measure IS success. As such, it is a logical starting point to conceptualize the operational aspects of IS.

Combining Information Systems Success Model and DevOps: A Preliminary Model

Based on this brief discussion and the variables introduced above, Figure 1 provides a preliminary conceptualization of the DevOps phenomenon from an ISSM perspective. Within our preliminary model, both IT development (Dev) and IT operations (Ops) have their respective *critical success criteria*. These independent variables impact success, either *ISD success* or *IS success*, and are moderated by *Dev success* and *Ops success*.

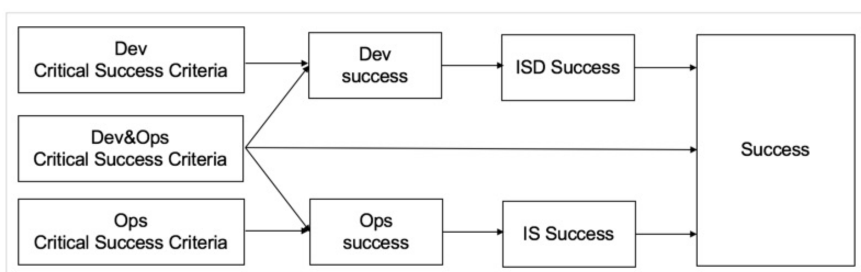

Figure 1. A Conceptualization of DevOps from a Success Perspective

With DevOps, *shared goals* do affect success as well. If the goals of both functions are unrelated or even conflicting, desired behavior of stakeholders in the Dev function as well as the Ops function positively moderates success of the respective enterprise entity, and negatively moderates the success of the respective other entity. Both interfacing functions, Dev and Ops, are aligned with each other through DevOps, which in turn relates to the ISSM. Similar to the ISSM, success in DevOps is also multi-dimensional. Particularly, DevOps can describe both *success criteria* (defining the success of an initiative, such as cost, time, performance, quality, team satisfaction) as well as *success factors* (that are made up by important influences that contribute to IS or ISD success) (Baccarini 1999).

Table 1 provides exemplary conceptualizations of the two concepts ISD success and IS success with respective exemplary sub-concepts (e.g., on-time completion, cycle time). The table also contains two examples for shared goals between development and operations, hinting to a strong implementation of DevOps: both IT functions utilize the same success sub-concept (e.g., cycle time), which in turn is part of both ISD success as well as IS success.

Table 1. Exemplary DevOps Conceptualizations

Authors	**Concepts / Major Focus**	**Success Sub-concepts**
Lee and Xia (2010)	ISD Success / Development	On-time completion, on-budget completion, software functionality
Recker et al. (2017)	ISD Success / Development	Customer satisfaction, process performance, software functionality
DeLone and McLean (2003)	IS Success / Operations	System quality, Information quality, service quality, Intention to use/use, User satisfaction, Net impact
Dekleva (1992)	IS Success / Operations	Maintenance time, Mean time between failures MTBF, Mean time to repair MTTR
Wetherbe and Frolick (2010)	ISD Success / Development IS Success / Operations	Cycle time
Poppendieck and Poppendieck (2003)	ISD Success / Development IS Success / Operations	Flow and cycle time

Preliminary Research Design

DevOps is a new and emerging phenomenon, where its role, its context, and the boundaries between phenomenon and context are not clearly evident (Yin 2018). Consequently, we propose to apply a *case study design* for developing explanatory theory (Eisenhardt 1989). Case studies allow researchers to develop a deep understanding of the phenomena within its natural setting and real-life context, especially when the boundaries between phenomena and context are not clearly evident (Yin 2018). Our preliminary research design consists of four stages (see Figure 2).

First, a *structured literature review* (Webster and Watson 2002) examines the current body of knowledge on both DevOps and on success criteria, which are used in enterprises to measure IS success and ISD success, and their respective origins in either IT development or IT operations. To synthesize relevant work in the body of knowledge, and to accumulate and identify concepts, we implement a concept-centric approach (Webster and Watson 2002). To identify relevant concepts, major contributions are likely to be published in leading journals. Therefore, our focus is on high quality, peer-reviewed outlets published in journals such as the “Seniors Scholars’ Basket of Journals” and selected outlets from Software Engineering and Project Management (e.g., “Empirical Software Engineering”, “Journal of Systems and Software”). Due to the broad context, we will also follow their advice to scan the journals’ table of contents to pinpoint articles that would not be caught by a strict keyword approach.

Second, we then go backward by reviewing the citations of articles identified in stage 1, and go forward by identifying articles citing the articles of the previous stage to identify more articles. Afterwards, we will create a *systematic literature map* with streams and lines of research (Creswell and Creswell 2018). We expect the review of current literature about the emerging topic of DevOps to be shorter compared to a detailed review for a mature topic where an accumulated body of research exists. Where possible, this study primarily focuses on already performed literature reviews on success criteria, since this is a more mature line of literature.

Third, we will perform a *multiple-case study* to explore the contemporary phenomenon in depth, to understand its how and why, and its real-life context. We are convinced that our design is the best fit to achieve high external validity, including gathering complementary as well as possibly contradictional insights from multiple, theoretically useful cases, and checking whether the findings can be generalized, and bringing together the academic with the practitioners’ views. Prior to starting the theory-building case study, important variables are identified, with reference to extant literature (e.g., based on the ISSM), to nail down knowledge about the domain, whereas the theory, including the relationships between variables and theory, is built as part of the case study (Eisenhardt 1989).

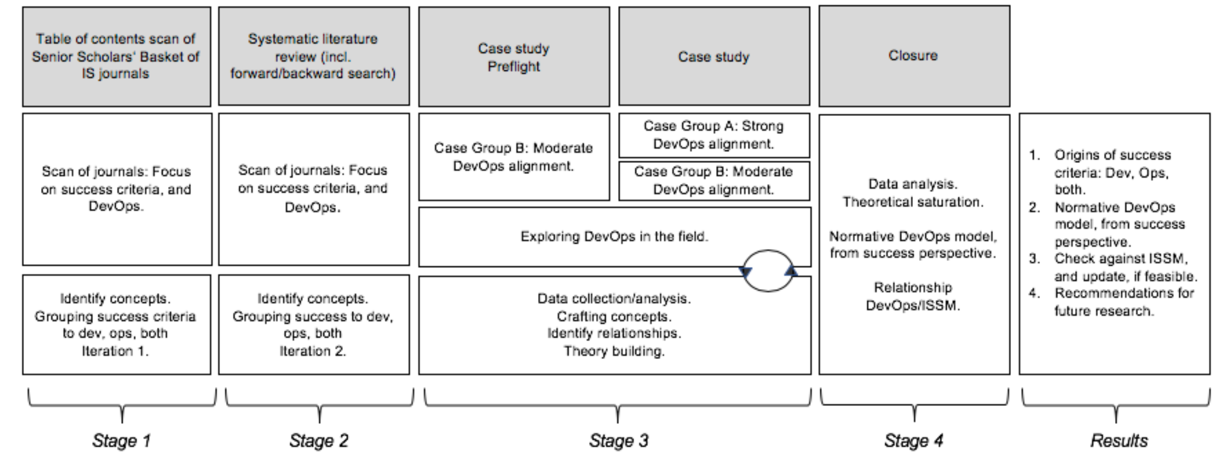

Figure 2. Preliminary Research Design

Our phased case study (Eisenhardt 1989; Yin 2018) will start with a preflight including a pilot case study (shaping relevant lines of questions and conceptual clarifications for the research design including detailing data collection plans) and a pre-test case study (including finalizing and pre-testing data collection plans). Afterwards, we will then study additional cases treating the series of cases similar to a series of experiments, with each case being a discrete experiment that serves as a replication, contrast, and extension to the evolving DevOps model. We predict to gain meaningful insights with sufficient theoretical saturation (i.e., minimal incremental learning combined with minimal incremental improvement to the theory) after performing four cases studies.

Cases are assigned to two groups. For group A, case sites are both revelatory and extreme while being successful in their domain that understands IT as a core asset and an inherent driver for success. Companies of this section comprise the largest value of all enterprises worldwide, based on market capitalization. As a result, these companies are important and do run a holistic approach to IS/D because business is driven by IT as a core asset for maximizing business value (Overby et al. 2006). These companies presumably are better integrated internally and arguably do successfully soften conceptional barriers between development and operations, and are listed in NASDAQ-100 (or similar). They are expected to strongly apply DevOps. Members of group B are comparable with members of group A except that they run a more conservative, classic approach to IT. We expect them to apply DevOps moderately, thus providing a contrast to group A. Via theoretical replication, due to contrasting results for anticipatable reasons, the rival group is supposed to help to gain better understanding of the studied DevOps phenomenon. The main unit of interest for both groups is the respective enterprise, the smallest units of interest are embedded teams of enterprises' IT development function and IT operations function. Preflight cases are from group B to better prepare the theory building (e.g., grounding with a more classic approach to IT). For the additional cases, two are of group A and two are of group B.

Data will be collected via interviews (including learning possible new questions from the interviews, and *snowball sampling* to find out more knowledgeable informants), observations, and document analysis, in order to triangulate data collection techniques (Eisenhardt 1989; Yin 2018). During a two weeks on-site period for each case, semi-structured interviews are planned with different key informants across organization functions, represented by specific individuals with assigned specific roles including developers, operation engineers, and managers. Observations also will be conducted by one of the authors being a participant-as-observer (Cassell and Symon 2012). Data collection and data pre-analysis do overlap in the field and are part of the overall process of building theory from case study research (Eisenhardt 1989): Aligned with the inductive, exploratory nature of this research, concepts and relationships are developed in sequential within-case analysis, before looking for similar concepts and relationships across multiple cases, to build and continuously further shape theory and to use theory to generalize from case study.

Access to appropriate case sites is possible based on the personal network of the authors. One member of the research team is also an independent freelance consultant on DevOps. Cassell and Symon (2012) argue that some degree of researcher bias is not only inevitable to the study, rather it is beneficial since such studies cannot be carried out in a social vacuum. In addition to highest standards of the scientific method, including replicability and independence of the research as well as the comprehensive chain of evidence, tactics to minimize participant bias include taking frequent breaks from the field to continue on theory building, and to reflect and analyze collected data (Cassell and Symon 2012).

Fourth, based on insights of these stages, this research will primarily inductively develop a conceptualization and explanatory model of DevOps, from a success perspective, and update the ISSM accordingly.

Expected Contribution and Outlook

This research adds important value to the existing body of knowledge in three ways. First, the findings will help understanding AISD and IS through the lens of the emerging DevOps phenomenon, and reconcile ISD with the ISSM – a part which hitherto has been largely neglected. We expect our results to considerably foster our understanding about initiatives in AISD, often driven by success criteria/factors, bridging different organizational entities, leading to the DevOps movement.

Second, exploring DevOps from this angle is timely, because in recent years enterprises have observed that a holistic approach to AISD and a closer integration of ISD with IS is needed - namely DevOps - to maximize the probability of success. The DevOps approach is often a holistic mash of different success criteria originated in different enterprise functions, and understanding of their origins does significantly contribute to further understanding.

Third, insights how DevOps and the ISSM can be reconciled will add significant understanding about DevOps to the academic field. The theoretical reasoning of the conceptualized DevOps model can be embedded into the broader debate of IS success and ISD success, and helps to bridge both domains.

We are convinced that this study is a significant contribution. The new DevOps movement lacks a theory, and once this is available, also directions for future research can be identified, e.g. extending the provided DevOps model beyond the foundational success perspective. This research aims to also provide guidance for practitioners since DevOps has strong momentum in the field of enterprise AISD and IS. After we have preliminary designed the research, with an understanding of the underlying domains including their concepts, and identified the research problem, as described above, we plan to finalize the research design, to perform the structured literature review, and to run the pilot case study, by end of 2019.

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