Adoption of Open-Source Software

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ABSTRACT

Although the open-source software (oss) adoption is highly discussed in public, the same topic has not drawn much intention in research. This work is closing the gap by presenting a detailed analysis of open-source software adoption. We construct a new model to explain the adoption of oss within this paper. Therefore, we do a meta-analysis of established oss migration studies and identify the factors which are influencing the decision to adopt oss in companies. To evaluate this model we perform a case study. The statistical results of this study are also used to classify and compare the influencing factors and the case study's participants.

Keywords: Open-source Software, Adoption, Adoption Research, Adoption Model, Case Study.

INTRODUCTION

Open-source software (oss) has become an highly recognized phenomena in recent years as the source code is freely available and the products often free of charge. In the past, open-source-products focused on a few, often specialized areas of application but nowadays a vast spectrum of oss, ranging from operating systems to office products, exist. Most of these products are similar to commercial once. Not only is the functional range comparable but also the software quality. This results in an increasing proliferation of oss in companies, organizations and the public administration.

Although the open-source software adoption is highly discussed by these organizations, it is astonishing that this topic has not gained much attention in the research community. This work is closing the gap by presenting a detailed analysis of open-source software adoption in companies. Therefore, we will answer the following research questions: Which factors influence the adoptions of open-source software? How does a model to explain the adoption of oss look like? Which findings regarding the adoption of oss in companies can be derived from such a model?

To answer these research questions, we present our research methodology (case study research) in Section 2. In Section 3 we introduce the foundation of adoption research, fist in general and second for the application to oss. Furthermore, we discuss the strength and weaknesses of existing approaches and develop a model to explain the adoption of oss in Section 4. In Section 5 we apply this new model within a case study. This paper will close in Section 6 with a summary of the most important results.

RESEARCH APPROACH

Several analysis of the most important approaches in implementation research have shown that two methods prevailed in recent years. These two methods are the survey and the case study method [4]. Overall the survey method is used most often. However, by looking closer at the geographical differences one can see that the two methods are nearly equally distributed in European publications [4, p. 7]. Furthermore, Choudrie and Dwivedi show that the application of one of the two methods is also determined by the objectives of the analysis [4, p. 6].

Research which breaks - like this one - new ground and where the objective is to develop new models to explain an issue, usually exploit the case study method. In contrast, the survey method is usually used for research which validates existing models. Based on this information, the case study method seems to be the most promising approach for this work and will be used within this paper. Yin defines a case study as follows: "A case study is an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" [21].

INTRODUCTION TO ADOPTION RESEARCH

Definition

The term adoption goes back to innovation research and describes in this context the decision of a person or organization to accept an innovation. Within this work the term also subsumes that the decision to adopt includes "the positive attitude [of a company] toward an innovation and the decision to use resources for the implementation of this innovation". Despite this focus, one can not equate the term adoption with the broad and lasting application of innovation. In fact, the adopter can desist from a further use of this technology if the expectations are not met, the technology is subsidiary or other reasons motivate it. This is the point where the decision-oriented adoption research differs from the more user-oriented acceptance research [2].

The term adoption is closely linked to the term diffusion. Diller defines diffusion as follows: "Diffusion is the aggregated result of the adoption decisions of the members of a social system (individuals, groups, organizations)" [8]. Therefore, diffusion is often defined as the result of the sum of all adoption decisions [10, p. 39] and mainly goes back to the work of Rogers [15] [16] [17] [18]. Based on statistical analysis, Rogers differentiates five categories of adopters over time,

- innovators: 5% of all adopters
- early adopters: 11% of all adopters
- early majority: 34% of all adopters

- late majority: 34% of all adopters
- laggards: 16% of all adopters

Review Of Existing Adoption Models

Several models exist in research, which describe the adoption of innovations - especially the adoption of open-source software. In the past, researchers developed a broad range of **general adoption models** which are usually empirically validated. Therefore, it is difficult and not useful to list all existing models. Despite the long research tradition in adoption research and the large number of general models, only a small number of **oss-specific models** exist. We will select and present four of these models more in detail. The models are:

- Model for open systems adoption from [3]
- Open-source platform adoption model from [5] [6]
- Conceptual model for the enterprise adoption of open-source software from [13]
- Commercial adoption model of open-source software [11]

First, we will have a closer look at the model which explains the **adoptions of open systems** from Chau and Tam [3]. The authors use a theory-building research design. Based on their own research and the model from Tornatzky and Klein [19], they developed a framework to explain the adoption of open systems. This framework was finally evaluated and expanded with a survey of 89 participants. After summarizing the results from Chau and Tam [3], one realizes that only three of the seven factors, which the authors use during their analysis, have a statistically significant impact on the adoption decision. Therefore, the part of the adoption decision which the model explains is with 14.0% relatively low [3, p. 13]. From these results, the authors derive several implications for future research. They propose to use more factors (e.g. technical knowledge of a company are the competitive position of a company).

Dedrick and West [5] [6] select a similar approach like Chau and Tam [3] within their **model to explain the adoption of oss**. They also use an explorative, theory-building research design to identify the relevant factors. In contrast to Chau and Tam [3] they do not use a quantitative approach but a qualitative design based on the grounded theory. The authors did 15 structured interviews with employees from ten different companies out of different industries. The result is a list of 17 factors, which the interview participants marked as a significant impact on the decision to adopt an innovation. It is not possible, not only because of the qualitative research design, to quantify the scale used by Dedrick and West [6]. The scale contains citations of the individual interview participants, which are hardly comparable without a concrete knowledge about the corporate environment where they are coming from. (e.g. "Phasing out Unix" and "Internet and Database Applications" [6, p. 242]).

The next model is the conceptual **model for the enterprise adoption of open-source software** from Kwan and West [13]. Analogical to its description, the model is of conceptual nature, this means that it is theory-based. In fact, the authors mention different interviews as an extension to the theoretical foundation. However, they do neither explain the survey method, the outline, the interview questions nor the number of participants.

Last, we will have a closer look at a **model to explain the commercial adoption of open-source software** from Glynn, Fitzgerald and Exton [11]. The model was developed with a case-study design. First, based on an analysis of several adoption models, the authors created a new model. Second, this model was operationalized and third, the new model was evaluated with a large survey of 111 members in different industries in Great Britain. Glynn et al. show that the 13 out of 16 factors have a large significance as they have a significant correlation with the adoption decision. Furthermore, they could prove a significant correlation between the factors company size, risk awareness and the availability of resources. A further analysis of the results was not done.

Although several models to explain the adoption of oss in companies exist, one can see that they all have restrictions. The need for a new, funded model to explain the adoption decision for this sector is immanent.

CONSTRUCTION OF THE OPEN-SOURCE ADOPTION MODEL

We discussed several models in the last section, which can be used to analyze companies' decision to adopt oss. Based on this discussion and the weaknesses of existing models, we will develop a new, oss-specific adoption model in this section. This model will be the foundation for a case study.

Several (professional) studies exist, which can help companies to decide whether an implementation of oss makes sense or not. These studies were mainly done by well-known market research companies (e.g. Gartner Group, Berlecon Research, Yankee Group, TechConsult, IDC). They usually used accepted methodical and statistical tools to develop these models [1]. We selected 36 studies to derive the influencing factors on the adoption of oss as a basis for the following analysis. A first overview over the 36 studies resulted in a list of 153 influencing factors. All these factors represented different aspects in different granularity of an adoption decision. For example, this list includes a very broad factor like the company's characteristics and very detailed factors like the test period for the open-source software.

As these factors were overlapping and sometimes even similar, we decided to structure the factors again. Out of the 153 factors from the first step, we distilled 44 basic factors. These 44 factors were compared to each other and after that we finally identified 29 different influencing factors (cp. Figure 1). The influencing factors contain not only factors which encourage the adoption of oss, like the free of charge or cheap availability of oss, but also factors which constrain the adoption of oss. The complexity to implement open-source software is such an example.

The large number of factors motivated us to classify them with the help of existing adoption models. Most models are dominated by three classes of technological, organizational and external conditions. This classification can be found in the general adoption models (cp. [7] [20]) but there are also several oss-specific models which use them (cp. [3] [6] [11]). By using a similar classification we are also able to better compare our results with other models.

- *Technology*: The dimension technology contains all influencing factors which can be directly linked to the technology. The technology is in our case the open-source software.
- *Organization*: The adoption of a new technology is also influenced by the organizational surrounding. Examples for this category are factors like the cost for training or planning the migration.
- *External Context*: The external context is the last of the three dimensions and describes factors, which are independent from the technology and the organization. Usually factors like the availability of professional support or the missing liability of oss are part of this category.

To assure the significance of the identified factors, we asked oss-practitioners to evaluate the relevance of these factors in an adhoc-survey. Therefore, we built a survey based on all influencing factors and the concrete specification and definition of this factor. Based on the positive experience with such a scale in the past, we used a six-stepped scale again. The scale goes from very relevant (1) to not relevant (6). Overall we asked 59 participants on open-source-conferences to fill out the form. The result shows, that two factors were marked as very relevant (1), 20 factors as relevant (2), seven factors as somehow relevant (3) and one factor as hardly relevant (5). Based on the argumentation in Section 3 we decided to integrate all influencing factors in the adoption model and therefore in the following case study. The categories and the remaining 29 factors can be found in Figure 1.
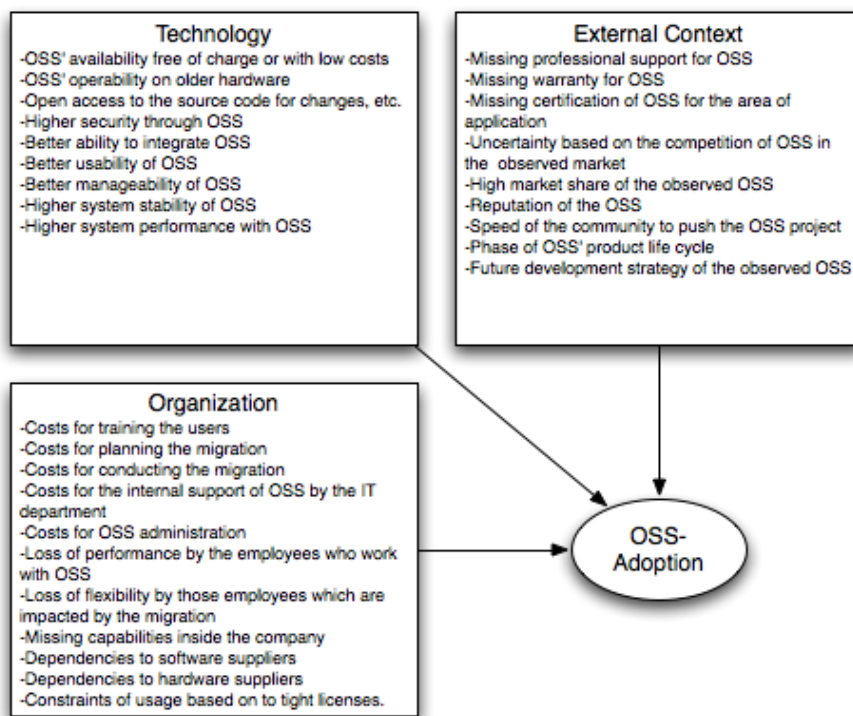

Figure 1: Model to explain the adoption of oss in companies

EVALUATION OF THE OPEN-SOURCE ADOPTION MODEL

Until now, we developed a model to explain the adoption of oss in companies. This model was based on a meta-analysis of several other studies. To evaluate the model, we will now design a case study.

Based on the objective to explain the adoption oss in companies, it is important that the described adoption model has to be evaluated in practice to gain valuable results. Therefore, we transformed the model into a survey, which was filled out by participants of different industries, branches, positions and oss-degrees of adoption. The objective of this survey was to evaluate the significance of this model for oss and to identify further insights regarding the different influencing factors and how they are interacting.

Project Setting

To evaluate the model, we transferred it into a survey. This survey covered two parts. First, a general socio-demographic part and second, a specific part in which the focus was on the 29 factors of adoption. In the general part, we asked for the participants'

background. This included her own position in the company, the profile of the company and how the company already deployed open-source software. For the latter information, we used a seven-step scale which was based on research done by Fichman and Kemerer and Glynn [11] [9]:

- **Unknown**
- **Awareness**
- **Interest**
- **Evaluation**
- **Decision to adopt**
- **Restricted use**
- **General use**

The specific part was mainly about the different adoption factors which we identified in the meta-study. We used a simple evaluation schema to allow a fast response to the already long list of factors. Therefore, we operationalized each factor, like it was done by [11], with only a single question. This methodology is accepted in adoption research on the organizational level. We decided that the survey's participants should rate each identified factor on the rating scale. The scale had six steps from not important (6) to very important (1).

Results Of The Case Study
In the next sections we will present the results of our case study. Overall, we contacted 263 known participants. Out of these 263 participants 56 took part in the case study. This is a rate of return of 23.23%.

Correlation Analysis
The correlation analysis is a statistical method, which aims at the degree and direction of correlation between two sizes and is often used within adoption research. A positive correlation of a variable with the adoption is known as adoption supportive (+) and a negative correlation as adoption retardant (-). The correlation analysis will be used with the same objective within this paper. Although the correlation coefficient is already a first sign of a similar development of two factors, we have to add the significance level. A higher significance level shows that the similar development of two variables is not random [14].

In our study, the correlation analysis proved the factors which supported an adoption and the factors which retard an adoption. Furthermore, we calculated the significance for the correlations. This analysis showed that only 13 of the 29 influencing factors (44.4%) correlated significant with the adoption. Such a number of factors is not unusual but was also found in other studies [3]. The other factors should be seen as noise and therefore eliminated from the model to improve its significance.

Factor Analysis
Another established method to identify common dimensions behind a number of variables and influencing factors is the factor analysis. The application of this analysis is useful, if a high correlation between different variables exist and one assumes that these variables measure a common dimension. Within the adoption research the factor analysis is often used (cp. [9]). This method is typically used to identify or confirm a common dimension of different influencing factors. For the factor analysis, we have to select the number of factors to extract. According to the convention to select factors with an eigenvalue of larger than one, we identified four factors. As mentioned in literature, we just interpreted factor loading with a value of larger than 0.5 [12].
The first identified factor can be interpreted as the **Technical Advantages of OSS**. This factor interpretation is similar to the factor **Relative Advantages** which was formed by Rogers [18]. We grounded this study on the technological features and characteristics of open-source; therefore we stepped away from the relative advantages and put the technological aspects into the focus. The second factor is regarding to the categories organizational aspects. Therefore, we interpret this factor as the **Anticipated Costs of Implementation**. This factor has an eigenvalue of 2.64 and thus is a very strong factor. It can be seen as the counterbalance to the technical advantages of oss. In adoption research the costs for implementing an innovation is often seen as something which reduces the relative advantage [18]. The third factor is the **Perceived Inadequacy of OSS for an Operational Area** (eigenvalue: 1.36) and the last factor is the **Existing Dependency** of companies with a week eigenvalue of 1.14. The **Existing Dependency** is an organizational factor, which has its roots in the dependencies of a company to software- and hardware suppliers. Regarding the impact, we anticipate that if this factor gets stronger it also results in a reduction of adoption.
We finally analyzed whether the four factors show any correlation between each other. The results were correlations between 0.01 and 0,10 and therefore, we can assume that the factors are nearly not correlated. This allows us to perform further analysis like regression- and cluster analysis. However, detailed results for the latter two methods won't be presented within this paper.

CONCLUSION AND OUTLOOK
During this paper, we first gave an overview about adoption research and the predominant general and oss-specific adoption models. After a critical analysis of the existing model, we proposed a new model to explain the adoption of oss in companies. Therefore, we did a meta-analysis of 36 established oss-migration studies and identified 29 influencing factors on the decision to adopt oss in companies. These factors were evaluated in a first, independent survey. Based on these factors we developed a

conceptual model to explain oss adoption.

This conceptual model was carefully analyzed with the help of a case study. The objective of this case study was to evaluate the expressiveness of this model based on a empirical study. Furthermore, we wanted to gain insights about the influencing factors and how they are linked together. We gave a quick introduction into the case and discussed the methodology of the case study before we analyzed this case with a detailed statistical analysis.

The statistical analysis proved that the influencing factors of the oss-adoption model can be seen as the occurrence of four independent dimensions: **Technical Advantage of OSS**, **Anticipated Costs of Implementation**, **Perceived Inadequacy of OSS** and **Existing Dependency**. Especially the first three dimensions have a significant impact on the final decision to adopt oss in companies. Regarding the evaluation of the proposed model, we were able to prove that 40% of the decision to adopt oss can be explained with this mode. This factor can be seen as satisfying enough for such a model. Different tests of the model's quality did not show any weaknesses. By summarizing all the results in one graphical representation, we visualized the proposed model in Figure 2.

A classification of the participants showed that the well known fragmentation within the implementation research into innovators, early adopters, early majority, late majority and latecomer can be also found within the implementation of oss. However, even if the results suggest the general applicability of our approach, researchers and practitioners should be aware of several limitations mainly originated in our research approach. Further analysis will be required to test and extend the boundaries of the model presented. For instance, the general applicability, the validity and reliability of our results need to be further analyzed in one or more longitudinal field studies including a higher number of projects, different migration strategies, varying implementation levels and even with a different impact on the employees' daily business. Our future work yields into that direction.
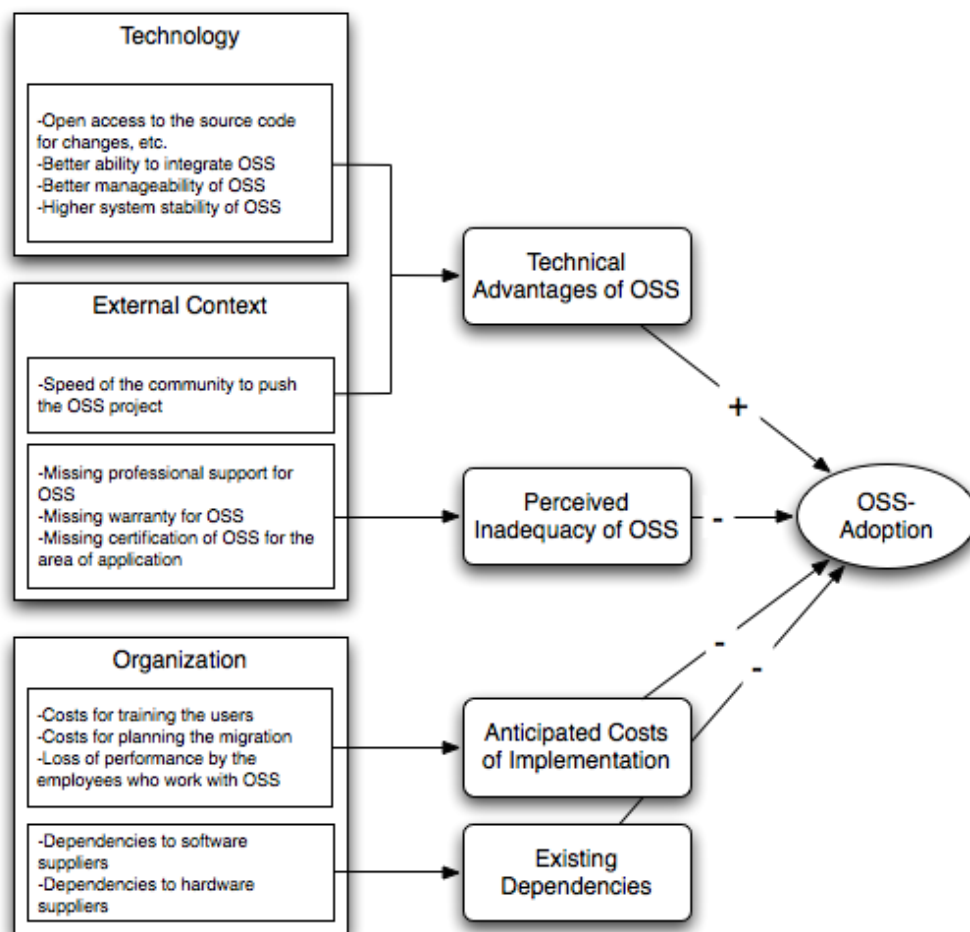

Figure 2: **Case study adoption: Proposed model to explain the adoption of OSS in companies**

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