Communications of the Association for Information Systems

Volume 27 Article 42

12-2010

Resource Dependencies in Socio-Technical Information Systems Design Research

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Abstract:

An Information Systems (IS) design research project is in many aspects fundamentally different from that of traditional behaviorist research. IS design research projects with the ambition to provide socio-technical solutions to real world problems require the contribution of external stakeholders to the development, testing, and implementation of the design contribution. This article analyzes socio-technical IS design research from a resource dependency perspective. Our objective is to identify and describe critical resources that need to be secured for completion of the research. We investigate three socio-technical IS design research projects. The first project is a small-scale project on design of eLearning courses, the second is a medium-scale industry-driven project on IS integration in corporate mergers and acquisitions, and the third is a large collaborative research project with the ambition to redesign European customs using IT. The most prominent resources are human (knowledge and skills) and organizational (reputation and trust). The main strategy to deal with dependencies is incorporation of resource controllers, which create reciprocal and sequential dependencies internally. Our study shows the importance of extending the existing view of IS design research, when applied to socio-technical research, with an "initiation phase" and an "impact phase," which are especially important in large-scale design research projects.

Keywords: design research, information systems, resource dependency theory, socio-technical systems, collaborative research

Volume 27, Article 42, pp. 777-802, December 2010

The manuscript was received 4/18/2009 and was with the authors 5 months for 1 revision.

Communications of the Association for Information Systems

I. INTRODUCTION

Information Systems (IS) design research has recently achieved increased attention from the community of IS researchers, based on its promise to enhance relevance in research. The development has taken place in light of the argument that IS research has a serious relevance and utilization problem [Iivari, 2003]. While traditional IS research tries to describe and explain encountered phenomena, IS design research develops knowledge useful for IS professionals to design solutions to field problems [Gregor and Jones, 2007].

In this article, our main focus is on one specific type of IS design research that we call *socio-technical IS design research*. The label *IS design research* covers a broad scope of different types of research projects from one-person projects, where the researcher/designer develops an IT artifact to solve a clearly defined technical problem, to large research programs where several research organizations and other stakeholders jointly approach socio-technical problems. With socio-technical IS design research we mean IS design research that in the design is not limited to the technological aspects of the IT artifact but also includes management and use of the artifact. Although the value of this type of IS design research is recognized by most authors, the most influential methodological frameworks for IS design research have principally focused on IT-artifact centered IS design research [Hevner et al., 2004; March and Smith, 1995], whereas challenges accentuating in socio-technical IS design research are more sparsely addressed. We approach socio-technical IS design research as a type of collaborative research [c.f. Mathiassen, 2002], where the design research takes place in an explicit or implicit action research setting [Baskerville, 1999; Baskerville and Meyers, 2004] to incorporate actors essential to the research project. As we show in this article, the socio-technical IS design research require, by nature of its objective, a close collaboration between stakeholders possessing the knowledge and skills to design the IT component of the redesign and the social organization that is the target for design efforts.

This article is based on the argument that setting up and pursuing a socio-technical IS design research project is something very different from setting up and pursuing IS research with the ambition to develop descriptive or explanatory theory. Whereas the behaviorist IS researcher can work in a fairly isolated manner and is mainly dependent on input of empirical data due to the nature of the research, the design researcher has to pursue a far more integrated approach with business and governmental organizations in order to achieve the objectives. More frequently now than in the past, IS design research takes place in special purpose organizations rather than being carried out solely by researchers. The rewards of doing research in close cooperation with nonacademic institutions, not the least in terms of increased research relevance, are known to be significant [Hevner et al., 2004; Nowotny et al., 2001]. However, it is also known that such research becomes more complex and vulnerable as the dependency on uncontrolled external resources increases [Nowotny et al., 2001].

Many papers advocate the usefulness of IS design research, but over the past fifteen years few examples of IS design research have been published in leading journals [Walls et al., 2004]. The lack of methodological support for conducting design research may have contributed to this absence [Peffers et al., 2008]. Through a handful of contributions [e.g., Carlsson, 2006; Hevner et al., 2004; Peffers et al., 2008; Pries-Heje and Baskerville, 2008; Vaishnavi and Kuechler Jr, 2008a], researchers have started to develop an understanding of activities that have to be included in IS design research. These activities are usually discussed along different stages of a design science cycle. Nevertheless, no previous research has focused on the requirements concerning the research setup that would enable the execution of these activities. Having in mind the increased interest in design research as a way of increasing the practical relevance of IS research and the gap that we identify in the existing literature, our goal in this article is to provide first insights into what is necessary in order to set up and carry out a socio-technical design research project.

In order to address the above issue, we propose utilizing resource dependence theory (RTD) [Pfeffer and Salancik, 1978] to explore what is necessary to set up and carry out a socio-technical design science research project. RDT presents a theoretical perspective that has the securing of resources as a focal point required for an organization to complete its objectives. While RDT has received a wide applicability in a number of domains, it has not yet been applied in the context of design science. In this article, we use RDT to analyze dependencies of socio-technical IS design research. Among other alternatives, we chose RDT based on its promising potential for fulfilling our purpose in this research. The potential lies in that RDT has within the field of organizational science proven useful for similar purposes. Although initially developed for stable organizations, RDT has also been found useful for describing and

explaining dependencies of project organizations [e.g., Newell et al., 2008]. More on why and how RDT is applicable to IS design is found in Section II of this article.

This article combines the phases of the IS design research (as found in the existing literature) with RDT into a conceptual model for resource dependency in socio-technical IS design research. More concretely, by looking at the different phases of the design science cycle, we investigate which key resources are necessary for carrying out the activities, explore the degree and type of dependency on these resources, and determine what the mechanisms are that can be used to secure the necessary resources. Guided by the model, we investigate dependencies in three socio-technical IS design research projects which differ in terms of scope, focus, and scale. We include one small-, one medium-, and one large-scale project in the study to investigate whether our findings concerning resource dependence will change when we move from simple to large-scale and complex design research. As it can be expected that dependencies increase by project size and general complexity; we are interested in which kinds of dependencies are increasing and how these can be addressed. By a cross-case comparison, we address similarities and differences in the three cases, and enhance our conceptual model based on the case findings. Finally, we discuss how our findings affect the IS researcher who chooses to engage in socio-technical IS design research.

II. THEORETICAL FRAMEWORK

Prior research in two different domains is relevant for the research in this article. First, we present how the IS design research process is depicted in existing literature as stages of a design science lifecycle. Second, we extend the phases of the design science lifecycle by introducing RDT as a complementary lens which can help to investigate the types of resources that need to be available throughout the different stages for carrying out a design research project, and then we explore how these can be secured. As a result, we propose an integrated research model for resource dependency in socio-technical IS design research.

This article combines the phases of the IS design research (as identified from the existing literature) with RDT into a conceptual model for resource dependency in IS design research. An alternative approach could have been to also focus on action research, as some types of IS design research have much in common with action research [Jarvinen, 2007]. It is hard to imagine socio-technical IS design research that does not also have an explicit or implicit agenda that corresponds to many action research approaches [e.g. Baskerville, 1999]. The three cases we present as the empirical input to this article are of this kind. Although they were based on design research methodology, with a clear focus on designing solutions for classes of IS problems, they also had features of action research. We have chosen to build our initial framework on the first approach, as we aim to contribute to the growing body of research on heuristic knowledge of the socio-technical artifacts and not on the solving of a specific organizational problem *per se*. We expect this difference to be of importance when it comes to strategies for dealing with resource dependencies, including the challenge of switching among collaborating with organizations, developing socio-technical artifacts, and conducting rigorous research. Taking the action research approach as our starting point, it is the organizational problem that is the focal point. In the design research approach, it is the design that is the focus, and the contributing organizations are relevant in regard to their contribution and the resources that they bring to the development of the design. However, it should be noted that the framework we develop below, and then elaborate on using three case studies, is developed for socio-technical IS design research that takes place in an action research setting. The framework and findings are likely to be very different if the focus was IS design research that could be carried out purely in academia, for example, the design of a novel database artifact.

The IS Design Research Process: The IS Design Science Cycle

IS design research can be roughly divided into two categories based on what is the desired outcome of the process. On the one hand, IS design research can develop physical instantiations of IT, i.e., applications, programs, algorithms, and devices [Hevner et al., 2004; Walls et al., 1992]. On the other hand, IS design research also involves design of socio-technical systems, including IS praxis and management [Baskerville, 1993; Gregor & Jones, 2007; March & Smith, 1995; Carlsson, 2006]. The designed artifact can thus be a method, approach, principle, guideline, or any construction that reflects the current knowledge in the field and that provides support for the intended audience of IS researchers in their work. Although the focus of this article is on the second type of IS design research, the sparse methodological literature on the matter and the fact that a designed IT artifact normally constitutes an important part of the socio-technical design leads us to consider also IT artifact design research in constructing our theoretical framework.

IS Design Research with IT Artifacts as Output

IS design research with IT artifact design as core activity is currently the predominating stream of IS design research. For a long time researchers have pursued this kind of research, without explicitly labeling it IS design research [e.g., Grohowski et al., 1990]. The influential frameworks for IT-artifact IS design research [Hevner et al., 2004; March and Smith, 1995] describe three principal activities of the research processes: problem definition,

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building, and evaluation. These activities can be further refined into sub-activities, as presented below. Hevner et al. [2004] describe building and evaluation as an iterative generate-test cycle, a search process producing a feasible, good design that can be implemented in business environments. Optimal solutions are normally not within reach for real world IS problems.

The constituent sub-activities can be described in various ways. Building means to actually construct something (an artifact) that defines and communicates a problem and a solution [Hevner et al., 2004]. In order to be effective, the constructed artifact should build on what is currently known, which is often referred to as kernel theories. One sub-activity thus needs to occur in order to investigate the existing research and knowledge of the problem domain, and thereafter, this knowledge should be reformulated into an artifact. Instantiated artifacts can become subject for evaluation. With the stance of pragmatism comes the desired output of utility for a specified problem as final criteria for evaluation [c.f., Hevner et al., 2004]. Utility is subjective, and in practical terms this requires a breakdown into criteria that are possible to evaluate. Hevner et al. suggest the use of mathematical evaluation when applicable, for example, to evaluate search algorithms by precision and recall.

Socio-technical IS Design Research

Baskerville, Pries-Heje, and Venable [2007] argue that much of current design science literature and practice is strongly influenced by engineering approaches, "hard" system views, and positivist research methods: *"…such an approach invites serious difficulties in the IS domain since it has such a strong organizational and social component*" (p. 19). Approaches to how to conduct "soft" IS design research generally suggest an iterative development cycle [e.g., Carlsson, 2006; Iivari, 2007; Vaishnavi and Kuechler Jr, 2008a]. Carlsson [2006] purports that IS design research is an iterative process between (a) identification of theory and/or problem, (b) development of prescriptive guidelines, (c) testing, and (d) reflection on the test results. In outline, this approach is similar to the steps of IT-artifact centric IS design research [c.f., Hevner et al., 2004]. It should, however, be noted that for socio-technical IS design research, these steps contain other activities than "hard" IS design research, due to the nature of the developed artifact.

The iterative design process starts with the identification of a perceived practical problem and theory potentially useful for approaching the problem. It lies within the very core of IS design research that it should address real world problems identified by the target group of design research [Baskerville, 1993; Iivari, 2007; March and Smith, 1995]. The design process is a process of knowledge accumulation [Vaishnavi and Kuechler Jr., 2008a]. Apart from the already existing design theories that can be refined, existing descriptive and explanatory theories are one starting point for artifact design [Iivari, 2007]. If having this starting point, the behavioral and explanatory theories may need to be concretized into so-called mid-range theories that are better suited to base design than upon grand behavioral theories [Vaishnavi and Kuechler Jr., 2008b]. Designed artifacts are also in themselves expressions of theory. The design and development of the inner environment of artifacts can be seen as theorizing in an interior mode that leads to accumulated knowledge [Gregor, 2009]. In the third activity of the IS design research cycle, the desired output is some kind of practical usable knowledge [Carlsson, 2006]. For design research with the ambition of developing IT artifacts, this would be a prototype, and for socio-technical design research, this would be in the form of, for example, a method or guidelines. The fourth activity of IS design research is testing of the initial design theory [Carlsson, 2006]. Rosemann and Vessey [2008] argue that it is essential to check the applicability of IS research toward the context in which it is to be used. They suggest that the academic researcher functions as a moderator of the process, but input on the applicability should come from the intended user. Whether using focus groups, as suggested by Rosemann and Vessey, Delphi-studies, Q methodology, or other evaluation methods, this puts requirements on active involvement from several parties. Especially the intended users are indispensable. After the testing as an iterative cycle, the design research process starts all over again with problem redefinition, modifications, further testing, and so on. Depending on the outset of the task, this cycle may be long lived and require active participation for an extended period of time.

Limitations of the Current Studies

While the existing literature does include discussions about the approach (i.e., hard vs. soft) and the lifecycle, in describing the phases through which a project can evolve, we identify a lack of theories in the field of design research which discuss what is necessary in order to set-up and carry out a socio-technical design research project. In order to address this gap, we propose to extend the existing socio-technical design research theories with the additional perspective of RDT.

RDT has received a wide applicability in organizational science. In the context of socio-technical IS design research, it can help as a conceptual lens in order to bring our attention to the resources that are needed for setting-up and carrying out a design research project, and to provide direction for how these resources can be secured. Having in

mind the complexities related to bringing multiple stakeholders into a socio-technical design research project and the high dependency on the actors' participation for the project outcomes makes such an analysis meaningful.

Resource Dependence Theory (RDT)

Among the different theoretical perspectives from which requirements of socio-technical IS design research could be studied, RDT [Pfeffer and Salancik, 1978] seems to be the most promising, based on its explicit focus and proven ability to explain organizational dependency. RDT has its roots in sociology [c.f., Weber, 1947] and builds on the view that organizations behave to acquire and maintain essential external resources. The theoretical perspective has been developed and refined by a number of authors [e.g., Medcof, 2001]. Lately it has been fruitfully applied in the area of IS [e.g., Tillquist et al., 2002].

Defining Organization

In consistency with RDT, we regard organizations as "*coalitions, maintained by providing inducements (satisfaction) to participants who support the organizations*" [Pfeffer and Salancik, 1978, p. 29]. In this article, we regard an initiative with the ambition to develop output according to the principles of IS design research as a project organization according to the definition of Newell et al., based on project organizations being organizations that possess certain characteristics*: "projects … are viewed as being initiated to accomplish pre-specified goals and objectives, within a defined period of time, and in a relatively autonomous way, unencumbered by established organizational routines and practices"* [Newell et al., 2008, p. 33]. RDT was originally developed for relationships between stable organizations with a long-time horizon and stable buyer–supplier relationships. However, it has also been found applicable to organizations with shorter lifecycles, to which research projects belong [Newell et al., 2008]. Whether or not it is useful to regard IS design research as project organizations and analyze it with RDT that initially was developed for more stable organizations, is a question addressed in this article.

As RDT is founded on the argument that organizations are dependent on resources in the external environment for their survival, the question of how to define the interior and exterior of the organization becomes a point of interest. Inclusion is a classical problem that has been discussed extensively in literature [i.e., Downs, 1967; Haberstroh, 1965; March and Simon, 1958]. Weick [1969] argues that this is partly due to the fact that it is activities, not people, that are organized. Any individual is only partly included in the organization. Consequently, individuals can be part of both an organization and its environment [Pfeffer and Salancik, 1978]. The problem is accentuated in an organization, such as a collaborative research project, where most of the individuals work in more than one set of coordinated activities. Pfeffer and Salancik [1978] argue that the problem of where an organization begins and ends will disappear when approaching it as a set of coordinated activities. The activities the project performs to fulfill the projects objectives are thus the basis for drawing boundaries in an IS design project.

Resource Types

RDT is founded on the assumption that there are dependencies between an organization and other organizations in the external environment that control resources upon which the organization is reliant. The focus on resource type is not a part of the initial RDT which implicitly assumes that identification of resources is unproblematic. RDT focuses not on *which* resource the organization is dependent on, but on *how* it is dependent on these resources. That the identification of resource type is not completely unproblematic is manifested by the more recent developments of the Resource Based View (RBV). RBV [Wernerfelt, 1984] holds true that organizations can be regarded as aggregations of resources. These resources can be combined with varying effectiveness, implying that some combinations of resources better utilize the potential of existing resources [Barney, 1991]. Organizations also use resources that through the organization's capabilities [Grant, 1991] are transformed into resources that are valuable to someone else and thus lead to the survival of the organization.

In light of the purpose of this article, it is a necessary starting point for an analysis based on RDT to extend the theoretical frame with a categorization of different types of resources. This categorization can be used to identify resources that are later analyzed by the core concepts of RDT. Resources creating dependency have been classified into four categories [Barney, 1991]:

- *Physical:* physical capital resources, including equipment, raw material, and location
- *Human:* human capital, experiences, knowledge, and skills
- *Organizational:* informal and formal planning, control systems and organizational structure
- *Financial:* monetary capital required for the organizational operations

Degree of Dependency

Not all resources in the external environment that are used by an organization are equally critical to the organization. This is due to several reasons. It might be that the organization can operate successfully even without the external resource. This could, for example, be a retailer who wishes to include a product in the offering, but can still do without the specific product. The criticality of a dependency might also be affected by the number of available alternatives. A broad range of alternative sources from which to obtain similar input decreases the criticality of a dependence. If a supplier is unable to deliver what the organization demands, it can just turn to another one. This is not the case for a drug manufacturer that bases products on a licensed substrate with patent protection [Pfeffer and Salancik, 1978]. For both project-based and stable organizations, three characteristics determine the dependency on a resource, drawn from Pfeffer and Salancik [1978]:

- *Resource importance*: The more critical a resource is, the greater the dependency.
- *Alternatives:* The fewer the alternative sources for a resource, the greater the dependency on the unit(s) controlling the existing source(s).
- *Discretion:* Legal constraints (e.g., antitrust laws), as well as cultural norms and values, may hinder an organization to fully use another organization's dependency. Extreme predator behavior can backfire after loss of goodwill among customers.

Dependency Types

Pfeffer and Salancik [1978] claim that dependencies can be differentiated by their characteristics. First, a dependency can be characterized in terms of *outcomes and/or processes*, i.e., an organization can be dependent on: (a) *an outcome of another organization*, (b) a *process within another organization*, or (c) *both the outcome and process of another organization*. An example of outcome dependency is the competition of two organizations in the same market. If organization A drops its price, it has an effect on the business of organization B. That is an outcome dependency. A process dependency may be illustrated by someone wanting to play football which is something that one cannot do by oneself, that is, there is a dependency on others' willingness to participate in the game.

Second, the dependency can be characterized as either *symbiotic or competitive*. The symbiotic dependency can be illustrated using the football game as well. Just as one is dependent on the participation of others, they are also dependent on one's participation. Symbiotic dependency is opposed to competitive dependency, which may be illustrated by two airlines competing on the same route. If one airline company has significant problems with delayed and cancelled flights, this is likely to positively affect the business of the other airline company as well.

A third characteristic that, according to Pfeffer and Salancik [1978], differentiates dependencies from each other is the distinction between interdependence and dependence. The first refers to a mutual dependence, and the latter to a one-way dependency. The distinction of interdependence and dependence can be elaborated further [Thompson, 2003; Van De Ven et al., 1976]:

- *Pooled*: Each part of the organization makes a contribution to the whole that forms an organization. The different parts of the organization do not need to depend directly on each other.
- *Sequential:* The output of one is the input for another, an example of which is an industrial value chain.
- *Reciprocal:* The output of one part is the input for another, which in turn, directly or via proxy, is the input for the first unit.
- *Team:* Simultaneous collaboration refers to work or output not being shuffled from one unit to another, but rather worked on simultaneously.

Securing Mechanisms

A frequently neglected part of the resource dependency perspective by Pfeffer and Salancik [1978] are the mechanisms that the authors present as means to secure resources on which the organization is dependent. RDT presents three mechanisms that explain how organizations work to acquire and maintain power, i.e., *incorporation*, *avoidance,* and *adaptation*.

First, organizations form internal and external coalitions to incorporate and thus control critical resources. If resources in the environment are scarce and critical to an organization, a straightforward solution is to incorporate critical resources into the controlled domain by acquisitions, mergers, alliances, joint ventures, or other forms of coalition building. However, a larger number of internal stakeholders and contributors increases the complexity of the organization and makes coordination a more intricate task [Malone and Crowston, 1994]. If the project

organization extends to a few actors, it will need an appropriate coordination strategy to maximize resource utilization [Malone and Crowston, 1990].

Second, organizations use strategies to avoid positions in which they are too dependent on other organizations. When supply is unstable, a common strategy is buffering. If the demand of output is unstable, a long-term contract can create a stable cash flow. According to Pfeffer and Salancik [1978], the most effective way for avoidance is to alter the purpose or structure of the organization to increase alternatives. For example, if all cars could run on a range of fossil and non-fossil fuels, the negotiation potential toward oil rich countries would be much higher.

Third, organizations that can neither avoid nor incorporate critical resources use strategies for adaptation to deal with the dependencies. Adaptation can be of internal character, for example, small suppliers to the automotive industry that obey the conditions for doing business with a large car manufacturer. Adaptation can also refer to changes in the external environment through, for example, marketing. When grocery chains market their own branded products they limit the customer's demand for specific brands of, for example, ketchup, thus putting the grocery chain in a better position to negotiate with the major ketchup brands.

Summary of Key RTD Concepts

Summarizing the previous research on organizational dependencies, it is possible to extract a framework consisting of the four dimensions: (a) resource type, (b) degree of dependency, (c) dependency type, and (d) securing mechanism, as seen in Table 1.

Table 1: A Preliminary RDT Framework

Dimension	Sub-concept	Description
A. Resource type	Physical	Physical assets like buildings, machines, and geographical location.
	Human	Knowledge, skills and other non-physical assets.
	Organizational	Organizational structures, working processes, culture, etc.
	Financial	Monetary capital required for the organizational operations.
B. Degree of dependence	Resource importance	The more critical a resource is, the greater the dependency.
	Alternatives	The fewer the alternative sources for a resource, the greater dependency on the unit(s) who controls the existing source(s).
	Discretion	Constraints may hinder an organization to fully use another organization's dependency
C. Dependence type	Outcome/Process/ Outcome & Process	Supply chains are typical examples of outcome dependence, while participation in a poker game is an example of process dependence.
	Competitive/Symbiotic	Whether the successful operations of organization A is affecting organization B positively or negatively.
	Pooled/Sequential Reciprocal/Team	Refinement of how two (or more) units are (inter-) dependent on each other.
D. Securing mechanisms	Incorporation	Forming internal and external coalition to secure resources.
	Avoidance	Altering the purpose or structure of the organization to increase alternatives.
	Adaptation	Changing the external context or by adapt to the premises by an independent organization.

A Preliminary Research Model for Resource Dependency in Socio-technical Design Research

Figure 1 is a visualization of our combined theoretical approach in which we extend the design research cycle with RDT. The research cycle is inspired by influential models of design research reviewed above, and extends Hevner et al.'s [2004] generate/test cycle. Although Hevner et al. emphasize the importance of the surrounding environment and the underlying knowledge base, we argue that a design research project cannot succeed if the necessary resources are not allocated. The model draws on both IT artifact-centric and socio-technical IS design research. On a high level such combination is meaningful, as the two approaches seemingly follow the same progression process. It should be noted, however, that, in reality, the steps refer to different activities, require different skills, and consequently depend on a different set of resources. Our application in Section IV and the analysis that follows are based only on socio-technical IS design research. Since the resources for artifact-centric research are frequently part of existing university laboratory facilities and are available without concern, or are made available and

considered during traditional grant application activity (i.e., NSF), we can guess that a resource dependency framework for this kind of IS design research would have less emphasize on resource dependencies in the initial stages of research project. However, the resource dependency framework we suggest could be useful in artifact-centric design research where the evaluation of the artifact requires extensive testing in an actual organizational setting. In this situation inter-organizational and coordination issues should become equally significant, as in socio-technical IS design research.

To combine IS design research with RDT, we focus on the activities that comprise the project, as suggested by Pfeffer and Salancik [1978]. The key to identifying organizational dependency is to understand which resources the research activities are dependent on. Via those resources it is then possible to identify which organizations control the critical resources, and then to analyze the relationship with these controlling organizations. By doing so, it is possible to understand to what degree these dependencies are critical to the IS design research project. It is further possible to understand the nature of these dependencies. This is presented in Figure 1.

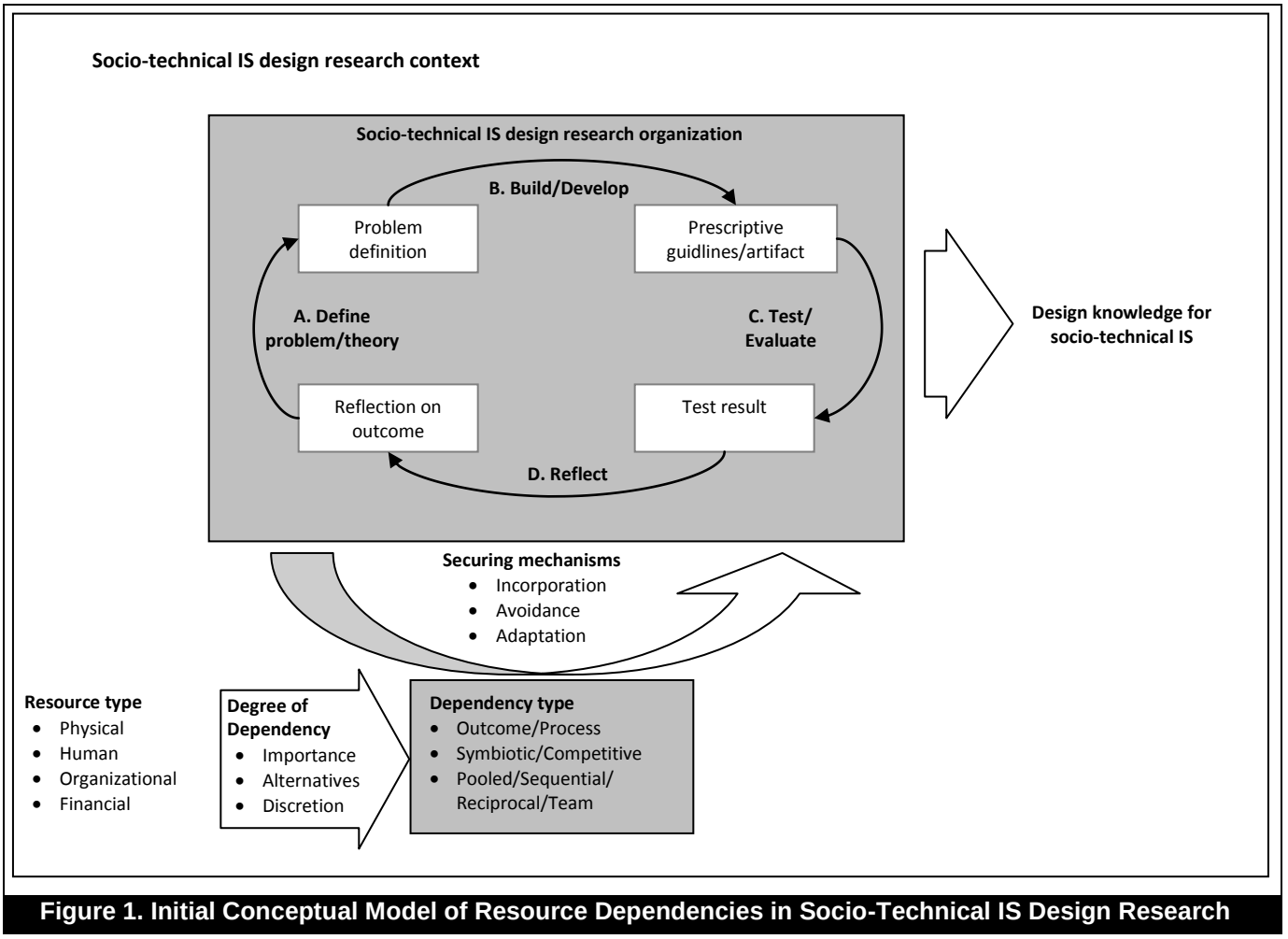

Figure 1. Initial Conceptual Model of Resource Dependencies in Socio-Technical IS Design Research

III. RESEARCH METHODOLOGY

The theoretical contributions we make in this article can be labeled as theory for analyzing and theory for explaining [Gregor, 2006]. The theoretical framework presented in Section II is a suggestion on a lens to capture dependencies of socio-technical IS design research. The motivation to develop such a framework is that, while securing resources is essential for carrying out design project, this specific focus has not been explored in the existing design research. The theoretical framework that we provide, therefore, is a first attempt to apply RDT in the setting of design science and to demonstrate that thinking about resources is a crucial step when setting up design research projects which have the ambition to produce a socio-technical artifact. Drawing on Gregor [2006], we conclude that the usefulness of the type of theory that we provide should be evaluated by its completeness, distinctiveness, and simplicity. Completeness means that important categories or elements should not be omitted from the classification system, that is, the framework should be able to capture all important resources. Distinctiveness means that boundaries between categories and characteristics that define each category are clear. The empirical phenomena encountered should be possible to categorize according to these criteria without too much difficulty [Gregor, 2006]. When a model

or framework is too elaborate or comprehensive, it is hard to work with, and, in the end, useless for its purpose. Simplicity addresses that problem.

The explanatory theory comprises the conclusions we draw regarding resource dependencies in socio-technical IS design research, as presented in the article's discussion section. To illustrate and further develop our conceptual framework, we used a comparative case study method [Eisenhardt, 1989] involving three different projects, i.e., the eLearning, the IS integration, and the eCustoms project. By using a comparative case study, we aimed to elicit similarities and differences between the cases, especially taking into account the varying scale and complexity of the three projects. Based on the analysis, we further developed our tentative conceptual framework presented in Section II [c.f. Eisenhardt and Graebner, 2007]. By doing so, we aimed to contribute insights into what types of resources are crucial and need to be secured when doing socio-technical IS design research, and to gain an understanding of how these may vary when we have projects that vary in terms of scale and complexity. The quality of this type of theory is also related to the three criteria of completeness, distinctiveness, and simplicity; however, plausibility and credibility of explanations are also expected.

We used theoretical sampling [Eisenhardt and Graebner, 2007] to select cases that represented the variety of research within the scope of socio-technical IS design research. First, the topics of eLearning, IS integration, and eCustoms represent different application areas for the research outcome. Second, the IT artifacts that are part of the socio-technical design may vary in terms of the scope and the scale of the artifacts. Third, socio-technical IS design research may be initiated by both practice and academia which logically have some impact on the resource base given at startup. Fourth, it has previously been noted that increasing scale and complexity may be drivers for increased dependency in collaborative research [Nowotny et al., 2001]. Fifth, the literature has examples of socio-technical IS design research with different degrees of inter-organizational collaboration; from large scale institutional driven projects to projects which have been the work of individuals. Sixth, as noted above, the IS design research-cycle is an iterative process that may require one lap before arriving at usable results, but may also be ongoing for years before the output is satisfactory. The three cases, briefly introduced below, represent variety in these characteristics.

About the Cases

Table 2 provides an overview of the three cases that we chose to embody socio-technical IS design research. The cases tell three different stories of IS design research put into practice. In the table, we summarize the cases using project characteristics such as size, duration, initiator, the IT artifact, and the desired outcome of the socio-technical design. We purposely chose design research projects which require inter-organizational collaboration (which presupposes greater complexity due to diversity of actors, compared to projects that take place in a single organization) and vary in terms of scale: one eLearning project (a small scale), the IS integration (medium scale) and eCustoms (large scale). Although these projects address different domains, they can all be seen as socio-technical IS design research projects in that they all aim to develop design knowledge which has both a social and technological component. In the table we also include a summary of the empirical sources that we used to study each of the cases. Evaluation was conducted through what Hevner et al. [2004] label observational and descriptive design evaluation, as our socio-technical design projects, which commonly are closely intertwined with the organizational context, were evaluated in naturalistic settings.

eLearning

The eLearning project was a Ph.D. project that included a number of case studies conducted in two phases. All studies focused on when and how to use and design synchronous eLearning, as a complement to asynchronous eLearning. The IT artifact in focus was an eLearning platform, and the social dimension of the redesign was the eLearning course to use the eLearning platform. The first phase included a series of studies on an undergraduate online course in Business English, which did not include any face-to-face meetings. The course involved group discussions and continuous assessment of individual and group work. The enrolled learners can be described as computer literate adult learners, most of whom were working and some living abroad. In the second phase, two series of online discussions with Master's students on knowledge management were studied. The first case setting was a series of online discussions with Master's students from two courses on knowledge management offered during 2004. One of the courses was delivered by a university in Argentina, and the other by a university in Sweden. Learners from the two universities participated in two asynchronous and two synchronous online discussions over a two-week period. Although the Argentineans and Swedes never met, introductory sessions were arranged in Argentina and Sweden respectively.

The second case setting was an online Master's course on knowledge management offered during 2005. The learners of the course participated in two asynchronous and two synchronous text-based online discussions over

Table 2: Case Characteristics				
Characteristic/Case		**eLearning project**	**IS integration project**	**eCustoms project**
Project characteristics		One single researcher assumed most project roles himself and carried out most research and design in comparative independence	Small team of participants from two research institutions and one large industry group	Large and formalized international initiative with participants from several European countries
Project size		Small (24 man months)	Medium (40 man months)	Large (82 man months)
Project duration		June 2004–April 2007	July 2005–December 2007	February 2006–December 2007 (Dissemination activities to continue till July 2010)
Project initiator		Academia	Business	Academia
Inter-organizational collaboration		Research institution and 3 educational institutions	Two research institutions and one industry group	4 key partners, including 1 business party, 1 technology provider, 1 tax and customs administration, and 1 university; 6 additional parties acting as supporting organizations for specific phases
IT artifact used in the socio-technical design		eLearning platform with synchronous and asynchronous features. The design guidelines suggests prescriptions on when and how to use and design synchronous eLearning.	Enterprise systems of acquiring and acquired companies. The redesign gives guidance on when IS integration becomes a critical issue to assess before an acquisitions, how to choose an integration architecture and how to learn and improve from one IS integration to the next.	The IT artifact is based on 3 key components: a smart container seal, service-oriented architecture and EPCIS open standard. Smart container seal • It can provide real-time location information. In addition, it can record events such as un-authorize opening, temperature drop below predefined margins, leaving of pre-defined geo-zones, etc. • Service-oriented architecture and EPCIS standard Allows for information sharing among all supply chain partners and interested governments
Desired outcome of the socio-technical design		Guidelines for eLearning course design	Tools for IS integration management	IT artifact (eCustoms prototype) and redesign customs process
Empirical sources				
	Interviews and questionnaires	*18 interviews* • With students *4 questionnaires* • *Learners' diaries*	*31 interviews* • For kernel theory *11 evaluations* • With experts and target audience for developed guidelines	*25 interviews* • Conducted with 14 eCustoms project participants • At the beginning of the project, as well as at the end to evaluate the results
	Meetings, brainstorming, and work sessions	Three focus group sessions with teachers, managers, administrators, and developers of eLearning	Feedback sessions	Meetings, brainstorming, and work sessions on continuous basis throughout the first 2 years
	Documents	• Electronic logs	• Annual and periodic reports • Project plans • Internal communication • User guides • Assessments • Due-diligence reports • Meeting protocols	• EU policy documents • EU documents on export of excise goods • Internal reports of the Dutch Tax and Customs Administration • Project reports
Evaluation of the outcomes		Focus groups	Interviews	Interviews

four weeks. Key actors in the eLearning project were teachers, researchers, and several groups of students. Based on the findings in the two cases studies, tentative guidelines on when and how to use synchronous eLearning were developed. The guidelines were exposed to practitioners and then refined through an iterative cycle. Focus group sessions were conducted in order to test six design propositions. Strong to intermediate support was found for each design proposition. This suggests that the developed design theory was perceived as valuable. "Practitioner-oriented" versions are now used as part of a successful book and in practitioner papers.

IS Integration

The IS integration project was based in the growth operations of Poly Group, a global industry group with 22,000 employees in more than forty countries. Annual sales are of approximately $3 billion. Poly Group, which has its main business in processed polymer materials, had for more than a decade pursued an aggressive growth strategy in which corporate mergers and acquisitions (M&As) were key components. The group noticed that they had trouble with IS integration issues in their M&A processes. The cost and complexity of the IS integration varied from almost none to well above what could be covered by synergies following the organizational combination. Poly Group had problems foreseeing when IS integration was to become problematic, and to anticipate the IS integration cost in their M&A. In collaboration with two Swedish research institutions, they launched a research project with the ambition of developing tools that could support the management to deal with IS integration issues in M&A. The IT artifacts in focus were the enterprise systems of the merging companies, and the social component of the design was the organizational integration.

Key actors in the IS integration case were Poly Group management, the two research institutions, Poly Group subdivisions' management (which were the ones actually implementing the M&A), and independent integration experts from various business organizations. In a first phase, four case studies of IS integration in four M&A were made. Upon the case findings, an explanatory model on how the relationship between IS integration solution and the M&A context affected each other was developed. The model showed how attributes of the IS integration approach chosen were affected and also affected attributes in the general M&A process. It was then possible to use the explanatory model for development of decision support models and design propositions on the IS integration approach, given that some of the M&A attributes (i.e., desired synergetic effects or power-relationship between the merging organizations) were assumed to be fixed. For example, a decision support model linking IT integration architecture to desired organizational synergies was developed. Propositions and models were exposed to practitioners in the field, and then iteratively refined according to the feedback.

eCustoms

The eCustoms project was part of an EU research program. The program aimed to design innovative IT-enabled solutions for cross-border trade (eCustoms), and involved sixteen partners, including international standardization bodies such as UN/CEFACT, large-scale technology providers, Tax and Customs Administrations in several member states, and universities. Four living labs in four different domains (beer, paper, food, and pharmaceutical) were set-up as real-life experimentation settings for developing and testing innovative concepts for cross-border trade, and, as such, could be seen as design research projects. In this article, we focus specifically on one of the living labs—the eCustoms project which addresses the handling (export) of excise goods and their movement in supply networks. Key partners involved were a large beer producer, the Dutch Tax and Customs Administration, a National University, and a technology provider. In addition, several other parties were also involved in some of the eCustoms project activities, including a Sea Carrier, UK Tax and Customs Administration (UK TCA), and a second technology provider. In the eCustoms project, the technological part of the design was innovative container seal technology and inter-organizational information systems that were used to prototype a redesign of the current procedures for the export of excise goods. The proposed eCustoms redesign concept is applicable for reliable companies which have the appropriate IS in place and are willing to provide the authorities with access to their commercial data. The results of the project suggest that the eCustoms project innovative redesign ensures that the control requirements are met; at the same time, the new concept allows for better trade facilitation for reliable traders, compared to the systems and approaches that are currently being introduced in the EU.

Method of Data Analysis

The data analysis was performed in two major steps. First, we used the conceptual framework presented in Section II to analyze each case. Second, we conducted a cross-case analysis to identify similarities and differences between the cases, and then we used the insights to further develop our conceptual framework.

For the analysis of the individual cases, we followed four steps that correspond to the four dimensions in Table 1 and interrelate, as depicted in Figure 1:

1. For the four phases of the IS design research cycle, we used the four resource types to identify the resources that the activity was reliant upon.

2. Based on the output from Step 1, we identified key dependencies for each phase using the three criteria for the degree of dependence: Importance, Alternatives, and Discretion.
3. For the key dependencies, we investigated the nature of the dependencies.
4. For the key resources, we identified what mechanisms were used to secure them.

For cross-case comparison, we used the similarities and differences in our cases (see Table 2) to compare dependent resources, dependencies, and securing mechanism. Each author applied the framework to the respective project. During this process, each of the authors used existing evidence from the case data. After that, we held several iterative sessions to discuss the specific findings, and then revised the findings based on the feedback from the discussions. We conducted this process in several iterative loops. Initially, we identified differences, as each of the authors interpreted some categories from the framework in a slightly different way. After several rounds of discussion, we reached a better understanding of the three cases, as well as how to apply the framework. The version of the findings, as they stand now in the article, is the final product of the authors' discussions and agreements. Based on the outcomes of the discussions, we also revisited our initial theoretical framework and the model for socio-technical IS design research and resource dependency.

IV. THREE CASES OF RESOURCE DEPENDENCY IN SOCIO-TECHNICAL IS DESIGN RESEARCH

In the following sections, we present the three cases of socio-technical IS design research, ordered by increasing scale and complexity. We follow the approach described in the methodological section; thus, we first discuss the resource dependencies that we observed in the cases. We then identify key resources and subsequently discuss the degree of dependency for these, as well as mechanisms used to secure them.

The eLearning Project

The smallest of our projects in terms of spent months of labor was the eLearning project. This project was characterized by one single researcher who assumed most of the project roles himself and managed to carry out the research and design in comparative independence.

Dependent Resources

To capture the resource dependencies in the three projects, we analyzed the different stages and types of resources used in the projects. We used the stages (i.e., problem definition, prescriptive guidelines, artifact, test result, and reflection on outcome) and resource types (i.e., physical, human, organizational, and financial), as presented in our conceptual framework in Section II.

The eLearning project was motivated mainly through analyzing previous research, which led to the identification of a key area where knowledge was needed, i.e., when and how to use and design synchronous eLearning. Researchers have argued that there is a need for design knowledge among practitioners. A major literature review confirmed this lack of research, and early discussions with practitioners confirmed an urgent need for support. First, a literature review was conducted by systematically reviewing eLearning literature with a focus on when and how synchronous eLearning supports enhanced learning. Then, naturalistic case studies were conducted. The possibility of conducting case studies was dependent on access to eLearning environments and transcripts of online communication. For this access to be available, the credibility of the researchers and trust to gain access to private communication were necessary.

Throughout the eLearning design project, empirical and theoretical evidence were used in complementary ways to motivate and test the design theory. By drawing on kernel theories, literature reviews and empirical studies, a number of design exemplars that were intended to be used by eLearning practitioners and that could be further developed and tested in future research were suggested. After having proposed an initial design theory, a test with practitioner involvement was conducted. A brief version of the design propositions was published in a Swedish eLearning magazine. In the article, teachers, managers, administrators and developers were invited to participate in focus groups to evaluate a number of design exemplars. The purpose was to get feedback on whether they could see applications of the design exemplars in their everyday work and also on whether the exemplars were explained and framed in appropriate ways. By drawing on the findings from the focus groups, the design exemplars were refined. An overview of the resource dependencies in the eLearning project is provided in Table 3, indicating that this project was primarily dependent on physical, human, and organizational resources. Of course, the involved researchers were financed by the research institution, but the project was not dependent on external financial resources. The key resource dependencies are discussed in the next section.

Table 3: Resource Dependencies in the eLearning Project				
Phase/Resource	**Physical**	**Human**	**Organizational**	**Financial**
Problem definition	▪ Access to prior research and studies	▪ Theoretical awareness ▪ Practical understanding ▪ Technical understanding	▪ Trust to gain access to eLearning systems and private communication	▪ General funding before research problem defined
Prescriptive guidelines/ Redesign	▪ Access to prior research and studies	▪ Pedagogical skills ▪ Designer skills		
Evaluation/Test	▪ Access to eLearning systems ▪ Meeting and communication facilities	▪ Feedback from e-learners ▪ Feedback from experts in focus group sessions ▪ Extensive practical understanding ▪ Moderating skills	▪ Trust to gain access to private communication ▪ Network of practitioners	▪ Funding for iterative cycles
Reflection/ Learning formalization	▪ Practitioner journals ▪ Book and book chapters written for practitioners	▪ Cognitive ability to use design exemplars in specific contexts		▪ Extended funding for spreading results

Key Resource Dependencies

Applying the three criteria of importance, alternatives, and discretion revealed that these three resources were more critical to the project than access to eLearning systems, feedback from e-learners, and commitment of experts to participate in focus group sessions. In order to study the use of eLearning systems, it was necessary to get access to teaching material and electronic communications. This was an example of an *outcome*, *symbiotic,* and *sequential* dependency, as access to eLearning system was necessary in order to conduct the design study. This can be viewed as both *physical* and *organizational* resource dependencies, as the teachers and learners needed to trust the researchers in order to give them access to private communication. It was necessary to come to an agreement with administrators responsible for the system, teachers, and learners. This is an example of great dependency: If one of these stakeholders had declined to provide us with access, the only *alternative* would have been to look for other case organizations, which would have been very time consuming. We also wanted to study private communication between learners when they used an instant messaging system, but this was difficult, as it required learners to send us log files that were stored locally on their computer. Although most participants agreed to do this beforehand, in the end, we received logs from about only half of the students because of technical difficulties or simply because some learners did not reply. The log data was, therefore, used mainly for illustrative purposes.

In order to evaluate the use of eLearning systems, it was also necessary to receive feedback from e-learners, i.e., a *human* resource dependency. This was also an example of an *outcome*, *symbiotic,* and *sequential* dependency, as feedback from e-learners was necessary in order to complete the study. Every learner was asked to continually complete questionnaires and keep a diary regarding their online communications. Some students were also interviewed. The dependency on students completing the questionnaires and diaries was great. As only some of the students were interviewed, the dependency on the interview was not high because alternative interviewees were available, i.e., other students in the class could be interviewed.

In the final stage of the project, we developed a number of design exemplars for when and how to use and design synchronous eLearning. In order to test and further refine the exemplars, focus group sessions with teachers, managers, administrators, and developers of eLearning were conducted. This is also an example of *human* resource dependency. The relationship between the researchers and the network of experts could be characterized as a *process*, *symbiotic* and *reciprocal* dependency; the resulting design exemplars were expected to be useful, both for the experts and for the research community. As will be discussed below, a prioritized list of experts was developed to ensure that alternative participants could be invited if those initially invited declined.

Securing Resources

The securing of the key resources in the eLearning project was achieved through incorporation and adaptation. Access to eLearning systems was secured mainly through *incorporation*. Prior to conducting the studies, access to the eLearning systems was discussed with the involved stakeholders which granted access. However, as problems

could have occurred, the securing mechanism of *adaptation* could have been necessary to be applied if the researchers had not gained access to data, information, and communications stored by the eLearning system.

In order to get feedback from e-learners, the dependency on students completing the questionnaires and diaries was great. If this had not succeeded, *adaptation* to alternative sources would have been necessary, i.e., other online courses could have been studied, but this would have been very time consuming. As mentioned, the dependency on the interview was not high because of the strategy of *incorporation* and other learners in the group could have been interviewed.

Commitment of experts to participate in focus group sessions was secured through incorporation by developing a prioritized list of experts that could be invited to participate in the focus groups. If the initial invitees declined, other practitioners could be contacted. In order to ensure that the participants would participate, despite being geographically dispersed, the principle of avoidance was applied, seen by the use of video conferencing tools that were used. In doing this, we avoided financial dependencies, such as funding for traveling.

The IS Integration Project

The medium scale IS integration project was the work of a small team of researchers and practitioners from one commercial organization, Poly Group, and one research institution.

Dependent Resources

Poly Group was naturally the key actor in defining a relevant research problem, as the organization had a real world problem that it was not able to solve. Poly Group provided the business case and the context where a specific piece of knowledge was lacking. On the other hand, the researchers from the research institution contributed with their knowledge on the theoretical domain. However, the theoretical understanding of the problem area was found insufficient to develop testable design propositions useful to PolyGroup. Suitable mid-range theory was simply lacking, or immediately rejected by PolyGroup representatives, based on their experience of mergers and acquisitions. Based on the existing kernel theories, the researchers conducted four in-depth case studies to develop mid-range theory addressing the problem area of interest to PolyGroup. The work required the availability of the strategic processes of companies, and access to board meetings and other meetings where possible M&A were discussed. For this access to be available, credibility of the research institute and trust from the investigated companies were necessary resources. A summary of resource dependencies in the IS integration project is found in Table 4.

Table 4: Resource Dependencies in the IS Integration Project

Phase/Resource	Physical	Human	Organizational	Financial
Problem definition	▪ Documentation of business cases ▪ Access to prior research and studies ▪ Meeting and communication facilities	▪ Theoretical awareness ▪ Practical understanding ▪ Technical understanding	▪ Network of practitioners ▪ Trust to gain access to strategic issues	▪ Willingness to spend funds without clear objectives
Prescriptive guidelines/ Redesign	▪ Development tools	▪ Pedagogical skills ▪ Designer skills	▪ Possibilities for fast feedback	▪ Funding to investigate international cases
Evaluation/Test	▪ Meeting and communication facilities ▪ Documentation equipment	▪ Moderating skills ▪ Extensive practical understanding	▪ Trust ▪ Commitment to use propositions ▪ Network of practitioners	▪ Additional funding to make process iterative
Reflection/ Learning formalization	▪ Evaluation reports	▪ Knowledge on where to fit new findings in a context ▪ Analytical ability		▪ Sustained funding for additional iterations

Once the mid-range theory was in place, the process of converting explanatory theory to tools that could be used by management in practice was started. For the researchers involved, this was a new activity; normally their research would end up in academic papers with a short section of practical implications, at best. The researchers took help from consultants within the field to discuss the kind of tools they could use in their everyday work, and how the

knowledge could be presented. At the end, something called design propositions (generic rules in the format "In situation S, to achieve consequence C, do A" [Bunge, 1967]), that is, rules of thumb and decision support models were created.

The border between creation and evaluation of managerial tools was not clear cut. One of the evaluation criteria was accessibility of the tool, which referred to how understandable and easy it was to use the tool. Comments on accessibility triggered creation of alternative ways of expressing the knowledge in the kernel theory. This part of the research process was dependent on evaluating organizations as well as people. To assess the usefulness of the suggested tools, they would have had to be tested in real world practice. However, the available resources and the time frame of the project made it unrealistic to conduct real world testing. In addition, consequences of an M&A are sometimes not seen in full until ten years after the deal has been closed. Therefore, testing using simulated cases with the accumulated experience of practitioners was carried out.

After exposing the managerial tools to practitioners and implementing the corresponding changes, the tools were not direct reflections of the kernel theory. Some mismatches existed where design theory and kernel theory indicated differences. As a consequence, modifications were made to the kernel theory and the revised kernel theory was then subject for traditional scientific publication. During this phase knowledge of the existing theories and awareness of where to fit the new knowledge were required. The researchers working on learning formalization used evaluation reports as input for their work.

Key Resource Dependencies

Applying the three criteria for determining the degree of dependency (importance, alternatives and discretion) on the identified resources revealed that three resources were more critical to the project than others: trust to gain access to case companies, knowledge (particularly on how the practitioners work with M&A), and sustained commitment from practitioners.

Although the companies that used M&A as an integrated part of their strategy were numerous, it was impossible to get access to their core strategic processes, which was necessary (*importance*) in order to understand how the company worked with IS integration in relation to M&A. The element of *discretion* was not applicable in this situation. In reality, the potential *alternatives* were limited to those organizations with which the researchers in the project already had long lasting relationships. The candidate conditions of well developed mutual trust and frequent M&A as a corporate strategy limited the candidate companies to three organizations. This dependency was a *process dependency*—participation of the case company in workshops, meetings, interviews, and reflections over their use of IS integration in M&A was required. Once accepted, the relationship between the case company and the IS design research project was *symbiotic*; project results were supposed to be beneficial to the case company. Due to the iterativeness and a collaborative work process, the project as a whole was characterized by *team-dependence*.

The second key dependency was sustained commitment from Poly Group. The nature of this dependency was the same as for the first key dependency, namely *process*, *symbiotic,* and *team-dependence*. However, the reasons for this dependency's criticality were different. The tools for IS integration in M&A developed in the project were customized to the situation of Poly Group. Thus, for the third phase of the IS design research-cycle to be possible, Poly Group needed to maintain their support. *Alternatives* were limited to Poly Group, and the activity *importance* was necessary. However, discretion was a factor to consider. No legal factors hampered Poly Group to use its full negotiation power, but socially, the group was constrained. Terminating the support would have caused ill will for the company, both in a general sense, but especially as a partner for future research.

Securing Resources

All three securing mechanisms: incorporation, avoidance, and adaptation were used in the project to a different extent. In order to secure the first key dependency, access to case companies to build a kernel theory, *incorporation* was used in that the research was launched as a collaborative research project together with Poly Group. As the industry group was actually the actor proposing the research subject to the research institution, the securing went relatively smooth. Yet, a number of times an issue of discussion was the access to meetings and internal reports. It was only because of full support from groups of CEOs that the subdivision managers were willing to accept researchers attending their meeting and taking part in their work.

With Poly Group internalized into the project, the second key dependency was partly ensured through incorporation. However, *adaptation* was also used to some extent. In addition to tests with experts from Poly Corp and its subdivision, the input from external experts was also required. While some IS design research output can be easily evaluated by real world use, the effects of the IS integration approach in M&A might only be seen five to ten years after the M&A. Thus, testing was reliant on extensive expert feedback and simulated cases. For this reason, external

experts with knowledge of different types of M&A were required. The adaptation part meant that tools for purposes not entirely in line with the initial outset were developed as compensation to the external experts. More effort than would otherwise have been the case was also devoted to customizing solutions and giving advice to companies that, in turn, gave feedback on the developed tools. In this way, the required external experts were convinced to participate in the tests.

The eCustoms Project

The large scale eCustoms project was an international initiative with participants from several European countries and ambitious goals. Compared to the two previous research projects, it was much more formalized with project manager, steering group, predefined objectives and elaborated project plans.

Dependent Resources

The results of the analysis are presented in Table 5 below. Reflecting on the results presented in Table 5, we derive several observations. First of all, the human resources can be seen as key resources and fundamental drivers for the whole project. This is not surprising, as the eCustoms project is a research and development project, and innovation relies heavily on human capital. Experts possessing domain knowledge were necessary throughout the stages; other skills that were required varied throughout the different stages. Analytical skills were essential for understanding the problem, for proposing the possible redesign and for evaluation of the results. Especially during the problem analysis and the redesign phase, a combination of theoretical knowledge and use of kernel theories, as well as common sense and practical expertise, guided the process. Moderator skills were essential for the problem analysis, as well as the redesign stage since it was important to have a party who took the concerns of all the stakeholders into account and who searched for common grounds to address all actors' strategic concerns. The skills of an innovator were essential during the redesign phase in order to provoke the participants to think out of the box and to come up with radically new concepts. Technical skills were necessary for development of the technical infrastructure and for executing the pilot. Finally, operational project management skills were required through the first three stages in order to handle the complex interactions between participants that evolved in these stages of intensive collaboration.

Table 5: Resource Dependencies in the eCustoms Project

Phase/Resource	Physical	Human	Organizational	Financial
Problem definition	▪ Meeting and communication facilities ▪ Documents	▪ Domain knowledge ▪ Analytical skills ▪ Moderating skills ▪ Operational management skills	▪ Network of participants ▪ Project structure, independent from the organizations involved	▪ Funding mainly necessary for human resources
Prescriptive guidelines/ Redesign	▪ Meeting and communication facilities ▪ Documents ▪ Access to prior research	▪ Domain knowledge ▪ Analytical skills ▪ Moderating skills ▪ Operational management skills ▪ Innovator skills	▪ Project sub-structures for general and individual group meetings	▪ Funding mainly necessary for human resources
Evaluation/Test	▪ Meeting and communication facilities ▪ ICT infrastructure ▪ Physical artifacts (e.g., containers) and equipment	▪ Domain knowledge ▪ Technical skills ▪ Operational management skills	▪ Pilot project sub-structure for running the pilot	▪ Funding mainly necessary for human resources and technical and communication infrastructure for the pilot ▪ Commitment of the practitioner to make own resources available for the pilot
Reflection/ Learning formalization	▪ Meeting and communication facilities	▪ Domain knowledge ▪ Analytical skills	▪ Loose sub-project structure for evaluation of the pilot results (meetings and interviews)	▪ Funding mainly necessary for human resources

Financial resources in the form of project funding were also crucial throughout the stages of the project. In the eCustoms project the financial resources were mainly necessary for compensating human resources for performing their tasks in the project, as well as for setting up the necessary infrastructure for carrying out the pilot. The project funding in the eCustoms project, however, also had a second purpose which was to ensure the commitment and to keep parties together in a project structure that was in principle, independent from their own organizations. In the

eCustoms project, a substantial part of the funding was provided by the IST program of the European Commission; however, the business partners also contributed with their own financial resources to the project. Committing certain financial resources to a partner to perform specific project tasks also provided obligations for these parties to deliver.

As the eCustoms project brought together parties from businesses, government, technology providers, and universities, it was essential to establish a new organizational project structure where these parties could meet and collaborate. The project structure that was set-up was flat and flexible, evolving during the stages of the project. At the beginning it was important to have an organizational structure to bring the different network actors together and to establish a basis for knowledge sharing and communication lines. This was done with multiple meetings and brainstorming sessions chaired by a moderator from the university. When the project progressed it become necessary to form subgroups to work on specific topics and to have mechanisms to consolidate and align the efforts of the different groups; an operational project manager was also essential for coordinating these activities. The organizational structure evolved further in the pilot stage where strict project plans were made about the development of the technical platform for the pilot, as well as the execution of the pilot which evolved shipment of real containers from the Netherlands to the US and UK. This phase was under the guidance of a manager representing the technology provider. In the evaluation stage, the project structure became much looser and more fluid, based on meetings and individual appointments for interviews to evaluate the results.

Finally, physical resources in the form of meeting and communication facilities were necessary throughout all four stages of the project. This is not very surprising, as the eCustoms project brought together a complex network of actors coming from different organizations; in order to deal with this complexity and achieve coordinated actions, the ability to meet and communicate were fundamental requirements.

When mapping the stages that we observed in the eCustoms project to those presented in our conceptual framework (i.e., Figure 1), we found that in the eCustoms project there were two additional phases (we call these the initiation and the impact phases) that could not be captured with our current framework; however, we also considered them to be very important, and thus they are briefly discussed below. The initiation stage was the stage when the network of actors that were to start a joint project was assembled, and initial commitment of these actors was secured. During this stage, human resources for securing commitment were essential. A moderator from the university was able to initiate the idea, find potential participants, and align and reframe the initial idea to the strategic concerns of the potential participants. In addition, it was important that the actors who agreed to participate in the project possessed a powerful position in their organizations, so that they were able to make commitments and follow up on these commitments. During this stage, securing some initial funding for the joint project activity served as a basis on which the collaboration would be developed and commitments strengthened. The other important stage that we observed was the impact stage, or the stage when the project participants utilized the results from the living lab to pursue higher level strategic goals. In the eCustoms project, in a big drive for the participants to form businesses, the goal for government and technology provider organizations was not the pilot, but rather, the use of pilot results to pursue changes in their legal and political environment. It is these higher level goals which were essential to keep the commitment throughout the different stages of the project as well as after that. In initial project plans the emphasis on the impact phase was minor, which made the business partners accordingly skeptical to participation in the project. Human resources were essential for the impact phase, where the eCustom project participants were engaged in numerous networking activities with business associations and policy makers to pursue wider impact and applicability of their ideas in practice.

Key Resource Dependencies

Applying the three criteria of importance, alternatives, and discretion reveals that gaining commitment of the parties involved, which relied heavily on the moderating skills (human resource) of the project initiator and securing the additional project funding (financial resource) for the pilot, were critical to the project.

For the initiation and subsequent development of the eCustoms project, the moderating skills were crucial for the project. During the initiation stage, the network formation was quite fluid and the project initiator (a university professor who acted as moderator) had more possibilities to select among *alternative* organizations (resource alternatives) to be involved. However, once a commitment was achieved, the actors that committed to join the project became very dependent on each other, and thus involving alternative actors would have been difficult and costly. In that respect, the *importance* of bringing in the resources that were initially committed (*resource importance*) became very high. This high degree of dependence on each other's resources continued throughout the whole duration of the project.

A specifically critical phase in the project was the execution of the pilot which was part of the testing phase, as during this stage the commitment of the business parties to invest a significant amount of their own financial resources became particularly visible. During this stage the technology provider in the eCustoms project had to

invest a significant amount of their own financial resources to set-up a team to build the technical infrastructure and secure the necessary equipment for the pilot. The people from the beer company needed to assign dedicated containers with beer and set up a team of experts available to send and follow the shipment according to the redesign procedure. Dutch Tax also had to set up a team in the Netherlands and mobilize a counterpart team involving their colleagues from UK customs to follow the shipment and to evaluate the reliability of the redesign procedure. The investment of these own financial resources (especially those invested by the technology providers) was of very *high importance* for the success of the project. In addition, there were almost no other feasible *alternatives* to involve another technology provider if needed, as the eCustoms project redesign was already tailored around the available technologies of the technology partner involved. During the pilot, tensions arose due to different notions of time in academia, industry, and government; while for the technology providers projects are usually run in a number of weeks, in academia and government they can last months or years. The university partner played a crucial role to mediate such tensions. For example, agreements were made not to work on strict deadlines but partners would do their best to deliver the input as soon as possible. In such a way, a mutual adjustment on the speed of the process of the pilot was made and partners reflected that in their own resource planning.

During the eCustoms project, all the actors needed to act collaboratively and depend heavily on each other's input. If the university partners did not facilitate the analysis and the redesign stage, and if the technology provider did not deliver the technical infrastructure, or if the beer company did not provide the containers, or if the government representatives did not set up a team of experts, the project would have been significantly delayed and may have even failed. The reason is that the execution of the project was tailored and depended very much on the input of the partners already involved, and switching costs would have been very high. Thus, in the eCustoms project we saw a high level of *process, symbiotic, and team* dependencies; this is with respect to both the key human, as well as the key financial, resource dependencies.

Securing Resources

The securing of the key resources in the eCustoms project was achieved mainly via *incorporation* and *adaptation*. As discussed in Section II, incorporation refers to forming internal and external coalitions to secure the resources. This coalition formation was a key aspect that took place in the initiation stage, which made the initiation phase so important for the follow-up success of the project. The project initiator, with his moderating skills, played a key role in the coalition formation in both searching for appropriate actors to join the project, as well as in the processes of gaining commitment. In order to ensure commitment, the project initiator was able to understand the strategic goals of the different actors and adapted the project scope to ensure that the strategic goals of the respective actors were also taken into account. By doing this, the initiator ensured that the parties were participating in the project, as they did see clear benefits for their own organization as well. However, securing initial commitment was not sufficient. As discussed earlier, the actors participating in the eCustoms project wanted to see a real impact on the political decision-making and the legislation. Thus, the project initiator had to ensure that throughout the subsequent stages of problem analysis, redesign, piloting, evaluation, and impact, the developments in the project remained aligned with the strategic objectives of the partners involved. This was crucial since if one partner felt that, for example, the redesign solution was not well aligned with his initial strategic concerns, this actor's commitment would have diminished, and he might have withdrawn from the project and not invested the intended human and financial resources. Having in mind the high degree of dependence after the initiation stage, this could have had a devastating effect on the project. In the eCustoms project, through his mediation skills, the project initiator was able to ensure that the strategic concerns of the eCustoms project participants were continuously considered and taken into account all the way to the impact stage.

V. DISCUSSION

In this section, we first compare the findings from our three case studies. By drawing on our findings, we evaluate the usefulness of the initially proposed framework and then propose a revised model of resource dependency for socio-technical IS design research. We also suggest implications for IS research.

Cross Case Analysis

All three projects successfully secured key resources in the sense that they arrived at designs that were valued by the intended target group. In the eLearning case design, contribution was evaluated with focus groups, while the IS integration project and the eCustoms project assessed value by interviewing the intended users of the redesign. In Table 6, we summarize findings from the three projects in terms of key resources, dependencies and securing mechanisms.

In all three projects, dependency on various human resources was prominent, and seen from the perspective of RBV, this was natural. Research organizations are primarily knowledge organizations. Commonly, for all three

Table 6: Cross Case Comparison on Resource Dependencies			
	eLearning	**IS integration**	**eCustoms**
Key resources	▪ Human ▪ Physical	▪ Human ▪ Organizational	▪ Human ▪ Financial
Dependencies	▪ Outcome/process ▪ Symbiotic ▪ Reciprocal	▪ Process ▪ Symbiotic ▪ Team	▪ Process ▪ Symbiotic ▪ Team
Securing mechanisms	▪ Incorporation ▪ Adaptation	▪ Incorporation, ▪ Avoidance (to some extent) ▪ Adaptation	▪ Incorporation ▪ Adaptation

projects, three types of knowledge were required during the problem identification phase: practical domain knowledge, theoretical awareness and knowledge of the topics state of art, and technical knowledge regarding the IT solutions to include in the design. People possessing knowledge on two or three of these areas became vital for the integrated work in all three projects. Further, all three projects showed dependency on pedagogical and representational skills, but these seemed generally to be easier to obtain as alternatives, meaning that available people possessing the skills, were more numerous. Noteworthy is also that in the eCustoms project, coordination skills turned out to be essential, which was not the case for the other two projects. A logical explanation for this is that the case was the largest project, both in terms of man-months spent and individuals working with the project. For the larger project, it seemed also to have been more difficult to estimate the resources required to arrive at the project objectives. More actors and activities meant more complexity and risks. Therefore, the ability to attract additional capital in later stages of the IS design research cycle was found to be important.

Generally it was the human resources that had the highest degree of dependency. Certain key individuals possessed knowledge and skills that were not replaceable. As the project continued, experiences and gained knowledge increased the dependency on certain individuals. The required physical resources were significantly easier to substitute.

Within the IS design research organization, both process- and outcome-dependency existed. Process dependency was mainly of sequential character between phases of the cycle, for example, dependency between problem definition and redesign suggestion. Within the phases there was team-dependency, and due to the iterations of the cycle, there was reciprocal dependency on phases. The high degree of internal dependencies created a need for a coordination function that managed the dependencies. In the eCustoms project, the preferred strategy to deal with dependencies was through incorporation in an initiation phase. By identifying the dependent resources, organizations controlled them, and then by convincing these organizations to join the project, it became possible to secure the necessary resources and have these available when needed. In contrast to the two projects discussed above, the eLearning project was mainly driven by previous research. Previous research had identified a general need among practitioners for guidance in the project area. In retrospect, it had been useful to define the research aim in closer collaboration with practitioners, although this would have been dependent on yet another resource, i.e., the active involvement of practitioners in the problem definition stage of the project. However, as discussed, it was important that the practitioners remained committed throughout the full duration of the project, as the evaluation and design of the exemplars were dependent on their feedback.

As expected, a comparison of the three cases reveals that resource dependency increased by increasing project complexity. In retrospect, what led to increased complexity was primarily the IT side of the socio-technical design. Especially in the eCustoms case, the IT artifact was an innovation process for which required resources were not possible to be foreseen beforehand. As the redesign turned out to be more demanding than expected, the stakeholders had to find additional financial funds. The IT artifact's complexity also led to increased project complexity for the reason that specialized IT providers and system developers had to develop the IT artifact. In both the eLearning and IS integration cases, the researchers could themselves realize and modify the design suggestions which reduced the need to engage IT providers in the projects.

Evaluating the Framework

As noted earlier, RDT was initially developed for organizations with a long-time horizon and stable buyer-supplier relationships. Although prior application of RDT suggested that the perspective was a promising way to approach IS design research, it is reasonable to question whether it was useful to regard IS design research as a project organization and to analyze it using RDT. Doubtlessly, drawing the boundaries of an IS design research project is problematic. The nature of IS design research as inter-organizational collaboration where participants are only partly engaged in the project makes it possible to question most resources, that is, whether they are on the inside or in the

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external environment of the organization. However, despite the problematic analysis, the findings presented in this article lead us to believe that it is fruitful to analyze IS design research, as also project organizations are dependent on external resources. With our analyses, we have been able to shed light on dependencies that exist and have highlighted issues that need to be addressed in socio-technical IS design research.

We argued in the methodological section that the framework used for describing resource dependency in our three projects should be evaluated by the criteria of completeness, distinctiveness, and simplicity. Completeness in this case would mean that no important resources were missed by the classification categories. Regarding the categories for resource type, we had no problem with resources falling outside all four categories. If any problem existed, it was rather that some resources could be categorized as more than one type, but more is said about that below when evaluating the framework's distinctiveness. Regarding our conceptualization of IS design research as four activities (Problem Definition, Prescriptive Guidelines/Artifact, Evaluation/Test, Reflection/Learning Formalization), this frame omitted important parts of at least one case. In the eCustoms case, many of the dependent resources were secured during an initiation phase. Professional organizations demanded practical useful output, and financing organizations (mainly the EU) required impact plans for providing finance. As tentatively assumed prior to the study (Figure 1), resources were not secured as the process unfolded, but rather before starting the actual work. To obtain the desired outcomes of the project, a dedicated impact phase was necessary. This phase was dependent on its own unique resources.

Initiation and dissemination were not equally prominent in the IS integration and eLearning projects. The initiation phase existed but was due to the minor number of actors and contributing partners being less extensive than in the eCustoms project. Both the IS integration and eLearning projects terminated with the existence of practical useful guidelines, but limited resources were spent to actually make them used in practice. With the acknowledgement that the projects have only recently ended and things may change, the outcomes of the two projects are still not extensively adopted in practice, despite their documented advantages. It is likely that a more elaborated impact phase would have affected adoption positively. With the argument that IS design research should try to understand the world but also change it [Iivari, 2003], we argue that our initial framework needs to be extended with both an initiation and an impact phase to conform to criteria of completeness.

Distinctiveness, referring to the ease with which elements (resources, activities) can be classified into the proposed categories, was perceived by the authors as being the most difficult part of framework application. This was partly due to difficulties of identifying the organizational boundaries. The experience was that the IS design research organization was evolving, partly due to the fact that incorporation was used as strategy for securing resources. Consequently, an actor that was initially in the external environment of the organization could in the later stages be part of the internal organization. Several approaches to solve this dilemma were tried out. However, by focusing on the activities of the IS design research and thus searching for resources that the activities were dependent on, as suggested by Pfeffer and Salancik [1978], we eventually managed to create a meaningful structure that permitted relevant conclusions regarding dependencies to be made. From a distinctiveness-perspective, the framework is far from perfect, but good enough to be useful. We encourage future attempts to improve this parameter.

Finally, to maintain the simplicity of the framework, we chose not to differentiate between soft and hard IS design research, but to describe the IS design research process in a simple four-phase cycle, using a very basic classification of resources. To increase the simplicity of the framework, it was bundled with the four-step approach (as described in Section III) that we used to identify and describe resource dependencies in our three cases.

A Revised Model of Resource Dependency for IS Design Research

To increase usefulness, we suggest that the following changes be made to our initial model of resource dependencies in IS design science:

- Completeness: Extension with initiation and impact phases
- Distinctiveness: None. Partly due to lack of better alternatives
- Simplicity: Bundling with step-by-step approach

The revised model is presented in Figure 2 which suggests an extension of the core IS design research-cycle with one pre- and one post-cycle phase. The core activity of the initiation phase is to incorporate and ensure access to resources that at this stage can be foreseen to be essential (activity X). The main activity in the impact phase is to disseminate the project results (Y). Notably, the importance of communicating results in design research has been emphasized earlier [e.g., Hevner et al., 2004], albeit not yet approached from a resource dependency perspective. With the resource dependency view, we show that the communication phase plays an important role in setting up

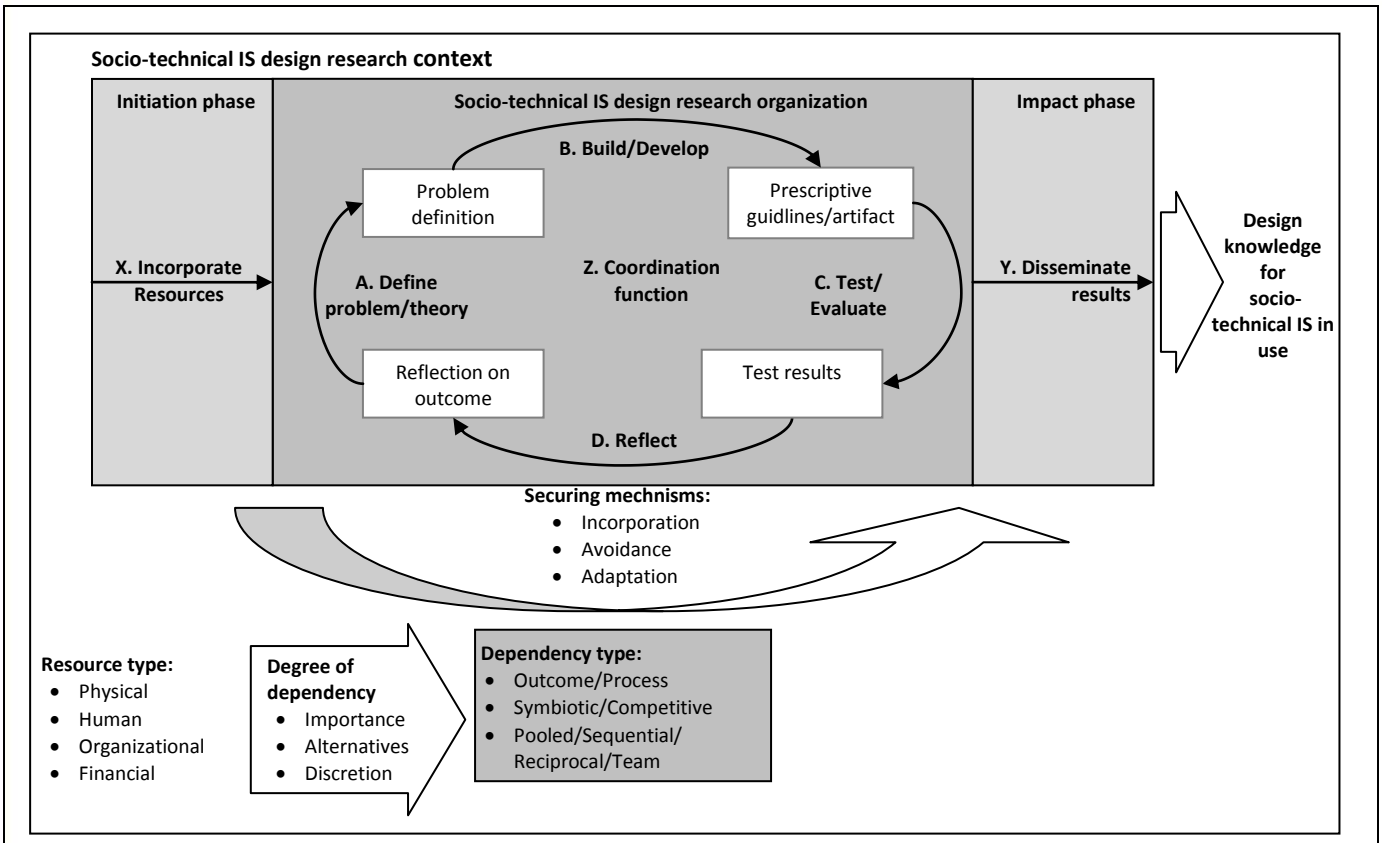

Figure 2. A Revised Model of Resource Dependencies in the Extended Socio-Technical IS Design Research Process

the project, convincing organizations to join the collaboration and securing the essential resources. The IS design research project is still depicted as four iterative activities that are dependent on resources in the external environment. What is new compared to Figure 1 is the coordination function (Z), which was a core activity of the eCustoms project. In other respects, the figure follows the same logic as Figure 1. Physical, Human, Organizational, and Financial resources exist in the external environment of the activity system of IS design research. The importance, alternatives, and discretion of these resources determine the key resources to be secured. Depending on the nature of these key resources, the resources are secured by different mechanisms.

Implications for IS Research

The research in this article was initially motivated by the argument that setting up and pursuing socio-technical IS design research is something very different from setting up and pursuing IS research with the ambition to develop descriptive or explanatory theory. Although the three analyzed cases addressed very different parts of the socio-technical IS design research spectra, they have in common that they tell stories of how IS researchers have worked tightly with business organizations (and governmental authorities) to achieve the results. The dependency on external resources was high in all four of the originally identified phases of the IS design research cycle, as well as the pre- and post-research phases of the extended cycle. We believe that recognition of the high dependency is a first step toward a successful socio-technical IS design research.

Compared to traditional IS research, the three cases depict scenarios where the involved researchers had to use skills and knowledge normally not associated with research. In all three cases, IS researchers had to assume the role of project managers and coordinators. The commercial partners had their specific interest for participating in the projects, while the researchers were seen as representatives of the common good, with no particular stakes in preferred outcome, apart from innovative research results. In the eCustoms project, perhaps the most important contribution by the researchers was bringing the knowledgeable actors from various organizations to the same table for a workshop on improvements in the customs process. Due to the sometimes political circumstances and distrust, it was found necessary and appropriate with the academic representatives acting as neutral mediators. They played a key role in making sure the concerns of the different parties are taken into account. Once in the same room, the workshop participants together held the knowledge required for developing innovative scenarios. The neutral university partner was also very instrumental in handling tensions that occurred during the project, such as those

caused due to different notion of time in business and government organizations and in such way prevented clashes that could have put the project on a hold. The skills required by the IS researchers in this approach is significantly different from skills required for making a quantitative analysis of critical success factors for technology adoption or in-depth interviews in order to understand the process of IT standards making. The question is thus whether the IS researchers are prepared for these new tasks. And if not, how can the IS research society contribute to development of these skills among the researchers?

The three cases also depict differences that have implications for IS researchers. Which resources are necessary for the project? The extent to which they can be secured prior to project start is related to scope, scale, and objectives. Scale is clearly a parameter influencing the need for the coordination activity and initiation phase. Scale is also related to scope. The step from developing and presenting practical promising outcomes to ensure the outcomes being used in practice requires a different planning horizon and is much more resource consuming. The step from developing an illustrative prototype to a mature product is a big step.

Many Ph.D. students worldwide are now looking at design research as a potential approach for their thesis work. Clearly, there are advantages to using a design approach. The close collaboration with practice should make results more practical and relevant, which are quality criteria for the work. In addition, the argument can be made that students who have been developing outcomes of practical relevance can be more attractive to the business society after graduation, compared to students that have been concerned only with high level theory building. The design approach does, however, also introduce increased dependencies that amplify risk in the dissertation work. Convincing practitioners to participate in real world testing is a challenging task for any researcher; for a post-graduate student the correct term might be demanding or even impossible. If real world impact is one criteria for successfully performing design research, then there is an issue in that it is hard to see impact being achieved within the timeframe of a dissertation project. In addition, naturally, the expected end of a thesis project is the thesis. A legitimate question to raise is then: Who will take care of disseminating research results once the Ph.D. student has left the project?

The insights from the three cases discussed earlier can provide a partial answer to this problem. As we can see, the three projects analyzed in this article differed in terms of scope, scale, and ambition regarding impact. Clearly large-scale socio-technical design research projects, such as the eCustoms project, require a lot of effort to be set up, and have a high ambition in terms of impact. It is clear that such projects would need to be set up by senior researchers and staff members, and they can even involve a number of universities. While such projects are definitely difficult to set up and require a vast mobilization of resources, they also have the advantage that they can provide grounds for multiple Ph.D. students and researchers to explore the problem from different theoretical perspectives (both design-science oriented and more behavioral oriented), and this can be seen as a good return on the efforts invested. In such cases, while the impact from the research may not be visible within the lifespan of Ph.D. research projects, the commitments made within the broader framework of the research program will require senior researchers and staff members to continue to pursue impact even afterwards. This is exactly the case of what we saw in the eCustoms project.

We can, therefore, see the various possibilities for getting involved in socio-technical IS design- research projects, and these can range from small-scale project set-up for a specific Ph.D. context to large-scale projects, where numerous researchers can benefit from the same set-up. We are strong advocators of design research due to its potential for increased research relevance, but it is important to acknowledge that there are issues to be solved, to the extent that possible dependencies can be secured in advance or at least alternative plans can be developed. In this process, developing and enhancing the necessary management skills required for initiating and carrying out the design science research process seem to be a necessary area in which researchers would need to invest.

VI. CONCLUSIONS

This article has developed an initial model for resource dependencies in socio-technical IS design research. Behind the model is an integrative approach to RDT and IS design research-literature, and an empirical investigation of resource dependency in three socio-technical IS design research projects. The three projects represent the variety of socio-technical IS research in scale, scope, and objectives. Findings are naturally not directly transferable to all other IS design research but may serve as an indication of what has to be considered when planning and setting up IS design research. The main findings differentiate socio-technical IS design research from “traditional” IS research. Our research suggests that socio-technical IS design research:

- requires long lasting relationships with a multitude of actors for its completion
- needs an impact phase to convince resource controlling parties to participate in the project

- may use incorporation of resource controlling organizations, in the presented case technology providers and organizations for testing the designed artifact, as strategy for securing resources as conditions and plans change as the project progress
- requires extensive coordination and management due to the internal reciprocal and sequential dependencies
- is primarily dependent on human and organizational resources, referring to the resource taxonomy by Barney [1991]

We have made the following contributions by the research presented here: first, we have developed an initial model for resource dependencies in socio-technical IS design research. Second, we have used the model to explain resource dependencies in three specific socio-technical IS design research projects. With these contributions, we increase the understanding of how to conduct IS research under the design paradigm. Addressing IS design research with RDT is one of many studies that we see as necessary, as the design approach is gaining a stronger foothold in IS research. The new way of doing research demands a new set of skills and knowledge from the researcher and capabilities from research organizations, such as universities.

This article has contributed with an understanding of how resource dependencies that are critical to the design research process can be secured. In essence, we suggest that this can be achieved through an iterative process, comprising: (1) identifying external resources, (2) assessing degrees of dependencies, (3) identifying key resource dependencies, and (4) securing key resource dependencies. These phases need to be reflected on prior to embarking on a design research project, but also throughout such projects, as unexpected things often occur.

An important contribution of our article is to support IS researchers in being able to conduct successful socio-technical IS design research projects. There may be a need to reconsider the education of doctoral students differently or to provide project management courses to post-doctoral researchers. There might also be a need to reconsider the valuation of characteristics when hiring new faculty or doctoral students, with greater significance given to abilities to interact with practitioners and communicate research to a nonacademic audience. The increased importance of nontraditional research skills, such as theory awareness and paper writing potential, is somewhat in cinch with the development toward valuation of researchers and research institutes by publication output that currently takes place in many countries. In the future, the ability to manage large research projects and to collaborate with practice will become a necessity, and, therefore, such efforts need to be rewarded.

It should be recognized that our research and conclusions are based on an implicit understanding of socio-technical IS design research as a type of collaborative research. The collaborative nature, and the resulting complexity in orchestrating actors, was a recurring theme in the occurrence and resolving of resource dependencies. All of the three cases also had features similar to action research approaches. This is no coincidence since the prospect of solving organizations' IS problems seemed to be an essential driver in attracting the essential commitment from non-academic organizations.

We believe that regardless of the type of IS design research much is to be learned from professional organizations and existing models on project management carrying out IS design research. But the particularities of socio-technical IS design research should also be acknowledged: not only the specificity of IS and knowledge of IS management/use as output, but also the frequently close connection to theory that differentiates socio-technical IS design research from most development projects. Among the studies that would enhance the understanding of socio-technical IS design research, we see an application of risk analysis frameworks [e.g., Baskerville et al., 2008]. For future research, we also recommend that more attention be devoted to the differences between IT-artifact centric and socio-technical IS design research. The nature of the design output should logically affect which activities need to be carried out and also show that organizational resources and human skills are the most critical resources.

ACKNOWLEDGMENTS

This research is part of the integrated project ITAIDE (Nr.027829) funded by the 6th Framework IST Programme of the European Commission (see www.itaide.org). The ideas and opinions expressed by the authors do not necessarily reflect the views/insights/interests of all ITAIDE partners.

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Communications of the Association for Information Systems

ISSN: 1529-3181

Communications of the Association for Information Systems