

# Software Component Allocation in Distributed Development Settings

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**Abstract.** Outsourcing in software development projects has become a widely adopted utility model for dealing with competitive issues such as cost pressure and the lack of skilled human resources. Established outsourcing relationships in terms of captive offshoring centers or client-vendor partnerships are prone to fail due to the lack of qualified outsourcing decisions for the allocation of software components to either in-house or external/offshored development. Therefore, this design-oriented research endeavor aims at developing a methodology and a corresponding tool to inform and improve the outsourcing decision in global software development projects on the basis of software components. For that reason, the results of explorative case studies researching outsourcing decision making as well as concepts of collaborative software development are combined and form the proposed methodology for supporting project leads in decision making and in avoiding of instinctive and spontaneous decisions on the allocation of software components.

## 1 Introduction

From a national and global perspective, the sourcing of application systems has significantly matured and been widely adopted over the past years. A significant amount of software companies nowadays engage in software development outsourcing (SDO) as they expect benefits such as cost reduction, round-the-clock-development, or additional skilled workforce [22, 20, 21, 6]. However, the success of outsourcing relationships in the IT sector is limited as about half of SDO projects are prone to fail [26]. A critical aspect for the outcome of outsourcing relationships is the sourcing decision [20, 21]. However, despite the vast amount and the variety of studies that analyze the outsourcing decision in SDO, the decision making of outsourcing clients on the allocation of software components has not been thoroughly analyzed in Information Systems (IS) research yet. However, a deeper understanding of the sourcing allocation behavior could on the one hand lead to contributions to the theoretical body of knowledge in terms of sourcing behavior and on the other side it could improve the sourcing strategy of software companies and thereby have a positive effect on the SDO outcomes like less software defects or better customer satisfaction.

From a global software development (GSD) perspective firms have to deal with collaboration of team members that are separated in different locations. Since separation in terms of location or time challenge GSD projects in regard to their success, collaboration platforms and smart concepts for communication and collaboration have been established. Amongst others, traceability has become a widespread methodology in GSD for controlling, tracing, and decision making in globally distributed software projects [16, 14].

As stated above, the sourcing decision of software components has only been scarcely researched while the development setups of companies have shifted to a global perspective. Hence, GSD provides approaches and concepts that fertilize the decision making in SDO. For that, the research questions of this doctoral thesis are as follows: 1) *Which influencing factors have an impact on the sourcing decision of software components?* 2) *How can a sourcing decision for software components based on the influencing factors be made?* These research questions lead to this theory-informed and design-oriented research endeavor including the following research objectives:

1. Developing a methodology to inform the outsourcing decision of SDO projects on the allocation of software components to either in-house or external/off-shored teams and
2. to design and to implement an information system for supporting and informing the component-based outsourcing decision.

The remainder of this research proposal is structured as follows: First, basic information about SDO and GSD as well as outsourcing decisions as foundation of this research endeavor are described in the next section. Following, related research in the area of outsourcing decisions is presented while selected theories providing determinants for the component-based outsourcing decision are introduced. In the consecutive subsection, the proposed approach and its deduction, the used research methodology, and the preliminary findings are described. Finally, this proposal is concluded in the last section.

## **2 Fundamentals**

### **2.1 Global Software Development and Outsourcing of Software Development Activities**

Development of software products in a globally distributed setting is the preferred software engineering mode for an increasing number of companies [18]. In so-called virtual teams, in which team members are spread internationally all over the world, software is developed by decision making regarding a common goal and as product of collaboratively contributed components [25]. Hence, a development team may consist of members from all over the world (e.g. members from Central Europe and Asia) and it is not bound to a single physical location. However, the team as a whole aims at creating a common software product independent from location, time zone, or organizational affiliation [24].

Software development with virtual teams is highly interconnected with outsourcing in software development projects which "is a multifaceted and complex activity in which clients and vendors interact in many different ways to produce and deliver the software services required" [10, p. 960]. This results in different settings of client-vendor-relationships which are considered as outsourcing of software activities to an external provider (classical outsourcing), as outsourcing to an external provider in an offshore/farshore country (offshoring), or as internal provision at an offshore location (captive offshoring) whereof each outsourcing type is challenging differently but is also strongly supported by concepts of GSD [29, 4, 31].

The variety and availability of different outsourcing types are not only means for large software companies. Even small and medium-sized enterprises make use of the described sourcing models as they want to participate in the advantages of GSD and SDO as well, which are for them primarily the access to skilled workforce, the flexibility to allocate and to clear resources, or to save costs [18]. However, a large number of companies struggle to handle several barriers and problems caused by outsourcing settings. Hence, just to name a few, vendor selection, relationship quality, knowledge transfer, or hidden transaction costs are cause for SDO projects that fail, since the goals of a software development project are not achieved in time or with reasonable costs [7, 28, 34].

As a consequence, this research endeavor aims at analyzing the concepts of GSD, especially the concept of traceability and rationale management (TRM), with regard to failing factors of SDO projects. As traceability and rationale information in distributed software development projects represent a network consisting of software development artifacts, connections between these artifacts, and annotations to these connections, the stringent maintenance of such data provides detailed information about planned software components [16, 23]. Since the allocation of software components (in-house vs. external/offshored) in the context of distributed software development is a crucial factor of the success of outsourcing relationships, the focus of this research work is set on component-based allocation decision making in SDO.

## 2.2 Outsourcing Decision Making

Decision making as a part of SDO is a vital element for minimizing the fault-proneness of an outsourcing relationship. It comprises the analysis of multifaceted influencers regarding their implications on the sourcing strategy of a company. Hence, a range of outsourcing decision making approaches has been proposed in past research.

[1] have set their focus on the make-or-buy decision, which analyzes the fundamental type of sourcing by not only focusing on IT functions but also on hardware. Furthermore, [13] have researched decision making with regard to specific IT functions while [11] have put emphasize on contractual issues of an outsourcing relationship. Additionally, decisions have been analyzed in consideration of the sourcing location by analyzing nearshore and farshore [17].

To sum it up, the influencing factors of an outsourcing decision can, according to [20], be categorized in:

- Motivation to Outsource
- Client Firm Characteristics
- Transaction Attributes
- Influence Sources

However, current outsourcing decisions are generally strategic in nature [9] and consider aspects that can be determined on a strategic level before an outsourcing relationship is initiated. For that purpose, several process models are provided by the literature [5]. Decision support methodologies that focus on the allocation of software components, meaning development decisions on the operational level of software projects, are currently missing in IS research, since determinants influencing the component-based outsourcing decision have not been researched in detail yet.

### **3 Decision Making in Software Development Outsourcing**

#### **3.1 Existing Research and Related Work**

The aim of this dissertation work is to analyze determinants and contingency factors that influence the allocation decision for software components in SDO (cf. research question 1). Additionally, this research endeavor seeks to develop a decision support approach for evaluating software components according to their outsourcing potential (cf. research question 2). Therefore, the wheel has not to be reinvented, since there already exist collections and literature synopses of decision determinants as shown by [5] and [20]. They show that the sourcing decision on the one hand depends on firm specific characteristics such as management capabilities and the nature of the activity. On the other hand, the decision is influenced by external environments and, hence, by economic factors. Depending on these factors, the decision can be mapped on different potential sourcing options – e.g. in-house, outsourced, captive offshored, or externally offshored [27]. However, the focus has not yet been set on specific software development tasks but only on a project level which disables component-based sourcing decisions. The collection of factors influencing the decision making is still expected to be incomplete.

Support of the decision making process in SDO has experienced little attention in IS research only. Similar to determinants and contingency factors in the paragraph above, decision making processes have been developed on a strategic level thoroughly but have been unattended on project level, where the question of component allocation arises. Thus, the dynamic model of offshore software development by [5] serves as existing research model for outsourcing decision making on project level, however, the granularity of the decision making process only allows to evaluate entire projects or development phases, but not software development tasks in terms of components. Another contribution delivers a decision matrix with best practices for a possible organization form according to

the decomposition of the product development [33]. Hence, a structured and rigorous component-based decision making in SDO remains open and is the aim of this dissertation endeavor.

### 3.2 Selected Theories

In the course of a theory informed design science research approach, relevant theories from IS literature that are used to inform the search for decision determinants have been selected and are explained in the following: The *Resource-based View* (RBV) considers a firm as a set of productive resources [2, 35]. It explicates that the set of resources contains a subset that is responsible for achieving competitive advantage and another one that enables superior long-term performance. Hence, the company is able to prevent resources from imitation, substitution, or transfer.

The *Knowledge-based View* (KBV) has its origin in the RBV of the firm and is a theoretical perspective that regards knowledge as the most important resource of the firm [12]. It states that in case of integrating knowledge from different sources under certain conditions the efficiency is higher when it is performed within the firm's boundaries.

Additionally, *Transaction Cost Economics* (TCE) consider the market participation as costly while identifying conditions under which market governance is more advantageous than internal governance of a firm [36, 37]. Hence, transaction costs have to be considered when participating in the market and the assumptions of bounded rationality and opportunistic behavior of other participants have to be taken into account. For protecting against opportunistic behavior of another market participant transaction costs occur.

Finally, the *Systems Theory* (ST) [32, 3] describes the interactions of complex systems. It states that a complex system consists of several subsystems that interact and are interdependent to a certain degree, depending on the design of the system. An implication of ST is that weak interactions between subsystems lead to an almost decomposable system.

### 3.3 Intended Research Approach and Preliminary Results

In order to meet the intended research goals, the structure of this dissertation endeavor is design-oriented in nature [15] and follows the research approach of theory building from case study research [8]. Hence, a theory-informed artifact is created from conducted case studies. The structure of the intended research work is briefly summarized in Table 1 and is described in detail after this. The descriptions are complemented with preliminary findings, if already available.

In a first step, case studies with eight small and medium-sized enterprises (SME) that engage in GSD with virtual teams have been conducted. The study describes the software development phases that are suitable for outsourcing, organizational and operational aspects of outsourcing decision, and characteristics of software components that qualify for outsourcing (the publication is under review at the moment). The study reveals the need for decision support in the role

**Table 1.** Research Agenda

<b>Step</b>	<b>Results / Planned Activity</b>	<b>Status</b>
Case studies	Identify need for a decision support methodology in SDO projects on the basis of software components.	Done
Deduction of requirements from theory	Deduction of requirements from RBV and KBV of the firm, from ST, and from software engineering principles. Development of a fit model including determinants of the allocation decision of SDO projects that affect software components.	Done
Complement determinants with input from practice	Extend the set of determinants with exploratory case studies to prove the relevance for practice.	In progress
Development of a decision support methodology	Development of an outsourcing decision support methodology for the allocation of software components (in-house development versus external or offshored development).	In progress
Development of a decision support tool	Implementing the requirements of the decision support methodology as mobile web-application by enriching the determinants and contingencies with available data from collaboration platforms of GSD teams.	Planned
Evaluation	Evaluation of the the developed methodology for component-based outsourcing decisions as an empirical study in an organizational setting.	Planned

of a project manager and shows that software development outsourcing is mainly affecting the implementation phase of a software project as software components are allocated either for in-house or outsourced development. Therefore, this research endeavor intends to develop a methodology and tool support for project managers in order to make informed outsourcing decisions for components.

In a second step, requirements for the intended decision support methodology were deduced from theories described in the previous subsection. From the RBV, the KBV, and the ST the following requirements have been derived:

- Software components that are highly interacting with other components of the software system should not be developed over company boundaries (ST).
- The priorities of connected requirements or requirements sets of a component describe the importance of the software component and, thus, increase the competitive advantage of a firm. Hence, the subsystem should not be outsourced (KBV).
- In the case of intense communication between software developers for the planning/implementation of a single component, the development should not be outsourced (RBV).
- Depending on the required knowledge for the software component to be developed, the component is either developed in-house or outsourced, depending on the skill availability. The required knowledge has to be differ-

entiated between functional knowledge, business process specific knowledge, and technical knowledge (KBV).

- The development of a component should not be outsourced if a frequent exchange of information is required (TCE).

Additional requirements were derived from outsourcing literature and software engineering practices in GSD:

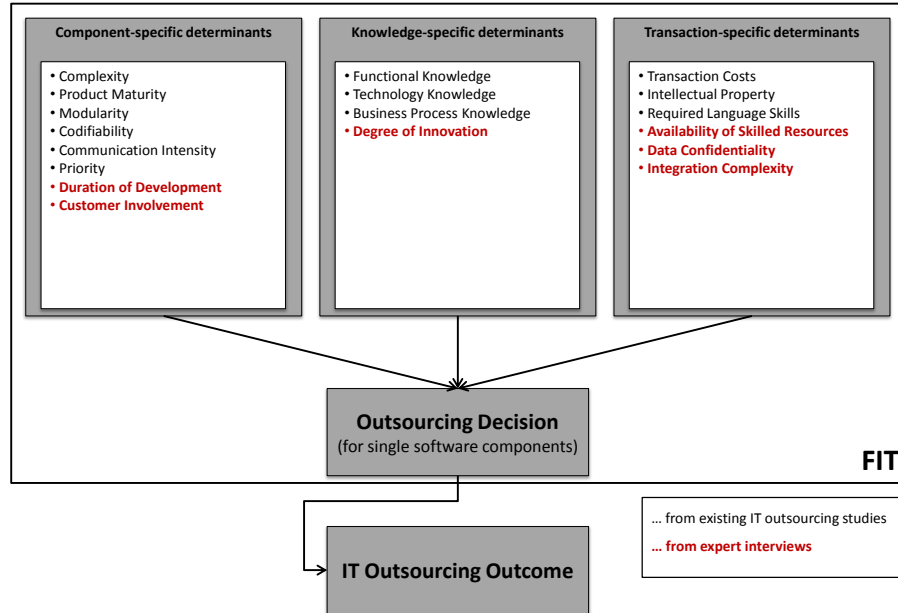
- Traceability and rationale information resulting from collaboration platforms should be used to improve the sourcing decision making process (e.g. use traceability details such as requirements and their connectivity to software components in order to determine the importance of a component by the priority of connected requirements).
- The solution should be optimized for project leads, since they are primarily in charge of outsourcing decision making. Thus, the software tool should be lightweight and should be provided as mobile solution but must not be lacking the interfaces to latest data stored in the firm’s collaboration platform.

As described in Table 1, in a third step, the requirements that were deduced from existing theories are enriched by multiple case studies of an explorative research design. The case studies consist of interviewing experts and reviewing as well as analyzing documents and data of software companies. For this purpose, semi-structured interviews according to a questionnaire consisting of 42 open questions are conducted [38]. The case studies aim at complementing the influencing determinants and contingency factors of component-based outsourcing decision making. Thus, the target groups of the interviews are project leads or deciders of SDO projects in small, medium-sized, or large software engineering enterprises. Currently, six companies have been analyzed and at least six more cases are planned. The preliminary results disclose further determinants and contingencies that influence the sourcing decision. Hence, the SDO decision and its determinants can be modeled by the fit model as presented in Figure 1.

According to the proposed conceptual fit model, the development of a component-based decision support methodology for SDO projects is in the focus of the next step. By incorporating the explored determinants of the outsourcing decision, the approach makes use of the TRM approach of GSD. For each determinant the possibility of using TRM data is analyzed and conceptually described. Hence, this research endeavor aims at informing the sourcing decision to a high degree with structured data from used collaboration platforms and to increase the utility of the proposed methodology. An initial instantiation of the component-based decision support methodology has already been published [19] and is continuously adapted to additional findings resulting from the described expert interviews of the case studies in step three.

Finally, in step five and six, the implementation and evaluation of the conceptual methodology complete the theory-informed artifact building from case studies [15, 30, 8]. The design oriented nature of this dissertation endeavor is further emphasized by a rigorous evaluation framework that checks for the following criteria that are notably relevant in practice: efficiency, practicability,

Fig. 1. Proposed conceptual model



quality of implemented components, rework rate, solution speed of the implementing team/company, and transfer effort. The criteria list is not claimed to be completed yet and is still subject to change. Due to time constraints of practitioners that are sought to evaluate the resulting artifact, it is intended to apply a two step approach which consists on the one hand of a real case evaluation and on the other hand of a virtual experiment based on the real case. In the controlled experiment the findings of the real case have to be refined by further experts.

#### 4 Conclusion

Researching component-based outsourcing decision making in SDO combined with the development of tool support by implementing concepts of GSD is highly demanded by companies in corresponding outsourcing relationships. However, not only the relevance for practice but also the request in academic research for theoretical contribution to outsourcing decision support on a component level lay the foundation for this research endeavor that has the goal to facilitate such sourcing decisions by structured and well informed analyses of the component specifics. At the same time this research work extends the knowledge base of decision making theory in SDO.



The next steps of this research endeavor include the completion of the exploratory phase by conducting the remaining case studies as well as the final definition of the described decision support methodology. Afterwards, the intended artifact in form of a software tool is implemented and used for the evaluation and testing of the underlying methodology.

## Acknowledgment

This doctoral research is being supervised by Prof. Armin Heinzl (University of Mannheim, [heinzl@uni-mannheim.de](mailto:heinzl@uni-mannheim.de)) and is supported by the German state of Baden-Wuerttemberg as part of the research project "GlobaliSE".

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