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Editorial

The mission of the *IJISPM - International Journal of Information Systems and Project Management* is the dissemination of new scientific knowledge on information systems management and project management, encouraging further progress in theory and practice.

It is our great pleasure to bring you the third number of the fifth volume of IJISPM. In this issue readers will find important contributions on Enterprise Resource Planning (ERP) systems implementation in small and medium enterprises (SME), government-driven open source projects, Project Management Offices (PMO) in the public sector, and Business Process Management (BPM).

The first article, "What are the requirements of a successful ERP implementation in SMEs? Special focus on Southern Africa", is authored by Victoria Hasheela-Mufeti and Kari Smolander. As the authors state, many ERP were developed based on the best practices of organizations in which they were developed. These organizations are usually large, and in developed countries. However, small organizations in other parts of the world are also implementing ERP. Implementing a system based on different practices that differ from yours is certainly bound to come with issues. The objective of this article is to identify challenges experienced by SMEs when implementing ERP systems, and to suggest requirements of achieving successful implementations in SMEs in Southern Africa. A thematic analysis methodology was used to explore identified challenges from fourteen SMEs and to identify themes within the data. The study suggested that a successful ERP implementation requires sufficient and appropriate training, reliable internet connection, involvement of end-users, change management, as well as sufficient demonstration of the prospective ERP system.

As Katja Henttonen, Jukka Kääriäinen and Jani Kylmäaho state in the second article "Lifecycle management in government-driven open source projects – practical framework", in many parts of the world public sector organizations are increasingly interested in collaborating across organizational (and even national) boundaries to develop software solutions under an open licence. However, without sound lifecycle management practices, the full benefits of open collaboration are not achieved and projects fail to achieve sustained success. This paper introduces a lifecycle management model and framework for government-driven open-source projects and reports about its use in a real-life case study. The focus is on lifecycle management activities which take place between deployment and end-of-life. The framework was developed iteratively through a series of focus group discussions with representatives of public sector organizations. After the framework had been taken into use in a real-life case project, individual qualitative interviews were conducted to collect experiences on its benefits and weaknesses. According to the initial evidence, the deployment of the framework seems to have brought concrete benefits to the project, e.g. by contributing positively to community growth, software quality and inter-organizational learning.

The third article "Are PMOs really that momentous for public authorities?" is authored by Siw Lundqvist. PMOs are frequently referred to as necessary, or even indispensable, for carrying out projects in multi-project settings, which often occur in public authorities' IT-projects; particularly in times of today's sweeping digitalization. Hence, this research studied Swedish public authorities and their Information Technology (IT) departments' use of PMOs; a survey was directed to IT project managers. Findings showed that even though PMOs are commonly described as significant, those that applied PMOs were fewer than those that did not. This research searched for correlations between the existence of PMOs and 88 variables that resulted in relatively few, mostly weak correlations. A hypothesis test did not show significant association between PMOs' usage and project models' usage. The research contributions are principally that PMOs do not appear to be that significant after all for public authorities, and to have reasonable expectations on PMOs. For practice, the implications foremost concern the importance of understanding conceivable pros and cons.

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As Latifa Ilahi, Sonia Ayachi Ghannouchi and Ricardo Martinho state in the fourth article "BPFlexTemplate: A Business Process template generation tool based on similarity and flexibility", in large organizations with multiple organizational units, process variants emerge due to many aspects, including local management policies, resources or socio-technical limitations. Organizations then struggle to improve a business process which has no longer a single process model to redesign, implement and adjust. In this paper, the authors propose an approach to tackle these two challenges: decrease the proliferation of process variants in these organizations, and foresee, at the same time, the need of having flexible business processes that allow for a certain degree of adjustment. To validate the approach, were first conducted case studies where the authors collected six real-world business process variants from two organizational units of the same healthcare organization. Then was proposed an algorithm to derive a template process model from all the variants, which includes common and flexible process elements. The approach was implemented in a software tool called BPFlexTemplate, and tested with the elicited variants.

We would like to take this opportunity to express our gratitude to the distinguished members of the Editorial Board, for their commitment and for sharing their knowledge and experience in supporting the IJISPM.

Finally, we would like to express our gratitude to all the authors who submitted their work, for their insightful visions and valuable contributions.

We hope that you, the readers, find the International Journal of Information Systems and Project Management an interesting and valuable source of information for your continued work.

The Editor-in-Chief,

João Varajão

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João Varajão is currently professor of information systems and project management at the *University of Minho*. He is also a researcher of the *Centro Algoritmi* at the *University of Minho*. Born and raised in Portugal, he attended the *University of Minho*, earning his Undergraduate (1995), Masters (1997) and Doctorate (2003) degrees in Technologies and Information Systems. In 2012, he received his Habilitation degree from the *University of Trás-os-Montes e Alto Douro*. His current main research interests are in Information Systems Management and Information Systems Project Management. Before joining academia, he worked as an IT/IS consultant, project manager, information systems analyst and software developer, for private companies and public institutions. He has supervised more than 80 Masters and Doctoral dissertations in the Information Systems field. He has published over 300 works, including refereed publications, authored books, edited books, as well as book chapters and communications at international conferences. He serves as editor-in-chief, associate editor and member of the editorial board for international journals and has served in numerous committees of international conferences and workshops. He is co-founder of CENTERIS – Conference on ENTERprise Information Systems and of ProjMAN – International Conference on Project MANagement.

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What are the requirements of a successful ERP implementation in SMEs? Special focus on Southern Africa

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What are the requirements of a successful ERP implementation in SMEs? Special focus on Southern Africa

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Abstract:
Many international Enterprise Resource Planning (ERP) systems were developed based on the best practices of organizations in which they were developed. These organizations are usually large, and in developed countries. However, small organizations in other parts of the world are also implementing ERP. Implementing a system based on different practices that differ from yours is certainly bound to come with issues. The objective of the study is to identify challenges experienced by SMEs when implementing ERP systems, and to suggest requirements of achieving successful implementations in SMEs in Southern Africa. A thematic analysis methodology was used to explore identified challenges from fourteen SMEs and to identify themes within the data. The study suggested that a successful ERP implementation requires sufficient and appropriate training, reliable internet connection, involvement of end-users, change management, as well as sufficient demonstration of the prospective ERP system.

Keywords:
Enterprise Resource Planning; Small and Medium Enterprises; challenges; solutions; requirements; Southern Africa.

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1. Introduction

Enterprise Resource Planning (ERP) continues to be adopted worldwide. It has become an essential part of organizational practices, guiding the operations of many organizations. ERP is known to improve efficiency, performance as well as productivity, and it is regarded as a strategic resource by organizations, providing competitive advantage and a strong market position [1]. It integrates the functional areas via a common database, which also results in an increase in organizational productivity [2]. ERP implementation can however be a costly and complex exercise as it involves large investments, which are usually doable only by large corporations [3].

Even though ERP was often implemented by large organizations, it is now being adopted by companies of all sizes. However, ERP is not a one-size-fits-all solution, because companies of different sizes and qualities do not have the same characteristics. Companies in other regions such as Africa and Asia are also adopting ERP, but they have different organizational culture [4]. In addition, their needs are not the same. For example, their business practices are carried out differently. The IT maturity and computer culture vary from country to country [2] and hence, there are often operational deficiencies. Also, telecommunications, internet and public database systems in developing countries are not as advanced as they are in developed countries, and this also negatively affects ERP implementation in these countries [2]. Some of ERP adopters are small and medium sized enterprises (SMEs). SMEs usually have informal structures, and they have limited resources [5]. However for many reasons they also choose to adopt ERP. ERP is known for efficiency improvement in businesses, cost reductions as well as integration of business processes [6]. These are all drivers for ERP implementation by companies of all sizes.

Even though many success factors have been pointed out by many researchers in studies of Enterprise Resource Planning (ERP) adoption, most of these studies have focused on large enterprises [1], [7]. However due to the differences in how organizations operate, the findings from large organizations cannot be applied to SMEs. The aim of this study is to identify requirements of a successful ERP implementation in the developing countries, focusing on Southern African context. A thematic analysis methodology was used in this study to identify themes across different challenges that SMEs experience when implementing ERP. This provided the authors with a scope to investigate the challenges further and to attempt finding solutions to them. Based on the identified challenges, the study offers guidelines that can help SMEs in the African context to make good decisions when implementing ERP.

The research focuses on SMEs. In order to achieve the aim of the study, the following questions were formulated:

1. What issues do African SMEs experience when implementing ERP?

2. What is required for the implementation to be successful?

The paper is structured as follows: the following section will look at the literature review, section three explains the research methodology, section four presents the findings, section five discusses the findings, and finally section six concludes the study.

2. Background and Related Work

2.1 ICT development in Southern Africa

According to the United Nations (UN) scheme of geographic regions, the Southern African region consists of ten countries, namely [8]: Angola, Botswana, Lesotho, Malawi, Mozambique, Namibia, South Africa, Swaziland, Zambia, and Zimbabwe. In 2001, a declaration of information and communication technologies was passed, with a mission to bridge the digital divide between Southern Africa and the rest of the world [9]. In 2012, about 68,000 km of submarine cable was laid over 615,000 km of national backbone networks in Africa, and this has greatly increased connectivity across Africa. Countries such as Botswana and Namibia acquired high-speed and reliable connectivity via this cable system [10]. With this rapid growth and opportunities that come with ICT, Southern Africa needs to harness the power of ICT, in order to address the challenges that it faces in its development.

Several governments such as that of Botswana have recognized the importance of ICT in its national development, and it has therefore invested in the government expenditure on ICT [11]. The Government of Namibia has also recognized the importance to be a part of the global information society, and it has therefore committed to utilizing ICT in order to reach the objective of moving towards the information society [12]. Despite the poor infrastructure in Lesotho and Swaziland, the governments of the two countries have also taken crucial steps in ensuring the improvement of ICT access within its communities [13]. Even though South Africa is categorized as a developing country, it also has characteristics of an advanced economy, therefore the social and economic development in South Africa is more advanced in comparison to the rest of Southern Africa [14]. The ICT Sector of South Africa continues to grow significantly.

However, despite the big improvement, about 80% of the population is still not connected, and the services are also expensive [15]. There are also high costs associated with telecommunication services [10]. Another issue that Southern Africa faces is the fact that there is still lack of electricity in several rural areas [16], hence it is difficult to make use of technology.

2.2 SMEs in Southern Africa

There is no single definition of an SME. It differs from country to country, and from organization to organization. For example, South Africa defines their SMEs based on sectors in which they belong. The agriculture's small business comprises of 50 or less employees and a turnover of 185 000 euro or less, while a medium sized company consists of equal to or less than 100 but greater than 50 employees and a turnover of less than or equal to 308 000 euro but greater than 185 000 euro [17]. This is not the same for other sectors.

The European Commission defines an SME as "a small and medium-sized organization that employ 250 employees or less and have an annual turnover or less than 50 million Euro [18]. This definition does not differ among different sectors and it is therefore better to use. This study adopts this definition. Table 1 shows a more detailed definition according to the European commission.

Table 1. SME Definition [18]

Company category	**Staff headcount**	**Turnover**
Medium-sized	<250	≤ € 50 m
Small	<50	≤ € 10 m
Micro	<10	≤ € 2 m

SMEs have become an economic backbone globally. Many have extended their domestic activities across national boundaries in order to grow their businesses. However, they often face difficulties in their operations. Financing from financial institutions is one of the main difficulties they experience, and this affects their development [19]. For example, SMEs in South Africa are likely to get financial assistance from banks only when they are in their later stage of development [20]. The lack of access to resources is one of the reasons why the business of SMEs often discontinues, as they often do not have adequate collateral that is required to obtain financial help.

In addition to the limit to market access is lack of efficient channels of distribution. This leads to less purchasing power of customers in comparison to their large enterprises counterparts that have access to wider markets [21].

Developing countries have to endure problems such as unemployment, poverty and weak economic growth [22]. This leads to unstable business environments. Due to several reasons related to the weak economic growth, many people open SMEs in order to be able to sustain themselves financially. A survey conducted in Namibia has revealed that the two main reasons for establishing an SME are the inability to find employment, as well as the motivation to pursue own businesses [23].

2.3 ERP in SMEs in Southern Africa

There are many SMEs in Southern Africa, and the number continues to grow [15]. These organizations are taking advantage of ICT applications and software in order for them to be efficient [15]. However, technology is often too expensive for the majority, and some may not have access, nor the knowledge about ICT. This is more so in rural areas, many of these areas are marginalized.

There are several SMEs that have implemented ERP [24]. There are also many studies that have been carried out in companies that have implemented ERP. For example, Lechesa et al. [25] has looked at the reasons of low SaaS ERP adoption in South Africa, SMEs specifically looking at barriers that affects SaaS ERP. They have identified security concerns, network limitations and cost constraints as the main barriers of SaaS adoption.

Similarly, Faasen et al. [26] did a similar study that looked at the adoption of SaaS in South Africa. IT has looked at the factors that influence the intention of adopting SaaS ERP, as well as barriers that limit the intention. Lack of vendor trust, satisfaction with existing systems, risks of data security, limitation of customization were all found to contribute to the slow adoption [26].

Hasheela et al. [27] also looked at factors that contribute to the reluctance of SaaS ERP adoption in SMEs in Namibia. The results were quite similar to the South African findings. But one barrier that stood out was the fact that there was lack of ERP knowledge among SME owners, despite the benefits that an ERP implementation could bring.

Hasheela [28] has also identified several challenges of implementing ERP in SMEs. The study found many drawbacks and issues that are specific to the developing world such as: network unreliability, poor IT infrastructure, lack of vendors in the region and expensive consultants, etc.

Apart from the few studies that have specifically looked at SMEs in Southern Africa, there are several others that looked at ERP implementation in the general African context. For example, a study by Mutongwa and Rabah [29] found lack of knowledgeable trainers who really understood the business processes. It also identified lack of technical and project knowledge, as well as lack of support from top and middle management. Users did not understand the system but they were expected to use it. The training offered is often not specific to users' processes but was very broad and covered many tasks from different processes. It is usually an all in one training that comprises of loads of information, which results with too much information and little knowledge since their processes are not adequately covered [30]. Munkelt and Volker [30] further stated that too much time lapses between training and operating the actual system. Even though this study was done in a large Kenyan organization, it shows similar challenges experienced in other African countries.

2.4 Critical success factors for ERP implementation

There are several studies that identified success factors for ERP systems implementation. Tchokogue et al. [31] identified a clear vision of the ERP project role, committed top management, involvement of knowledgeable technological experts in the project, training of employees to become instructors as well as adequate management skills as the success ERP factors. Gupta et al. [32] also identified the support of top management, effective change management, effective training as well as effective projections management as the top success factors for ERP implementation. Furumo and Kimberly [[33]41] has identified lack of in-house human resources with project management skills, conflict of interest among shareholders, lack of functionality in the ERP system that supports existing business processes, lack of commitment to change management and insufficient technical knowledge as impediments that hinder ERP success. The study further suggested that allocation of adequate financial and human resources to IT projects as well as careful management of the change process should be a priority in order to achieve a successful implementation.

There are other several studies that looked at ERP implementation success factors. There are summarized in Table 2. But majority of these are done in developed countries. However, there is a difference between developed countries and

developing countries. Some of the main differences are found in culture, infrastructure and the economy [32]. These differences therefore also lead to differences in implementing ERP in countries from the two categories.

2.5 Gaps in research

It is evident that there is lack of research in the area of ERP implementation in Southern African SMEs. There are still questions that remain to be answered. With all issues experienced within the ERP lifecycle, how can they be eliminated in order to reach successful implementation? What is required to make implementation successful? These questions are what this study entails. The research aims to find requirements of a successful ERP implementation specifically in Southern African SMEs.

Table 2. Critical Success Factors for ERP implementation

Top Management Support	[25]–[31]
Training	[25]–[29]
Communication	[29], [32]–[34]
Monitoring & Evaluation	[35], [36]
Business Process Requirements	[37], [38]
User Involvement	[25], [32], [33], [36], [39], [40]
Project Management	[30], [36], [40]
Change Management	[29], [36], [41], [42]
Selection of a good ERP package	[29], [41], [42]
Clear Vision & Efficient Business Plan	[30], [36]

3. Research Methodology

In order to answer our research questions, our study has started with getting information about SMEs implementation experiences by carrying out face to face interviews. For this study, we have used the thematic analysis, a qualitative analytic method that is used to identify, analyze and report themes within data [34]. The process of thematic analysis according to Braun and Clarke [34] starts with searching for meanings and interesting patterns in the data after having read the entire data, as this will help with understanding it. After being familiar with the data, the production of generating initial codes from the data commences [34]. The flexibility of this research methodology allows a researcher to develop themes that are either data driven or theory driven [34].

When coding the data, the researcher writes notes on the analyzed data to indicate identified potential patterns. After coding the data and having a list of codes, the next step is to sort the codes into different themes. At this stage, a researcher analyses the codes and sort them into different themes that are motivated by similarities in the codes.

The next step involves reviewing the themes, dissolving those do not seem necessary after all, and collapsing others within other themes that seem similar to each other and can be merged into one theme. In the next step the researcher has to define each individual theme and write a detailed analysis about it. The final step is to write the report that consist of the final analysis with fully worked out themes [34]. Thematic analysis was chosen because it allows to sort out identified issues into different themes that can be further analyzed.

3.1 Research Instrument

The research instrument used consists of six sections. The first section of the interview consists of general questions such as the interviewees roles in the organization and in ERP. The second section comprises SME specific questions, in relation to the organization environment and its management. The third section consists of questions regarding the ERP system and the reasons behind its implementation. The fourth section is concerned with the people involved in the implementation process such as the external consultants, and any conflicts experienced with the people. The fifth section includes questions related to the experiences with the system, for example: the effects of customization, systems deficiencies, etc. The final section deals with developing countries' related questions, e.g. mismatches between the system and the companies culture.

3.2 Data Collection

Data was collected by carrying out interviews with SME owners and IT specialists. The data was recorded from 14 companies. The respondents ranged from company owners, IT Managers to Programmers. The companies ranged from the size of 14 to 260 employees. All interviews were recorded. The interview duration ranged between 40 to 60 minutes. The aim was to gain enough data in order to create a clear picture of what companies perceive as a successful implementation and how it can be achieved. To complement interviews, an open ended questionnaire was also carried out and sent to South Africa and 5 responses were received. Table 2 presents the information about the respondents.

Table 3. Participants in the study

Company	Company Size (employees)	Role of the Interviewees	Industry
A	120	IT Manager	Motor Vehicle Fund
B	24	Manager: Systems & software	Civil Engineering
C	200	Business Analyst	IT Consultancy
D	240	IT Director	Education
E	90	ERP Manager	Mobile e-Payments
F	200	System Analyst	Auditing
G	50	ERP Manager	Mobile e-Payments
H	260	CEO	Finance
I	14	IT Manager	Reinsurance
J	150	Software Development Head	IT Consultancy
K	170	IT Manager	IT Consultancy
L	200	Operational Manager	IT Consultancy
M	230	Executive Manager	Finance
N	30	Principal Engineer	Civil Engineering
O	200	Owner	Pharmacy
P	250	Head: ICT	Education
Q	190	Programmer	Mobile e-Payments
R	200	Financial Accountant	Finance
S	220	Programmer	IT Consultancy

3.3 Data Analysis

The data was analyzed using thematic analysis. First, we transcribed the data. Then we looked for interesting features in the transcripts. We gave codes to those features and collated them into different themes. We defined the themes inductively according to the coded texts in the data. For example, in this data extract "*There is lack of certified consultants here, and we had to source one from South Africa to assist us on an HCM module, and it was very expensive. There is also lack of technical staff.*" The codes of interest have been underlined, and put under one theme "ERP Actors". The following themes were identified: Business environment, ERP system, ERP actors and Training.

4. Findings

This section looks at the themes that were identified.

4.1 The business environment

The business environment refers to the environment in which ERP is being adopted. It refers to internal and external factors that have an effect on the implementation and the operation on the system. It may include economic factors, legal factors, technical factors, demographic factors which can all have an effect on the company [35]. Business environment differs from country to country, because there is a variation in values and priorities by people from different places [35].

An issue was raised regarding power cuts, which allegedly affect business operations. However, only two of the interviewees raised this issue, and they also stressed that it does not happen often.

> "*When blackout happens, you have to start over because the computer goes off. The work is also affected. You have to login again*." Programmer, Company Q.

Another issue found within the business environment is unreliable internet connections, which affects operations that require internet. The participants expressed their dissatisfaction with their internet services and stated that it affects their services that require an internet connection.

> "*Our main problem is that we sometimes experience internet cut offs when Telecom has problems, we also experience electricity cuts.*" CEO, Company H.

> "*Our web services are sometimes interrupted by slow internet, and sometimes the internet is completely disconnected for some minutes."* IT Manager, Company K.

Another issue identified was that SMEs usually focus on their line of business. For example, in an engineering company, the employees have only engineering expertise. The managers overlooked the need to recruit anyone with right kind of experience, from which followed that the company lacked understanding of business process engineering. No one even had reliable project management skills. In the end, the lack of necessary expertise led to the ERP system being entirely outsourced to external consultants.

4.2 ERP System

This theme includes issues that are related to the ERP system itself. There were complains about misfits between the systems' built in processes and company processes. All the interviewed companies have implemented pre-packaged ERP systems, and all of them were international, as there are no local ERP systems available. However international ERP systems come with standard business processes and they are not a one size fits all.

> "*Our business processes are not 100% satisfied by the processes found in the system. We found out only later that that the system did not provide some calculations we needed. For example, it cannot check whether you have enough money in your budget before you can create a purchase requisition.*" System Analyst, Company F.

The operational costs are also perceived to be very high. The consultants that assist with the implementation are perceived to be expensive.

> "*The consultants are not cheap. We used one company from Windhoek but their rates were exorbitant. But that was the cheapest we could get. And we have a contract with them to be taking care of the maintenance and upgrades*." IT Director, Company D.

The ERP system is also perceived not to be user friendly and users become hesitant to use it.

4.3 ERP Actors

ERP actors refer to all the stakeholders that have a major part to play on the ERP system, namely: the vendor, the implementing company and the consultant. The study found that top management in small organizations lack understanding about change management. This results in conflicts between management and end users. Many company owners specialize in their lines of business and management of organizations can be a challenge.

The study also identified dissatisfaction with vendors.

> "*They didn't make everything clear. I think they have mispresented the system. Have we known better, we would have chosen something much simpler*." Head: ICT, Company P.

Another significant issue was lack of in-house project management knowledge and skills. Similar to change management skills, project management skills are crucial. However, due to the same reasons of small organization specializing in their core business, many of the necessary organizational skills are missing. This results in external consultants taking over the project, including partaking in specifying requirements which they do not necessarily understand. This results in critical functionalities being not well defined. The consultants are also left to make big decisions that can affect the business.

> "*The document management system requirements were not properly understood, hence the system is not fully operational as expected. There were a number of critical systems functionalities that were not defined clearly and as a result not implemented. Some critical reports were also omitted*." ERP Manager, Company D.

> "*At the time of implementing ERP, there was no internal project management capability and hence an external consultant was hired to oversee and manage the implementation process.*" CEO, Company H.

> "*There is lack of certified consultants here, and we had to source one from South Africa to assist us on an HCM module, and it was very expensive.*" Operational Manager, Company L.

4.4 Training

Training refers to developing someone's skills and knowledge. Investing in internal employees and making them part of the implementation process will help organizations, as it will avoid the necessity to engage a third party consultant for even the smallest issues. The interviewed companies however reported unavailability of local training. This was especially so for SAP ERP, which was the most sought after ERP system.

> "*We had to send two of our people to South Africa for training, since we do not have any SAP training available locally. But this involves a lot of costs*." ERP Manager, Company E.

There were also complains in the study, that training was usually done at the end of the implementation after the system goes live, but this was perceived not to be sufficient and it led to lack of confidence in the end users. This caused anxiety among users, as there was no internal assistance to complement the training they initially received apart from manuals that do not always cover all scenarios. This also leads to additional costs to companies for hiring consultants.

4.5 Recommendations to other SMEs

We asked participants this question: "*If you were to advise other companies, what would you advise them to avoid or to do in order to maximize the ERP benefits*?", in order to extract ideas of what other SMEs should do in order to achieve successful implementations.

Communication among stakeholders is deemed crucial during implementation. This was a recommendation by some of the participants.

> "*Communication is vital to ensure all project stakeholders are involved." Head: ICT, Company P.*
>
> *"Plan well in advance, communicate everything to Management Team as this is a big project. Include Line managers in the planning phase. Do a proper Analysis and have clear goals of your objectives. Communication to all staff members is also important. Have a working backup procedure in place. Consult with experts in this field."* Manager: Systems & Software, Company B.

The participants have also emphasized the importance of training and involving everyone who will use the system in order to get their input as it can be useful.

> *"Training is crucial to the success of the ERP project to ensure maximum use of the system post-implementation. Ensure regular refresher training to ensure users are properly trained and able to use all the systems functionalities." Head ICT, Company P.*
>
> *"Involve everyone who will be an end-user at the end, as they have valuable information that managers do not have."* IT Manager, Company A.
>
> *"Also think about training for the users and consultants."* Manager: Systems & Software, Company B.

Figure 1 shows a cause-effect diagram of the challenges identified.

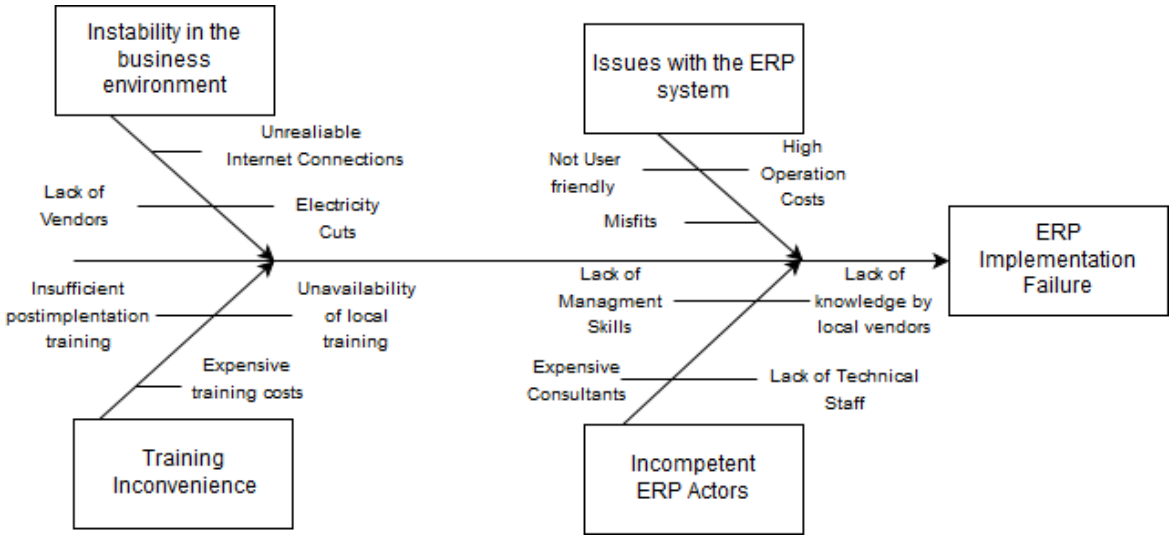

Fig. 1. Cause-effect diagram of ERP implementation challenges in SMEs

Testing is also highly recommended to avoid going live prematurely, which can leave dire consequences such as functionalities not being implemented according to the requirements. Other recommendations include change management, thorough requirement gathering and analysis.

> "*Proper requirement gathering. Everything configured has to be documented. Involve the business in the unit testing. Ensure that all scenarios are tested*." Executive Manager, Company M.
>
> "*Spend enough time in the planning and plan well. Do thorough testing. Do not go live prematurely. Manage the Human resources properly. Stick to the project plan and only accept additions that are beneficial to the project. Record keeping of all documentations is important*." IT Manager, Company A.
>
> "*Change management is also a very important aspect that needs utmost attention to ensure buy-in across the organization." Head ICT, Company P.*

5. Discussion

The research problem of the study is "What are the requirements for a successful implementation in SMEs?" The problem was addressed by interviewing companies in Southern Africa to find out what they have perceived as challenges during and after their implementation, in order to figure out what might be required to solve the problems for future implementation. The study attempted to answer the following questions.

What issues do Southern African SMEs experience when implementing ERP?

One of the main issues we have identified is high implementation and operation costs. This is not unique to our study, as it is also a major challenge to many SMEs [24]–[27]. One of the reasons why especially operation and maintenance is so expensive for small companies is because they seldom have internal staff that can take care of maintenance. Usually ERP project including maintenance services is outsourced to third party companies, which are usually very expensive. It has also been suggested by Lewandowski [36] that SMEs should set up dedicated internal IT personnel. The availability of on-site support will reduce costs of always having an external party to consult [36]. Another finding was that there were misfits between the ERP system and the business processes. One of the reasons was the fact that these ERP systems are all international ERP systems. For example, SAP is originally developed in Germany [37], and Oracle E-Business Suite originates from United States. These systems were designed based on the best practices of companies in these regions. The processes are not one size fits all, and it is therefore not unusual that misfits can happen. Many times customization is necessary to be done to these pre-packaged systems. We have learned that vendor representatives often use their datasets when demonstrating the functionality of their ERP systems. But due to previous studies, this is not recommendable [38]. Seethamraju [38] in his study suggested that companies should only shortlist vendors that would use datasets given by the client company in order to demonstrate the functionality of the solution. This will help companies to decide if the solutions really suit their needs [38]. Haddara [39] also emphasized the importance of choosing the right vendor, one that understands the company's requirements or is keen enough to commit to an ERP project of a small customers. Vendors should also demonstrate their processes to the stakeholders and must be willing to demonstrate all suggested scenarios.

Another significant finding is that users often become hesitant to use the system. We have learned that they usually receive training after the system goes live, they have expressed that the training that they receive is not sufficient. They perceive the system to be user unfriendly. This is because the ERP system is much more complicated in comparison to the legacy systems they are used to.

Studies suggested that it is important to engage users in the implementation process so that they feel that they are a part of the process. This will help avoid anxiety, as well as unwillingness to use to the system. The study by Hasheela [28] has found that large organizations often engage their users in the implementation processes. For example, employees are included in meeting discussions in their respective departments, meeting minutes are sent to everyone, etc., whereas meetings in SMEs are usually strictly for management only, and employees are not engaged during project

implementation. Additionally as suggested by Munkelt and Volker [30], the training is usually broad and covers lots of information and a lot of time lapses between training and operating the system. It is therefore important to have specific training for a specific area in order to avoid bombarding users with overwhelming information.

Another identified challenge is the lack of local training in ERP systems in many countries were ERP is implemented. All the interviewed companies have either implemented SAP and Oracle. In Southern Africa, training for both these are only done in South Africa, This is a challenge for companies in other countries because it is costly to send their people to South Africa each time they need training. However companies should work together to share costs to pay for costs for trainers from South Africa, then it could make training costs much lower. As training could be done at the same time for employers from different companies. In addition to sharing costs for bringing trainers locally, companies could also invest in eLearning training, which has a lot of advantage, as this training is available to the employees at any time. It is important to invest in ongoing training, as it boots the users' confidence in the system [40].

There were also complains about unstable internet connections. This contributes to companies not investing in Cloud ERP. Even though as we have learned that internet is expensive in Southern Africa [15], companies that are interested in Cloud ERP must be prepared to invest in reliable internet connection. There are several excellent internet providers that offer reliable solutions. This may be perceived to be costly, but it is more costly for the work to be disrupted than to pay for reliable internet.

This study has also seen that there are different actors of ERP, namely: the vendor, the implementing company and the consultant. Research has emphasized the importance of commitment these actors should display, and the importance of knowledge in their respective role. For example, it was learned that even though a consultant may have a know-how of configuring the ERP system and running an ERP project, it is important for the implementing system to involve users and train them to have some sort of understanding of their business processes better. It was evident in studies that when consultants or the vendor do not really understand the requirements and the business processes of the implementing organization, the result could be disastrous, as some of important requirements may be left out. Therefore, a workforce comprising of users is absolutely necessary. Also, employees should be engaged throughout the project implementation process to ensure acceptance.

In addition, it was observed that power concentration lies mostly with management, and therefore major decisions lie with management. Based on the characteristics of the main decision maker, and their knowledge about information systems, the company can either win or suffer. For example, it is important when they understand the value of continuous training in order to motivate it.

The study also found that costs constraints was one of the main challenges that were being experienced in SMEs. All companies deemed to find operation and maintenance to be very expensive. Lewandowski, Salako and Garcia-Perez [36] suggested that SMEs should set up dedicated internal IT personnel. As the availability if on-site support will reduce costs of always having an external party to consult [36]. In addition to the costs, it was also realized that sometimes SMEs buy pre-packaged ERP, but they only get to use a fraction of the functionality.

What is required for ERP implantations to be successful?

We have compiled the requirements together as following:

- Investment in reliable internet;
- Training of internal trainers to reduce costs of external consultants;
- Investment in eLearning for the employees to have access to continuous training;
- Training for employees according to the roles they will play;
- Involvement of users in the implementation process;
- Shortlisted vendors must be required to demonstrate their ERP systems using the client's dataset;
- Change management training for managers;
- Project management training for a selected number of internal employees.

6. Conclusion

The purpose of this paper was to identify what is required for successful SME ERP implementation, with a focus on Southern Africa. It has looked at challenges that SMEs in Southern Africa experience and how they can overcome them.

Our study has found that incompetent ERP actors such as the technical staff as well as incompetent local vendors contribute to ERP failure. Our study has also found that insufficient training after implementation and failure to invest in ongoing training leads to resistance by users from using the system.

The study has suggested requirements that can help guide small organizations in developing countries when implementing ERP systems. The study has suggested that organizations should invest in reliable internet connections. This is especially important for companies that want to implement Cloud ERP. Companies should also invest in internal trainers to avoid the extensive costs of external consultants. They should also invest in eLearning so that employees can have access to continuous training. It is also important that training is customized for employees according to their roles. The study also suggested that users should be involved during the implementation process, managers should undergo change management training, and a selected number of internal employees should undergo a project management training to avoid incurring costs of hiring external consultants to manage project management in ERP projects. The study further suggested that prospective vendors need to demonstrate their systems using the datasets of the potential client.

6.1 Validity of the research

It is crucial to address any validity threats a study may hold. Validity refers to the degree to which the researchers results can be trusted [41]. First, the methodology chosen might have pitfalls, which might have affected the results. Secondly, our findings are based on interviews from mostly SME owners and managers, which may be biased and self-centered around the individuals. Thirdly, the findings are based on the Namibian and South African context, which may have different financial conditions from other countries in Southern Africa. Restricting our analysis to these countries may fall short of representing a transparent picture of Southern Africa. It is therefore important that future research should replicate this study in other countries.

6.2 Limitations of the study

Getting results depends of getting access to people, however this proves to be a challenge because not many companies were willing to take part in the study. Only 14 out of 40 requested companies agreed to take part. People in the area were not that opened to interviews.

The second limitation is that, even though cloud ERP is quite common, we could not locate any company that has implemented it. Therefore, we could not learn about the challenges of implementing Cloud ERP, which limited the scope of our analysis.

In this study, we have only looked at commercial international ERP systems. But there is a variety of open-source ERP systems that are implemented by SMEs. It is therefore important for further studies to be carried out in this area, in order to understand challenges of open-source ERP and how they can be contained.

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Appendix A. Interview questions: Challenges of ERP Implementation, Empirical study in SMEs in developing countries

General questions:

- What is your role in the organization?
- How many people are in the organization?
- What is your role in ERP?
- How many people are involved in ERP projects?

SME specific questions:

- Is there any IT department in the organization?
- How is your internet facility in the organization?
- Who are the people involved in decision making?

Pre-implementation questions:

- What was the main aim for introducing ERP in the company?
- How were the following done? (Who were the parties involved?)
    - The decision to select this specific ERP
    - The evaluation process for different products
    - Requirement specifications
    - What challenges were experienced when specifying requirements?
    - What challenges were experienced with evaluating different ERP systems?

Implementation questions:

- Who were the people involved in the implementation process? (Job titles)
- Were the any external consultants involved and what roles did they play?
- Would you say there were any conflicts experienced and how were they solved?

Post-implementation questions:

- Would you say the system is fulfilling its intended purpose?
- What are the main problems that you experience while working?
- Where there any customization done and what effects did they have?
- What would you say have not been met by the system in terms of what was expected?
- Is there any performance evaluation done and in this case how was it achieved?
- Who is responsible for the maintenance of the system?
- What would you say are the main challenges when it comes to maintenance?
- What else would you like to tell me regarding challenges with the ERP system?
- Would you say you are satisfied with the current system?
- If you were to advise other companies, what would you advise them to avoid or do in order to maximize the ERP benefits?
- What are deficiencies of your ERP system if any?
- What would you say about the following?
    - Top Management Commitment to ERP
    - Relationship Between different departments
    - Active participation of end users in the project
    - Necessary knowledge by users using the system
    - Funding dedicated for ERP
    - User training
    - Availability of technical support towards the system

Developing countries specific questions

- Are there any mismatch between the company's culture and the business processes in the system?
- How do you deal with them?

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Lifecycle management in government-driven open source projects – practical framework

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Abstract:
In many parts of the world, public sector organizations are increasingly interested in collaborating across organizational (and even national) boundaries to develop software solutions under an open licence. However, without sound lifecycle management practices, the full benefits of open collaboration are not achieved and projects fail to achieve sustained success. This paper introduces a lifecycle management model and framework for government-driven open-source projects and reports about its use in a real-life case study. Our focus is on lifecycle management activities which take place between deployment and end-of-life. The framework was developed iteratively through a series of focus group discussions with representatives of public sector organizations. After the framework had been taken into use in our real-life case project, individual qualitative interviews were conducted to collect experiences on its benefits and weaknesses. According to the initial evidence, the deployment of the framework seems to have brought concrete benefits to the project, e.g. by contributing positively to community growth, software quality and inter-organizational learning.

Keywords:
public information systems; open source; open-source software; free software; e-government; public sector; software lifecycle management; software evolution; information systems; public sector.

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1. Introduction

In many countries, governments agencies have started to open up bespoke software developed with public funding, often by releasing it under an open source license [1]–[3]. This may stem from governments' desire to spur innovation (by letting all citizens to gain from software at no additional costs) and/or to improve transparency (e.g. by making source code of an electronic voting system subject to public scrutiny) [2]. Another key rational behind open sourcing is a belief that other government agencies, who have similar software development needs, can reuse the software [1]–[3].

For example, in Finland, it was noticed that public sector organizations did not sufficiently co-operate on the field of bespoke software development [1]. In the absence of inter-agency collaboration, software vendors could charge each administrative unit a full price for the same or similar customizations and, thus, in the worst case, the same piece of code was purchased multiple times with tax-payer money [1]. For these reasons, the Finnish Ministry of Finance [4] and Public Administration Recommendations [5] have started to encourage public sector organizations to co-purchase bespoke software and publish it under an open-source license.

However, avoiding duplicate effort by open sourcing is not straightforward. It may be difficult for other organizations to exploit the source code purchased by one organization, e.g. due to lack of support and maintenance, multiple parallel development paths and uncertainty on the future development direction [1], [3], [6]. Therefore, there is a need to build public sector communities around these software initiatives to collaboratively manage the lifecycle [1], [2], [6], [7].

To address these issues, Kääriäinen et al. [1] developed a model where public sector agencies co-produce and co-maintain open-source software products together. However, at the time, the model had not been tested in any organization and its presentation remained abstract. This article concretizes the model introduced by Kääriäinen et al. [1] and demonstrates its practical value. The aims of the study are two-fold: firstly, to develop a practical framework that facilitates adoption of the model and, secondly, to use the framework for organizing collaborative lifecycle management in a real-life case study. The case study is an open source spatial data visualization software called Oskari, which is currently being co-produced by more than ten public sector organizations and companies in Finland.

The authors have studied the concept of the lifecycle management previously focusing on the development phase of the software (SW) product [8]. The emphasis of this article is on the lifecycle management actions taken after the implementation of the first software version i.e. how the developed SW product under the operation and maintenance could be collaboratively maintained and further developed by the group of public sector organizations.

The article is structured as follows. The next section covers theoretical background and related work, reviewing different approaches to change/lifecycle management in software production and summarizing studies on open-source lifecycle management and government-driven open-source software development. The third section introduces the model on which the framework has been built. The fourth section introduces the research approach and methodology. The fifth section introduces the practical framework which supports the deployment of the model. The sixth section demonstrates the deployment of the model and the framework of the Oskari project and reports on the experience gained. Finally, discussion and conclusions are drawn.

2. Theoretical background and related work

2.1 Lifecycle management and software evolution

Software lifecycle management (SLM) is herein understood as a process of coordinating activities and managing resources (e.g. people, money, documentation, technical artefacts) during the entire lifecycle of a software product, from initial ideation to retirement [9]. This definition comes from the application lifecycle management (ALM) literature, but similar issues have also been addressed by studies on software configuration management (SCM) and software evolution. However, SLM is different from software product management (SPM), which focuses solely on managerial actions taken before customer delivery of a software product [10].

Application lifecycle management (ALM) is a relatively new concept [11]. Chappell [12] presents ALM as a combination of three functions: governance, development and operations – and three milestones: (start of) ideation, deployment and end-of life. Development takes place at the beginning of the lifecycle, between ideation and deployment, and then periodically (after deployment) when the application is updated. Operations, which involve monitoring and deployment of updates, always happen after deployment of the first software version. Governance, which means supervising the software's evolution towards predefined goals, is needed during entire lifecycle. The emphasis of this article is on lifecycle management actions which take place between deployment and end-of life. Out of the three functions, most attention is given to governance but development and operations issues are also touched.

Software Configuration Management (SCM) is a much older discipline and can be seen as the basis upon which ALM is founded [13]. SCM is essentially about controlling and tracking changes to the software, and it has been discussed in the literature for more than three decades [14]–[17]. SCM research has significantly impacted software engineering practices [18]. The (sub)areas of SCM provide techniques for change control boards, defect tracking, build and release management, versioning and team/workflow management, for example [15], [17].

The term software evolution was originally used to differentiate from software maintenance which, at the time, was seen as a post-deployment activity consisting only of bug fixes and minor adjustments [19]. Early software evolution literature [20] noted that requirements continue to change and software needs to be adapted during its entire lifetime. Because the idea of iterative software development has become widely accepted, some authors use the terms software maintenance and software evolution synonymously [19]. However, there are two prevalent perspectives to software evolution, dubbed 'what/why' and 'how' by [19]. The former (what/why) refers to academic research on the nature of the software evolution phenomenon, its driving forces and impact [19], [21]. The latter (how) refers to engineering studies on practical means (e.g. technology, methods, tools) to direct, implement and control software evolution [22]. The focus of this article resembles the 'how perspective' on software evolution. However, the authors felt that when talking about the purposeful actions taken to ensure that a software product develops in the desired direction, lifecycle management is a more suitable term.

2.2 Open-source software production in the public sector

The term open source can be used to refer either to a licensing model or a software-development model [23]. Open-source licensing allows anyone to access the source code of the software, modify the software as desired and share it with others by redistributing a modified or unmodified version [24]. As a development model, open source refers to projects where relatively loosely coupled individuals and organizations collaborate to co-develop a piece of software together, typically working over the Internet in a distributed environment [25], [26]. Practices typically associated with open-source development include agile development, meritocratic governance and volunteer participation [26] for example.

During the last decade, government agencies all over the world have also become interested in open-source software development. Several communities or repositories for public sector open-source software development have sprung up, e.g. European-level Joinup, Finnish Yhteentoimivuus and Government GitHub. Joinup is meant for sharing and reusing open-source software, semantic assets and other inter-operability solutions for public administrations. Yhteentoimivuus is a delivery channel for public sector interoperability assets administrated by the Finnish Ministry of Finance. Government GitHub allows government agencies to share code and data on the social coding platform GitHub. While some government-driven open-source development projects have been abandoned, many others are active and continue to grow: CONNECT Health, OskarEMR, WorldWind and CAMAC, for example. Surprisingly, while there is a large body of research on open-source adoption by government organizations, e.g. [27]–[30], very few studies have looked at open-source production by government organizations. The latter are reviewed below.

Mergel [3] studied a context where government agencies share code through a common repository but do not form an open-source project or otherwise co-ordinate collaboration. The most common activity was found to be forking: participants copied the code release of another organization and then possibly modified it for their own needs internally [3]. Contribution back to the original project was not usual [3]. In other words, participants seemed to favor the

relatively passive process of 'copy and reuse' over active collaboration. These findings on government code-sharing mechanisms are in line with [1]: the absence of lifecycle management practices leads to multiple forks and therefore the potential benefits of collaborative development are not fully achieved.

Bryant and Ramsamy [31] analyzed ten open-source projects where public sector agents are key contributors. There are also few academic case studies on specific open-source collaborations in the public sector [32]–[34]. Studies demonstrate that organizational and political factors play a large role in government open-source projects [31], just like many other IS projects in public sector [35]. Success factors include trust between key stakeholders, skilled in-house ICT personnel and steady financial support [31], [34]. Projects were found to be particularly vulnerable to sudden changes in political leadership and loss of key personnel [31], [34] . Some studies underline the importance of retaining the agility/flexibility inherent in the open-source model [31] while others emphasize managerial control [32]. Interest conflicts are also a common challenge. Feldman and Horan [32] note that public and private sector participants had varying perceptions of value propositions. Bryant and Ramsamy [31] report that end users experienced difficulties in making their 'voices heard' over bureaucrats whose budgets paid for the development.

2.3 The community-based software lifecycle management model

Kääriäinen et al. [1] introduced the community-based software lifecycle management model (CO-SLM) aimed particularly at public sector organizations that finance and develop software collaboratively. In this model the term lifecycle management refers to actions taken after the implementation of the first software version. The model is applicable to free/open-source software development but also to other collaborative development models, as long as the licensing is sufficiently permissive to prevent vendor-locking and allows sharing of source code with other organizations. The model is depicted in Figure 1. The community has a common repository where the baseline version of the software product is stored. Each organization can use their own software supplier to take care of deployment, maintenance and customization of the software. However, they are encouraged to inform the rest of the community on changes made and contribute them back to the baseline version for integration. The integration work is coordinated by a 'product manager' and financed as agreed by the community (e.g. costs are equally shared by the community members). Parallel baseline versions are not maintained. The inclusiveness and openness of the development process are safe-guarded via a 'community manager' role.

According to Kääriäinen et al. [1], the core community consists of public sector organizations which have primary authority over lifecycle management decisions. Thus, the community becomes a key decision-making arena: individual government organizations can influence the development goals and evolution of the baseline software product by participating in the community. Very much like in 'traditional' open-source projects, the community can also become an arena for collaborative learning and knowledge sharing (e.g. sharing solutions to common deployment problems) and even collective innovation (e.g. ideating new functionality). Outside of the core community but still functioning as key partners are software companies that are tendered to develop the software [1]. However, in some cases companies may also participate in the community as full community members if the intention is to support the application of the software for the private sector as well (note that the model itself does not limit this). The community manages the software according to the lifecycle management plan initiated by the financier of the first version [1]. The plan defines who will do what and when in relation to the lifecycle management activities (e.g. documentation requirements, versioning model, change and release management practices and financing). Basically, this is a similar job that companies make for software products they own. Similarly, companies have product managers who are responsible for coordinating the lifecycle management actions to software products. However, when the group of public sector organizations start to jointly manage SW products the case is just more complex since there has to be found a consensus between the organizations what are the responsibilities, financing model, rights, etc.

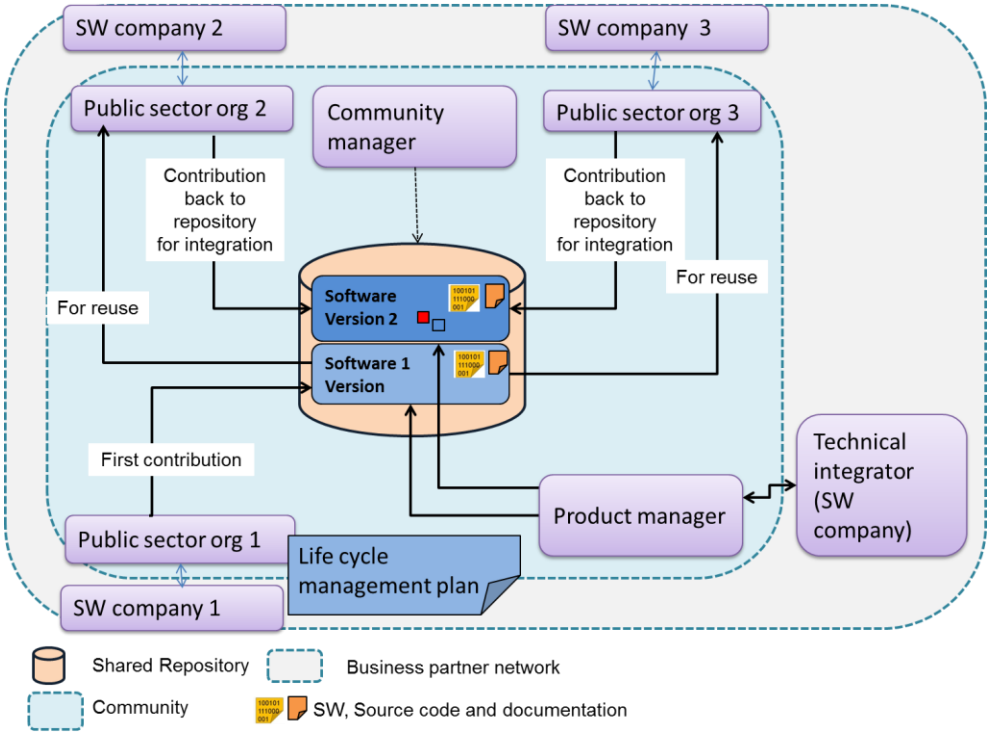

Fig. 1. Community-based Application Lifecycle Management Model

3. Research approach and methodology

The Ministry of Finance, our organization and a number of public sector organizations have collaborated in defining, piloting and deploying lifecycle management as depicted in Figure 2. The model creation process and the introduction to the models were published in [1]. This effort has since continued by piloting the planning of software lifecycle management in practice in the public sector. After successful piloting, the deployment of this model started in public sector organizations (the Finnish Ministry of Finance has accepted the model for production).

Prior and during the pilot phase, we developed the CO-SLM framework that is introduced in this article. The CO-SLM framework is a check list and documentation template to facilitate the definition of project-specific lifecycle management plans for software products. It helps software product communities to define a lifecycle management plan that describes who will do what and when related to the lifecycle management activities in the public sector software community environment. The framework has been tested and refined through deployment in real organizations.

The research presented in this article has an interpretive and an interventionary stance and, therefore, the approach could be described as an 'action case'. The term 'action case' was originally coined by Vidgen and Braa [36] to describe in-context information systems (IS) research which both aims to accumulate rich understanding on an organizational dilemma (interpretation) and to change the status quo in that organization (intervention). The interventionist phase typically takes place later in the research and involves the testing of the previously developed methods [36].

The CO-SLM framework was developed through iterative rounds of data collection and analysis. The primary data collection method was a series of six focus group discussions with information systems experts working in public sector

organizations. There were participants from both municipal (e.g. City of Espoo, the Association of Finnish Local and Regional Authorities) and national (e.g. State Treasury, Finnish Ministry of the Environment) levels of government. In addition, the representative from the Finnish Centre for Open Systems and Solutions (COSS) and a lawyer appointed by the Finnish Ministry of Finance participated some of the sessions. In the discussion sessions, participants were prompted to assess draft versions of the framework and their feedback was used to improve the framework iteratively. The point of saturation was reached after six consequent meetings. In addition to the focus group discussions, six Finnish, SME-sized software companies were asked to reply interview questions by email and clarifications were asked on the phone where necessary. These companies were selected for email interview due to prior collaborations with the public sector and consequent good knowledge of the domain. Complementary data collection methods also included few workshops with the Finnish Ministry of Finance and informal discussions with different stakeholders.

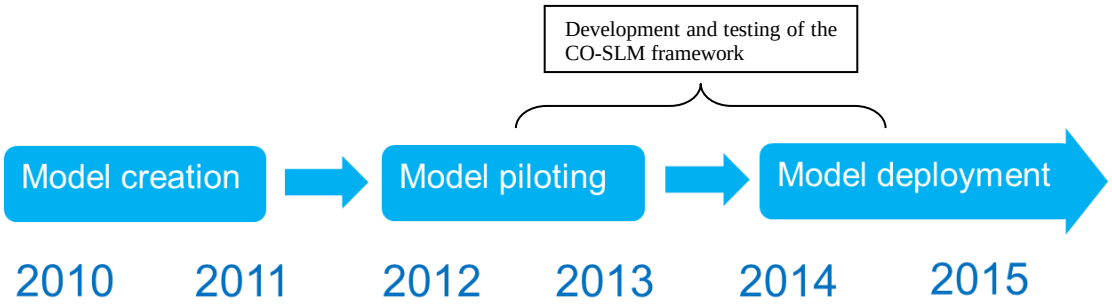

Fig. 2. Timeline for the development of the CO-SLM model

The testing and modification of the CO-SLM framework took place 'in situ' at multiple organizations during the years 2014 and 2015. For example, the National Land Survey of Finland (NLS) and the Ministry of Finance's JulkICT Lab project have adopted the model for their operation. This article explains and analyses its deployment within "Oskari", an NLS-led project which develops an open source geospatial toolkit. The reported experiences are based on two sources: 1) analytical observations from two of the authors who have been engaged in the Oskari project for a long time and (b) lengthy, semi-structured interviews of representatives from organizations who are key contributors to Oskari: National Land Survey of Finland (NLS), Finnish Transport Agency and The Finnish National Board of Antiquities. The interviewees were senior professionals who have co-ordinator responsibilities in the Oskari project, either in technical development or communications. Four out of five interviews were recorded and all were selectively transcribed. The thematic coding of the interview data followed a method called Template Analysis [37].

4. Framework for community-based lifecycle planning (CO-SLM framework)

In this chapter, we introduce a practical framework which helps with the application of the CO-SLM model into real-life situations where public sector organizations wish to develop software collaboratively. The framework focuses on the governance aspect of lifecycle management. The origins of the framework come from the SCM research area. One part of the SCM is a planning activity that forms an SCM plan [38]. The basic idea of the SCM plan is to define who is going to do what, when, where and how in relation to the configuration management [39]. When applied to the context of CO-SLM the goal is to help a consortium of public sector organizations to define what to manage, who will do the management, how the management will be done and how to finance the management and further development of a software product. Financing practices were included in the framework because collective purchasing and cost sharing is a significant and obvious concern for public sector organizations. Figure 3 depicts the four main elements of the product-management plan and Tables 1-4 present each of them in detail. The framework can be used as a check list and

template to form a lifecycle plan for a software product that needs governance during its lifecycle. The following four tables then describe each element in detail. Each element contains issues that need to be considered and documented for any software under management. Therefore, when applying the CO-SLM model and CO-SLM framework it should be borne in mind that each software product – and its associated community – is unique. Thus the model and framework must be applied to suit the context. This means making adjustments to terminology and content when applicable.

Fig. 3. Elements of the product-management plan

Table 1. What to manage?

Issues	Description
Name of the software	What is the name of the software program?
Licensing scheme	What are licensing terms for the source code and documentation?
User organizations	Which organizations will use the software?
Schedule for the first version	When is the baseline version of the software schedule to be ready?
Distribution channel	Where are the source code and documentation distributed?
Social media	Which social media channels are used by the project?

Table 2. Who will manage?

Issues	Description
Owner of the software product	Who 'takes care of' the software product? Who owns the copyright to the software?
Community structure and membership	How is the consortium of organizations structured? Are there community and steering groups? Who has the highest decision-making authority concerning the software product and its evolution?
Product manager (Development Co-ordinator)	Who supervises the software's evolution towards the commonly agreed goals? How is the role mandated? Coordinates the software product-related lifecycle management activities so that the software product evolves in the direction that serves the needs of the community and business.
Community manager (Openness Co-ordinator)	Who consolidates conflicts and protects the inclusiveness and openness of the development process? How is this role mandated? Coordinates the operation in the community. Checks that the licence is used as agreed by the community.

Table 2. Who will manage? (cont.)

Issues	Description
Repository maintainer(s)	Who maintains the shared repository containing the source code and documentation?
Technical integrator (Baseline Developer)	Who develops and maintains the baseline version of the software? Who is responsible for integrating the desired customisations to the baseline as agreed by the community? If the integrator function is outsourced, who does the tendering?
Providers of customisation and deployment services	Who can provide customisation and deployment services on the software product to individual member organizations?

Table 3. How to manage?

Issues	Description
Decision-making bodies	Responsibilities for making managerial and technical decisions regarding software development. How are the decision-making bodies (e.g. managerial board, change control board, steering group) organised, elected and assembled for a meeting?
Collaborative development approach	What are the key principles guiding collaborative development? How are the development efforts co-ordinated?
Road mapping	Who is responsible for creating and updating the roadmap documents? Who is responsible for accepting a new roadmap? Where are the documents located?
Change management	Who can initiate change requests, and how? Who analyses the change requests? How are requests prioritised? Who makes the final decision on what is included in the next software version?
Release management and versioning	How often are releases made? Who accepts a new baseline version for deployment? How are versions named/numbered?
Urgent bug fixes	Who/how to handle urgent bug fixes required to the baseline version already in deployment?
Communications	Who defines and supervises the community's communication strategy? What are the primary channels for internal and external communication?
Documentation	What documents are required and where are they located?

Table 4. How to finance?

Issues	Description
Co-ordination work	How are the efforts of the product and community manager financed?
Repository maintenance	How is repository maintenance financed?
Baseline development (Technical integrator)	How is the further development of the software product financed, including integration of external contributions? How to finance the bug fixes?
Deployment and customisation	Who pays for deployment and customisation work within an individual organization?
Community and steering group meetings	Who pays for organising and participating in the community meetings and steering group meetings?
New entrants	Who can join the community and how? Are there any joining fees?

5. Case study: Oskari software

This chapter presents a real-life case study where the CO-SLM framework has been applied. This chapter is structured as follows. The first sub-section introduces the Oskari case study. The second sub-section presents the lifecycle management plan for Oskari, which is based on the CO-SLM framework and briefly explains how the plan was made. The third sub-section reports on the benefits and challenges of lifecycle management as well as the experiences of using the framework in practice.

5.1 Introduction to the OSKARI case

Oskari is an open source software originally developed by the National Land Survey of Finland. Initially, Oskari was developed to offer easy-to-use browser-based tools to access and re-use information from various data sources, including the INSPIRE Spatial Data Infrastructure (SDI) and the Finnish National SDI. Oskari software has been adopted by about a dozen public sector organizations in Finland, including the City of Tampere, Finnish e-Government portal, Finnish Transport Agency and the Helsinki Regional Environmental Authority. Two major international co-operation projects utilising Oskari are currently running: European Location Services (ELS) and the Arctic Spatial Data Infrastructure (ASDI). The first independent Oskari installations are also emerging outside Finland: the National Land Survey of Iceland has set up Oskari, followed by Agency for Land Relations and Cadastre of the Republic of Moldovia.

Oskari makes it possible to view, visualize, analyze and even edit spatial data using just a web browser and standards-compliant APIs, such as OGC WMS (Web Map Service), OGC WFS (Web Feature Services) and OGC WPS (Web Processing Service). One of the most used features of Oskari implementations is the embedded maps functionality. It enables the user to choose applicable map layers and to create a map client using a WYSIWYG user interface without programming skills. The embedded map client can then be placed on any website in a similar manner as in Google Maps, just by placing a piece of HTML code into the website. The difference is that Oskari leverages standards-compliant APIs, which means that there are thousands of spatial data resources to choose from.

The Oskari network is a consortium of organizations that have entered into a formal agreement to co-develop the Oskari software. Oskari is published under open source licenses (MIT and EUPL) and therefore anyone can download the source code and utilise the software without joining the Oskari network. This means that anyone can try the software without committing to it or even without letting the network know about it, or use and extend it as they see fit. However, it is the appointed representatives of the steering committee member organizations who oversee which developed features or changes are integrated to the Oskari repository. The most important benefit of the steering committee membership is the ability to get support from other organizations and agree on the development goals together.

5.2 Lifecycle management plan for Oskari

The CO-SLM framework was used as a template and instructive guide when writing the lifecycle management plan for the Oskari software. The first draft of the plan was created by collecting existing practices found from websites and documents. Then the plan was discussed and refined to fill in any missing information. The plan template was also modified to be in the line with the terminology of software products and the software community. Finally, the plan was reviewed by the key members of the Oskari software team (the coordinator and the chairperson of the steering committee) and the plan was discussed and agreed (Version 1.0) in a steering committee meeting. The resulting plan is presented in the following tables 5-8 below.

Table 5. Basic information about the Oskari software

Issues	Details
Name of the software	Oskari
Licensing scheme	Open Source. Source code can be utilised using an MIT licence or EUPL licence.
User organizations	Public sector organizations, companies, non-profit organizations.
Schedule for the first baseline version	First public version was released 2011 (first version was financed by the National Land Survey Development Centre).
Distribution channel, repositories	Documentation, examples, etc.: http://www.oskari.org Source code: https://github.com/oskariorg General introduction to the software and the Oskari network (in Finnish): http://verkosto.oskari.org
Social media	Twitter: the @oskari_org Twitter channel reports new releases, bug and security fixes as well as events related to Oskari. The release plan and roadmap are presented on a Trello board (in Finnish): http://oskari.org/trello Slack: Slack is a team communication platform: https://oskari.slack.com

Table 6. Roles and organizations

Issues	Details
Owner of the software product	The Oskari network
Community structure and membership	The Oskari network is the development network for Oskari software that is open for anyone that signs the Memorandum of Understanding. Members (listed in Finnish): http://verkosto.oskari.org/oskari-verkosto/jasenet/
	Organization of the Oskari Steering committee: representatives of projects that exploit Oskari and sign the Integration agreement, coordinator (chosen by steering committee) and 1-2 representatives from the Oskari network member organizations (nominated annually by the Oskari network).
	Members (listed in Finnish): http://verkosto.oskari.org/oskari-verkosto/ohjausryhma/
Technical Coordinator (Product manager)	National Land Survey Development Centre (Jani Kylmäaho, Inkeri Lantta) http://verkosto.oskari.org/oskari-verkosto/koordinaattori
	The coordinator was selected by the Oskari steering committee. The coordinator coordinates (using the available resources) the software product-related lifecycle management activities so that the software product evolves optimally in the direction that serves the needs of the network and businesses. Furthermore, the coordinator facilitates the network and its activities, provides support to the projects utilising the software and works as a secretary for the steering committee. An architecture board meets 2 to 3 times per year to discuss and agree upon changes proposed to the technical architecture.
Community manager (Openness co-ordinator)	The National Land Survey Development Centre has the responsibility for this task as well.
Repository maintainer(s)	Technical coordinator
Integrator (Baseline developer)	The coordinator takes care of the integration work. The selected integrator is responsible for technical coordination, e.g. regarding the architecture of the software core. The integrator takes care of the integration work: coding, testing, version updates, documentation and any necessary IT support. The integrator reviews pull requests proposed by contributors, maintains repositories and core documentation and manages software versions, working in close cooperation with the coordinator.
Providers of customisation and deployment services	Each customer organization that applies Oskari software may select an IT provider for Oskari customisations without limitation. Customer organizations are encouraged to follow the architecture principles defined by the Oskari network if they wish to include modifications or extensions into the Oskari software.

Table 7. Practices for lifecycle management

Issues	Details
Tasks of the decision-making bodies	The Oskari network is open for anyone who signs the Memorandum of Understanding. The agreement describes the goals, tasks and decision-making practices for the Oskari network. The network communicates information about the Oskari software and its development, as well as discussing the future needs of the software. It has a mailing list and communicates actively in social media. Network members are invited to networking days (the steering committee schedules networking days at least once a year). Agenda for networking days: ▪ Status reporting and future activities ▪ Presentations of projects and activities around the software ▪ Selection of representatives of the steering committee Furthermore, developer meetings take place and the architecture group assembles 3 to 4 times each year. The goal of the developer meetings is to collect input that supports the development of the Oskari software core. The tasks of the Oskari steering committee are: ▪ Overseeing the network and planning activities ▪ Choosing the coordinator and setting the annual fees ▪ Prioritising the roadmap ▪ Communicating with the coordinator The steering committee also checks the status of the Oskari network (new members, etc.), communications activities, ongoing development projects, planned development projects, the roadmap and updated documents. The coordinator works as a secretary of the steering committee. The steering committee can invite the representatives of development projects to introduce and discuss their projects.
Collaborative development approach	The Oskari software is reused in development projects that need to create a web map application, a geoportal or to embed map clients into other web applications. The development project downloads the Oskari software and applies it; and further develops it, if needed. The development needs will be discussed with the coordinator and other development projects to avoid overlapping development work. The project is requested to follow the Oskari architectural principles and to provide modifications (Oskari open source licence) back to the Oskari network for integration. The Oskari steering committee decides what will be integrated into the next public Oskari release (or road mapped into future releases) based on the coordinator's proposal. Development projects are requested to document new source code to facilitate reuse (a documentation guide can be found on the Oskari website). The coordinator is responsible for checking the documentation during integration.
Road mapping	The coordinator maintains the Oskari roadmap (short-term roadmap and longer-term (1 year) roadmap) and is responsible for introducing new releases in steering committee meetings. The steering committee has the responsibility of checking and agreeing on any major changes before release. The roadmaps can be found at: ▪ http://oskari.org/trello (in Finnish) ▪ http://www.oskari.org/documentation/development/roadmap (in English)
Change management	Requesting changes: Based on proposals from the development projects, the Oskari coordinator collects the new features that are proposed to be integrated into Oskari. Major changes in the software core are planned by the coordinator and presented to the Oskari architecture board, which discusses and agrees on the proposed changes. All other remarks and proposals will be reported as GitHub issues. Change proposal: The coordinator prepares the proposal. Change decision: The Oskari steering committee makes change decisions based on the coordinator's proposals. Change implementation: The coordinator arranges tendering for Oskari integration and core framework development work and makes acquisitions based on the tendering results. Tendering material templates are provided as guidance for other projects for their tendering purposes. The coordinator maintains the Oskari integration backlog in cooperation with the integrator. The coordinator updates the backlog based on the agreed integration tasks. The integrator is responsible for defining and scheduling more detailed tasks and setting foreseeable version numbers for backlogged items. The selected integrator takes care of the integration work: coding, testing, version updates, documentation and any necessary IT support.

Table 7. Practices for lifecycle management (cont.)

Issues	Details
Release management and versioning	After integration and testing, the integrator prepares a software version for release. The version numbering scheme is as follows: ▪ X = Major version with significant changes in architecture and/or APIs of the software: planned in the Oskari roadmap. ▪ Y = Minor version: planned in the Oskari roadmap. ▪ Z = Maintenance version: other small changes and bug fixes are marked with a maintenance version number. The coordinator introduces a new software release proposal (major or minor release) for the Oskari steering committee who check and agree on major integrations before the release. The steering committee is informed of any major plans to change the software core. The committee schedules the major changes to ensure smooth transition to the new version within member organizations. The coordinator takes care of any other necessary small changes and bug fixes (maintenance releases). Instructions on how to contribute to Oskari development using GitHub branches: http://www.oskari.org/documentation/development/how-to-contribute
Communications	The Oskari steering committee is responsible for the communication plan. The coordinator prepares change requests to the communication plan and the steering committee agrees them. The coordinator is responsible for implementing the communication activities as scheduled.
Documentation	Functional specification: http://www.oskari.org/ User guides: Developer guides for applying Oskari: http://www.oskari.org/ http://oskari.org/examples/rpc-api/rpc_example.html End-user guides: ELF service http://demo.locationframework.eu/ National Geoportal Map window: http://www.paikkatietoikkuna.fi/web/en/user-guide Installation and operational environment: http://oskari.org/documentation/ Technical description and instructions for Oskari developers: http://oskari.org/documentation/

Table 8. Financing practices

Issues	Details
Coordinator	Mostly integration fees collected from organizations who have signed the Integration agreement.
Community manager	Financed as part of the coordinator's work.
Integrator	Will be financed by the partners who have signed the Integration agreement (annual integration fee). The coordinator and development projects can also negotiate the sharing of integration costs if the integration fee turns out to be too low.
Oskari development	National Land Survey Development Centre/SDI team. Oskari network. Project funding.
Deployment and customisation	Each organization takes care of its own funding to apply the Oskari software.
Network and steering committee meetings	Each organization takes care of its own participation expenses. Meeting costs are covered by the integration fee.
New entrants	Oskari network: Free of charge. New members have to sign the Memorandum of Understanding. Oskari steering committee: steering committee members (development projects) sign the Integration agreement where they agree the annual integration fee. The steering committee agrees on the annual integration fee.

6. Experiences on deploying CO-SLM

This chapter reports experiences, particularly benefits, challenges and lessons from deploying CO-SLM model and framework within the Oskari project.

6.1 Product acceptance and quality

CO-SLM model and framework provided a strong governance model for cooperation by clearly defining responsibilities and processes. As one of the interviewees point out, "lifecycle management is what actually turns an open software application into a software product…". Being a product means the availability of technical support and documentation, version schemes and roadmaps for future development, for example. This allows potential users to evaluate the suitability of the software to their current and future needs. The productization also includes communications and marketing activities, which – together with the robust management model – have helped to improve the "brand" of the software and make it more attractive to adopt. Overall, many interviewees talked about the Oskari brand and its importance to project acceptance.

The Oskari project had recently entered incubation process to join the OSGeo foundation, a not-for-profit legal entity supporting the open source geospatial community. This is expected to further improve the Oskari brand and acceptance of the software product, also internationally, but the process is in early stage. Generally, presence on platforms like GitHub and OSGeo where curious outsiders can explore the software without making financial or other commitments, is seen as a key to identifying stakeholders and growing the user base. One of the interviewees expressed this as follows:

> OsGEO, GitHub and other platforms where anybody can participate in the discussion are really good. You do not have to identify all stakeholders in advance, but just throw out something and interested parties will come to you. We have received inquiries from as far as Moldova…[ ]... If you want "fresh blood" [into the project], it is great that people can start following you without commitment and then deepen their involvement gradually.

The CO-SLM model has also helped to improve non-functional qualities of the software, particularly adaptability and extensibility. When a software is developed by a single organization alone, hectic demands and limited resources can cause focusing on immediate user needs at the expense of long-terms software quality, e.g. architecture design that allows software to adopt to future needs. Consequently, the software becomes hard to maintain within a single organization and impossible to share with other organizations without significant refactoring. However, CO-SLM model forces the owner to look at the software from a wider perspective, beyond their own immediate use cases. Each modification to the baseline version is considered from the viewpoint of multiple organizations, leading to improved adaptability. One informant explained:

> Our understanding [of software design] has broadened so much after we started talking with other organizations who have similar needs. It was a bit like 'oh, right, we do not have to reinvent that wheel'. We have learned that we can develop things collaboratively even though the needs are not exactly the same".

The CO-SLM model has also helped to secure resources for developing project-wide testing methods and tools available to all member organizations. This has reportedly decreased the number of software bugs in new releases.

6.2 Resource pooling

6.2.1 Human resources

For more than two decades, public sector organizations in Finland have been inclined to outsource all their software-development activities. This has caused a shortage of skilled in-house ICT personnel in many organizations, making it harder for them to take responsibility for software development and lifecycle activities. For example, when

organizations buy Oskari implementations from software companies, they may not know how to communicate key architectural principles to the companies or conduct tendering process in a manner that obligates companies to follow them.

This has sometimes led to poor-quality code contributions, e.g. new functionalities have been placed in illogical parts of code structure and/or interfaces are used in a non-standardised way. The resulting problems require significant effort from the technical coordinator (NLS) who underlines that, in the future, more effort must be put into ensuring a common understanding of proper architecture principles and their inclusion in the request for tenders.

The alternative strategy to address human resource deficits has been to acquire manpower from software companies in a form of 'body shopping'. This differs significantly from a process where public sector organizations place a request for tenders (RFT) for software implementation. As the bidders aim to offer the lowest possible price, no requirements apart from those explicitly mentioned in the RFT will be taken into account. According to both the interviewees and prior studies [35], [40], the heavy-weight requirements specification (for RTF) makes it difficult to incorporate new ideas afterwards and can thus hinder innovativeness. Oskari community has noticed that, in complex development cases, it is often better to tender for individual developers instead of tendering for specific implementations. This approach has enabled agile software development processes and intensified knowledge exchange between public- and private-sector organizations. In this model, the leadership of the software-development process stays entirely with the public sector, which again requires specific skills, different from those required by mere software acquisition.

It was also repeatedly noted that, while CO-SLM model does indeed require new skills, it also creates an environment for inter-organizational learning and thereby helps building new skills. For example, interviewees gave statements like "inter-organizational learning is a key benefit [from Oskari participation]", "even organizations who do not contribute code have provided much valuable inputs [of skills and ideas]" and "we have learned so much just by talking to other organizations with similar needs".

6.2.2 Financial resources

Because Oskari is open source licenced, any organization could download it and use it without participating in development expenses. However, the majority of organizational users have chosen to pay an integration fee. The payment ensures them a membership in the steering group and an opportunity to influence the future development of the software. By participating in the decision-making, organizations can ensure that the software will continue to meet their needs in the future. This has been enough to motivate organizations to contribute financially, and, thus, open source licensing has not lead to a significant 'free riding' problem.

Despite this, financing the Oskari baseline software development has not been easy. The relatively low integration fee (currently EUR 5,000 per organization annually) has been sufficient to cover the integration, co-ordination and communication activities of the Oskari community but not maintenance of the baseline software. Steering committee members felt it was impossible to increase the fee without forcing member organizations to go through a significant amount of bureaucracy. For long time, the development of the baseline version was paid for entirely by the National Land Survey of Finland, which made the project extremely dependent on a single organization. However, the increasing number of participants has recently improved finances and Oskari community is moving towards a model where it is less dependent on NLS funding.

In general, interviewees felt that the CO-SLM model has enabled significant savings because development cost can be split with others. One of the informants put it as follows:

> One of the major goals of this collaborative development model has been to save funds. I feel that we have achieved that… We can go to a steering group and split up tasks [between organizations], like 'you do this and I do that'… If we did not have this collaboration, we would have had to pay everything alone.

In practice, there were two ways to finance major extensions to Oskari: (1) some member organizations pay for Oskari extensions alone but comply with architectural rules and share them with others for free and (2) some organizations

form ‘mini consortia’ with other organizations who needed the same functionality and make the requirement analysis, tendering and financing jointly. The latter was considered as more mature form of co-development but required more inter-organizational communication and trust. One interviewee explained:

> The first level is that each organization manages their own projects but follows some commonly agreed principles. Meanwhile, others are waiting to get their hands on it. This is the most common way because it is fast and easy if you have money [within one organization]. The second level involves collaborative financing; it is much more complex and requires trust. One organization is chosen as a leader and then the leader organization makes consortium agreement with other organizations to co-finance and co-develop something together.

6.3 Project sustainability

Because big money is circulated in public sector ICT procurement, successful new models, which create savings for governmental organizations, unavoidably shrink revenues of some companies. Consequently, Finnish Location Information Cluster, an advocacy group of some established companies offering geospatial solutions, has been very critical of the Oskari project and tried to create political pressure against it. While no significant harm has been caused, aggressive industrial lobbying was noted to be a risk factor which can negatively influence sustainability of any government-driven open source project. CO-SLM approach partially helped to tackle the issue, e.g. by resourcing communication and public relations (PR) activities.

However, with Oskari, the biggest sustainability challenge is to decrease the project’s dependence on the coordinator, NLS, and thus make it less vulnerable to changing management interests and/or shifts in key personnel within that organization. This was expressed in several interviews, for example as follows: “even though NLS has been a primus motor in the start, there is no particular reason why it should remain as a primary or principal actor” and “other actors must take more responsibility because we [the project] should not be overly dependent on NLS”.

Significant informing and marketing effort has been undertaken to attract more organizations to the Oskari network. When more organizations are participating, more financing will come in and relevant technical knowledge will be distributed among multiple organizations and people. If the software is strategically important to a sufficiently large number of organizations, the development will continue even if the NLS decides to drop out. The project is now entering a new phase as the co-ordinator role is planned to be shifted from NLS to an outsourced project organization whose costs are covered with integration fees.

7. Discussion

7.1 Lessons for researchers and practitioners

For practitioners in the public sector who consider engaging their organizations in collaborative open source projects, the case study highlights the importance of ensuring sufficient in-house IS skills. This is in line with prior literature pointing out in-house IS skills as a key success factor to open source and other agile projects on the public sector [32], [35]. Even though it is possible and often recommended [34] to exploit external experts, open source development requires the public sector to take on the responsibility of a software owner. This requires both sufficient technical competence and knowledge in software lifecycle management. To support the latter, the CO-SLM framework acts as a document template for planning software governance and lifecycle activities.

The second lesson for practitioners has to do with the importance of enabling community growth. A ‘critical mass’ of active organizational users helps to ensure steady funding and guarantee project continuity, even if one dominant organization drops out. This is also in line with prior studies which have emphasised versatile developer and donor bases as a success factor to all types of open source projects [41], [42]. In part, CO-SLM supports community growth by making the software more attractive to new users. This is because clarified governance processes and responsibilities make the whole process more predictable and manageable. Software must also be ‘generic’ enough so that it can be

adapted to the diverse use cases for heterogeneous organizations. As the software is developed further, one must keep a multi-organizational perspective in mind.

For researchers and consultants, a key lesson relates to appreciating the huge diversity of organizations and software projects. Due to the heterogeneity of environments, it has proven pointless to develop a detailed predefined set of lifecycle management practices for all public sector driven open source projects. We noticed that a high flexibility of the framework is more important, taking, e.g. the form of 'check lists' on lifecycle management issues to be taken into account. Each project can then take the framework as a basis and develop lifecycle management practices suitable to their particular circumstances. If one wishes to develop 'best practices' on lifecycle management, one must focus on a particular software domain and type of application, not public sector driven OSS projects in general.

7.2 Limitations of the study and further research

While diverse stakeholders were involved in the drafting and development of the CO-SLM framework (see Section 3 for details), we did not interview all members of the Oskari network after its deployment. Because we had an opportunity to interview only people from three heavily-engaged organizations (see chapter 3), the results are biased towards their perspectives. We acknowledge that 'peripheral' members of the Oskari community may have different perspectives that are not visible in this study. We also understand that a single case study is not enough to make definitive conclusions regarding the applicability of the framework in diverse public sector environments. Our next step is to deploy the CO-SLM model and framework in other public sector open source software development efforts and, thereby, to gain further experience on their applicability in different organizational settings. We also hope to collect and analyse more qualitative and quantitative data on the supposed benefits of the CO-SLM approach.

8. Conclusions

This paper introduced the CO-SLM model and flexible framework developed for helping public sector organizations to follow sound lifecycle management practices in open source development projects. The model and the framework were successfully deployed in a real-life setting, where a dozen public sector organizations were jointly developing spatial data analysis software under an open source licence. The adoption of CO-SLM benefited the software project by encouraging community growth, improving the 'image' of the software and enhancing software quality, especially regarding software maintainability and extensibility. Challenges stemmed from deficit software development and acquisition skills in some organizations and insufficient funding due to relatively low membership fees. Furthermore, the study shows that a project's financial and technical dependence on the leading organization should be decreased in the future to lower risks and ensure long-term sustainability.

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Are PMOs really that momentous for public authorities?

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Abstract:
Project management offices (PMOs) are frequently referred to as necessary, or even indispensable, for carrying out projects in multi-project settings, which often occur in public authorities' Information Technology (IT) projects; particularly in times of today's sweeping digitalization. Hence, this research studied Swedish public authorities and their IT departments' use of PMOs; a survey was directed to IT project managers. Findings showed that even though PMOs are commonly described as significant, those that applied PMOs were fewer than those that did not. This research searched for correlations between the existence of PMOs and 88 variables that resulted in relatively few, mostly weak correlations. A hypothesis test did not show significant association between PMOs' usage and project models' usage. The research contributions are principally that PMOs do not appear to be that significant after all for Swedish public authorities, and to have reasonable expectations on PMOs. For practice, the implications foremost concern the importance of understanding conceivable pros and cons.

Keywords:
project management office; PMO; public authorities; IT projects; IT project manager.

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1. Introduction

Projects are carried out in all kinds of organizations, not least in public authorities; particularly when Information Technology (IT) is involved, like in digitalization projects that are frequently applied today. Public organizations are of especial interest since they are not just as any other organization. To begin with, there are some prominent, distinguishing features about public organizations, not least the fact that public officials are used to exercise power from their authoritative positions, e.g. to make decisions that affect citizens' living conditions. Further, these organizations do not exist to make a profit for the owners; they are paid for, and maintained by tax revenues, i.e. conveying a responsibility for common economy. Hence, public organizations are in focus of both citizens', and other (higher) authorities' scrutiny since they are expected to act in accordance with existing laws and regulations. Santos and Varajão [1] pointed out several aspects that distinguish public organizations from others. With these aspects in mind, projects could be an efficient and effective way of carrying out tasks that fit into the project conception. Klakegg et al. [2] discussed major public projects' challenges from the perspective of how these could be mastered. Williams et al. [3] found that applying institutional frameworks, as well as the governing of project activities, were highly important to fulfil purposes of legitimization and reassurance. Aubry and Brunet [4] propagated the need for public administrations to configure the authorities' PMOs in compliance with specific, local requirements, and contexts. In other words, it is not possible to consult existing models with the aim to copy them because each project management office (henceforth PMO) must acknowledge the need for specialization, and the actual context. Parchami and Koosha [5] also proposed the use of PMOs, and stated that different configurations of PMOs should be expected in different organizations/contexts. Further, the PMOs must be proactive in anticipating changes that need to be carried out to deliver successful project outcomes to the organization [4]. Still, as pointed out by Artto et al. [6], organizations sometimes practice managerial control arrangements in a similar way that would be applied by a PMO, even though such a specialized unit does not even exist; a situation that could be equally accurate for public authorities.

PMOs are often described as sufficient and important for carrying out successful projects (e.g. [7]), but there are other opinions that point out problems as well [8], [9]. To look further into these matters is important since it is indisputable that it is both costly, and resource consuming to put PMOs into practice, no matter how valuable they turn out to be. A fundamental assumption that often exists concerning PMOs, is that they must be considered as evidently worthwhile if they should be implemented and applied. To quote Forrest and Rowe [10], who propagate PMOs' necessity of making their customers more productive, "… they must offer a clear, well-articulated value proposition". Hence, those who decide on establishing PMOs should be aware of both upsides and downsides to PMOs, to be able to make initiated, well-considered decisions. This is particularly important in public authorities that spend public revenues, i.e. the citizens' taxes. According to Khalema et al. [11] and PM Solutions [12] the strategic maturity of PMOs is of considerable importance for the prospects of deriving advantage from projects; a direct correlation exists between PMO maturity and its value for the company.

Despite the value that PMOs deliver, their contributions are often not recognized, which leads to PMO members experiencing a need to justify their existence [13]. A key for being considered to provide value is closely connected to PMOs' ability to support the end users, and to how the PMOs manage to deliver successful outcomes. Those who decide about the PMOs' existence should be convinced about the PMOs' prospects of delivering valuable contributions before PMOs are implemented [13]. This is particularly important for public authorities. PMOs are often recommended [14], [7] in organizations that usually carry out several projects at the same time, and especially when big, complex projects are involved. Still, there are also doubtful voices describing PMOs as less useful than they generally are described [15], and that many PMOs are closed down or reconstructed [16]. Now and then, project organizations and programs are mixed up with PMOs [17]; well-managed projects are not necessarily managed by PMOs [6], which is not to say that PMOs are generally overrated. Nevertheless, organizations could run a well-functioning, sufficient, and adequate project management organization without a PMO. In Sweden, IT projects are frequently carried out; commonly due to the ongoing digitalization in society. Hence, it is of interest to look further into the reasons for applying PMOs. Particularly when it comes to public authorities that handle citizens' common economy, and therefore

should carry out their tasks as effectively and efficiently as possible. Hence, the research question is: *How significant are PMOs for (Swedish) public authorities?*

The remaining of this paper is structured as follows: Section 2 provides a background to PMOs; section 3 presents the method, including the data collection; section 4 presents the findings; section 5 analyzes and discusses the findings, and section 6 concludes; i.e. answers the research question, highlights implications, and proposes further research.

2. Background – theoretical frameworks for PMO

To sort things out a little bit more about PMOs' possible advantages and drawbacks, as well as providing initiated background information about PMOs, this section is digging further into these matters.

2.1 Basic concepts

The intention behind this sub-section is to provide a fundamental understanding of PMO. A recent definition of PMO is provided by the Project Management Institute's PMBOK [18, p. 554]: "An organizational structure that standardizes the project-related governance processes and facilitates the sharing of resources, methodologies, tools, and techniques". However, some [4] still favor an earlier definition [19] as being more adequate in describing PMOs in accordance with its responsibilities. The first PMOs (program offices at that time) were put into practice in the 1950s during the cold war's big US defense projects, and according to Kerzner [9] they were established to get in closer contact with the customers, who were more interested of the technology and schedules than of the costs, even though they had to finance them. This changed a bit during the 1980s as the budget aspects became more important and watched over. The 1990s regarded PMOs as cost efficient, and from year 2000 (to present), PMOs became commonplace in different kind of organizations [9]. According to Darling and Whitty [15] PMOs have changed throughout the years and from starting out as managing non-operational work they have evolved to also include management of human resources that are involved in the projects. Even though projects nowadays are carried out in all kinds of organizations, projects are still deeply connected with IT. De Carvalho [20] studied opinions among IT personnel, PMO staff, and business personnel and found that IT personnel had a higher commitment to project management methods than business personnel had. Still, these two groups of personnel had a similar view of project conflicts stemming from partly a semantic gap, partly from a lack of trust. The PMO staff on the other hand reported different project priorities, and a lack of commitment to follow project management methods as the main reasons for communication barriers during IT projects. Andersen et al. [21] propagated some features that stood out as being especially important for establishing PMOs in large organizations. To begin with, there should be an unambiguous and clear need for the PMO, and the top management's support should be evident and explicit. Further, the credibility and organizational authority must be manifest since PMO successes are tightly connected to these basic conditions. This is in line with Aubry et al.'s [22] statement about PMOs that should not "be considered an isolated island within an organization" (p. 328).

Aubry et al. [23] found that PMOs are instable organizational entities, characterized by tensions and various states of transitions that often changes. Still, Aubry et al. [23] did not consider that these changes should be regarded as if there were something wrong with the PMOs, instead should these changes be regarded as necessary, and rather deal with aspects about why they should change, i.e. outline the reasons for the change. A PMO that is successful must be able to implement the project management standards to a point where the project management practice is embedded in the organization. However, by doing so, the PMO is almost making itself unnecessary, and "could be unable to justify its survival" [24, p. 767]. According to Aubry et al. [24, p. 767] this "emptying process" (p. 768) should be considered an effect of PMOs being embedded in their host organizations. Hurt and Thomas [7] seemed to agree when it came to looking upon PMO changes as natural and necessary development activities that are used as means for PMOs to remain fit and useful. Hobbs et al. [8] also described PMO changes as expected and natural events. Hence, PMOs should be regarded as organizational innovations that could take place in any type of organization [8]. Additionally, there could be different ideas about whether PMOs should be outsourced or not, and Martins and Martins' [25] research findings did not support outsourcing of PMOs since appliance to the organizational culture was considered particularly important for

the opportunity to take substantial advantage from the PMOs' benefits. Establishment of PMOs convey considerable costs, which makes it important to carefully consider the consequences. Darling and Whitty [15] argued that it could be doubted whether the costs associated with implementing PMOs really would create the expected return, even if the performance were assumed as being in compliance with "best practice". There could, however, be different ways to determine a PMOs value except the direct financial effects, e.g. impact on organizational changes. The basic value concerns the goals that were set for the PMO when it was created / implemented and how these goals are eventually fulfilled [26]. The ability to make relevant decisions about public authorities' practicing of PMOs, implies that the decision makers hold at least a fundamental understanding of what such an establishment would entail. The public officials, who have the power to decide, should agree with both positive and negative aspects associated with PMOs.

2.2 Conceivable pros and cons

Dai and Wells [14] found that organizations with an established PMO were more successful regarding their project performance (according to the authors, not statistically significant though!). The reason was that the PMOs distinctly promoted project management standards and methods, and could therefore better avoid failure. Martin et al. [27] argued that PMOs did not apply standard project management practices to a higher degree to judge from their research findings. Hobbs and Aubry [16] stated various literatures' commonly propagating of PMOs' value for project successes, and for applying of best practices, as being widely exaggerated. Their [16] research showed opposite result with a clear lack of consensus about PMOs' value. PMOs that did not perform well were considered far too costly and inefficient, and PMOs that were regarded as value-adding entities were highly appreciated, and the conclusion was that PMOs were more legitimate in mature organizations [16]. Hobbs and Aubry [16] proposed that there is no such thing as a general promise of value for money for those who decide to apply PMOs. Nevertheless, Aubry and Hobbs [28] stated that PMOs are important since "…they are in touch with the projects, programs, project portfolios, corporate strategy, and functional and business units" (p. 12). Additionally, there are also other problems associated with PMOs; Kerzner [9] raised a bundle of negative aspects and risks of applying PMOs such as employee burnout and excessive administrative tasks. Still, there are also positive sides such as more effective scheduling, standardized reporting formats, synchronization, fewer delayed decisions, and information that are adjusted to the current needs [9].

Projects' successes or failures are often discussed today; projects are commonly applied, and not only for IT related projects. It is often put forward as necessary for achieving project success that the project managers hold project certificates. Research findings however, indicate that Swedish employers do not value, or search after certified IT project managers [29]. Malloy and Stewart [17] noted that people often are being careless with how they name projects and programs; these are different phenomena to begin with, and probably falsely, are projects being more associated with failure. Maybe, the unsuccessful projects were not really about projects in the first place. Müller et al. [30] claimed that PMOs are on the one hand, important for successful projects, and on the other hand, PMO members did not turn out as the most popular knowledge providers. Instead, it was earlier partners that had been working together in other projects, who turned to each other when they needed support. Neither did PMO members exchange much knowledge among themselves, even though they shared knowledge with project managers outside the PMO. They did however show a tendency to overrate their importance as knowledge providers. Despite this, the PMOs turned out to be highly esteemed when it came to delivering successful project outcomes [30]. Pemsel and Wiewiora [31] found project managers in general as being reluctant to share project experiences and knowledge, even though they often talk about their projects per se. Further, they needed PMOs as knowledge brokers if they should share knowledge with others, and expected the PMOs to arrange e.g. workshops and cross-project discussions [31]. McKay et al. [32] found that it varied how many projects IT PMO leaders had an oversight of, and that they often handled projects spanning over several organizational units. Tsaturyan and Müller [33] propagated the need for coexistence of formal and informal networks that should ensure integration with a good balance between project concepts and other organizational tasks. Their study however, found that the PMO staff perceived employees outside the PMO as unwilling to contact them for help or consultancy because of the heavy bureaucracy associated with PMOs. Parchami and Koosha [5] also dealt with issues concerning PMOs' place in project-oriented organizations, and propagated the necessity of senior managers' supporting the PMOs. Additionally, there is a need for an organizational understanding of project methods, as well as an

understanding of, the presence of project managers and other project professionals in the organization. Such support and tolerance for the PMOs could not to be taken for granted according to the research findings [5]. Tsaturyan and Müller [33] put forward a discussion about large organizations that often must manage several PMOs. Because of these, often loose-coupled entities that have been established at different hierarchical levels within the organization, there is a need for control. At the same time, it is important for projects (and PMOs) to be able to remain unique and autonomous.

Ward and Daniel [34] stated that managers who are planning to establish a PMO should be aware of that there is a risk associated with such an implementation; a risk of being exposed to more scrutiny and intolerance regarding possible project problems (at least if problems seem to stem from the projects) from senior management. To deal with these problems, Ward and Daniel [34] suggested that PMOs should not primarily focus on controlling that the organizations' projects are carrying out an effective project process as regards keeping to budget, planning and following up on plans. PMOs do not contribute sufficiently if they only are used for basic project management tasks [35]. Instead, the PMOs must be more interested in improvement of the project success and in satisfying management, i.e. they should be more involved during the pre-project phases and at the end of the project's lifecycle [34]. Heising [36] also put forward a necessity to focus more on the early project phases. Aubry [37] proclaimed that the PMO's supportive role is the factor that actually, increases project success, business performance and project maturity, i.e. it is not its controlling role that is achieving it. According to Spelta and Albertin [38, p. 50) their findings suggested that "…some firms create an IT PMO despite a high level of satisfaction with project deliveries" even though it is more usual that firms that are not satisfied create an IT PMO.

3. Method

The research method is a survey, based on a prior designed questionnaire (Appendix A for more detailed information). This method section presents the data collection, the profile of the participants, and method critique.

3.1 Data collection

The data was collected (during 2016) by a designed questionnaire sent out to all Swedish public authorities. A similar questionnaire had been used in another research in 2007 [39]. In this current case, the respondent group were IT project managers in Swedish public authorities, and the steps taken for getting in contact with them can be described as follows. All Swedish public authorities were contacted (535), 50.3% percentages (269) answered that they would forward the message to the requested individuals, who were in charge for the IT departments. The remaining 266 (49.7%) authorities did not answer at all. About the 269 that answered positively to the initial request, there were 64 (24%) contacts saying that they did not have their own IT staff. Of the remaining 205 public authorities, 73 (36%) authorities did participate. It was 104 questionnaires sent out to these 73 authorities, and 82 individuals participated.

The statistical analysis of the data was conducted by using IBM SPSS 22.0. Firstly, a descriptive analysis was made (accounted for in sub-sections 3.2 and 4.1). Secondly, correlations were calculated with Spearman's correlations since the variables were of ordinal or of ranked data only. The significant correlations are presented in sub-section 4.2, and the not statistically significant correlations are presented in sub-section 4.3. Even though the latter correlations should not be interpreted, they are in this case still presented. Finally, a hypothesis test was carried out (accounted for in sub-section 4.4). The questionnaire was used before, so the questions had been tested [39], which is helpful for the validity. Additionally, minor re-formulations were made in order to better apply to the actual context, i.e. public authorities. The reliability is another important issue, which is trickier, since IT is in focus here, beside PMO, and there are steadily ongoing changes regarding IT, which in turn are most likely to affect the frequency, and mode of PMO entities in Swedish public authorities. Issues related to project interdependencies are most relevant [40].

3.2 Profile of the participants

After the initial procedures, 104 questionnaires were sent out; 82 individuals answered (response rate 79%). These 82 individuals were appointed in 73 different authorities. The profile of the participants is summarized (N=82) in Table 1.

Table 1. The profile of the respondents

Questions	Variables	Frequencies % N= 82
What is your gender?	Male	56.1
	Female	43.9
What type of public authority do you work in?	Other	37.8
	Municipality	25.6
	County council /Region	15.9
	University	13.4
	Supervising authority	7.3
What is the emphasis of the authority? (multiple-choice item)	Other	29.3
	Education / Competence development	34.1
	Health and medical service	26,8
	Law	18.3
	Inspection and controlling	17.1
	Infrastructure	9.8
	National defense/Police/Fire department	4.9
	R&D	6.1
	Event	1.2
Period of employment with the authority?	0 – 3 years	39.0
	4 – 6	19.5
	7 – 10	13.4
	11 – 20	19.5
	21 years –	8.5
How many are employed in the authority?	1 – 50 employees	2.4
	51 – 100	3.7
	101 – 250	9.8
	251 – 500	6.1
	501 – 1000	17.1
	1001 –	61.0
Do you hold a project management certificate?	Yes, IPMA	8.5
	Yes, PMI	3.7
	Yes, other	26.8
	No	61.0

3.3 Limitations

This study is subject to limitations. It was complicated to reach the IT managers that could provide further information about whom to contact, and many of those who were contacted revealed that their authority were not applicable for the study, since they either had their IT department outsourced, or they stood right before an outsourcing of IT. This conveyed a problem when it came to the opportunities for relevant testing of e.g. hypotheses that were notably reduced.

As regards the figure concerning PMO usage (Table 2, Yes = 42.7 %), it must be taken into seriously consideration if this is a particularly low figure or not. A best practice report from Computer Economics [41] revealed that even though PMO use generally remains high, it is relatively low in government/education (35%). This was a declining figure compared with the year before when 57 percentages (government/education) used PMOs, which were reported to be growing in popularity at that time [42]. However, it would have been preferable with more respondents than the 85 individuals, from 73 authorities, who after all, were possible to engage for participation. It would also have been favorable if the survey had included questions about previous existence of PMOs in the studied authorities.

4. Presentation of the findings

This section presents the study's descriptive findings, correlations, and a Chi-square test.

4.1 PMO related descriptive findings

The findings related to issues directly concerning PMOs are presented in Table 2.

Table 2. PMO usage

Questions	Variables	Frequencies %
Does the authority that you work in apply PMO? N=82	Yes	42.7
	No	52.4
	Do not know	4.9
How many years have PMO been practiced in this authority? N=35	0 – 2 years	40.0
	3 – 5	40.0
	6 – 10	11.4
	11 years –	8.6
How does the PMO function? N=35	1 (bad)	2.9
	2	8.6
	3	37.1
	4	37.1
	5 (good)	14.3
Which duties are handled by the PMO? N=35 (multiple-choice item)	Method / Model	74.3
	Coordination	68.6
	Quality	51.4
	Training / Education	40.0
	Project start decisions	37.1
	Other	22.9

Eight (22.9 %) respondents chose the alternative *other* to complete their responses regarding the duties that the PMOs handle. Other duties were: supporting portfolio management, funding, applying for grants from the European Union, following up on finances and on big projects, dealing with issues that cover the whole, and establishing the initial project process.

4.2 PMO related correlations

In order to carry out the correlation statistics as accurate as possible, the four respondents that *did not know* if they had a PMO or not were temporarily removed (marked as missing with the option "exclude cases pairwise") from the variable view, a procedure that entailed: N=78 (Table 3). A similar procedure was applied regarding the question about if there was an established project model (N=77, Table 4), and support for that model (N=67, Table 3). The correlation statistics resulted in s*even significant correlation on the 0.01 level*, *18 on the 0.05* level, and *63 that were not significantly correlated*. Table 3 and Table 4 shows the significant correlations; The analysis of the correlations set out from the question about if PMO was applied. Spearman's correlation was used (IBM SPSS 22.0) with the aim to: i) Explore the strength of the relationship between two continuous variables, and ii) the direction of the relationship as well. The variables are of ordinal level or rank data.

Table 3. Two-tailed correlations ($p < .01$)

Questions	**Correlation coefficient Sig. (2-tailed)** Is there a PMO? N=78
How often do you use the project model?	.321** .004
How would you describe your competence in the authority's project model?	318** .005
Is there any support available in the authority on its project model? N=67	.317** .009
To what extent are you and other project managers trained for your roles?	407** .000
How structurally does the authority work with the realization of the business value?	.331** .003
To what extent do you think that the sponsor is able to distinguish between technical IT-issues and business issues?	.426** .000
How do you value the sponsors' work?	.311** .006

The correlations in Table 3 are of a medium strength according to Cohen [43], who suggests, as a guideline, medium strength to be r = .30 to .49.

The correlations accounted for in Table 4 are weak [43].

Table 4. Two-tailed correlations ($p < .05$)

Questions	**Correlation coefficient Sig. (2-tailed)** Is there a PMO? N=78
Is there an established project model? N=77	.248 * .029
What is your judgement about the users' knowledge level during the project?	273* .016
How important is the IS for your project work?	.268* .018
How would you consider your employer's appreciation for your work?	.274* .015
To what extent are different experiences represented in the projects?	.288* .011
To what extent do you consider that you can take in the whole project?	.228* .045
To what extent do the users get any training for their project role?	.237* .037
To what extent can you influence the user training?	.278* .014
How complete decision support can you supply the decision makers with?	.226* .046
How understandable decision support can you supply the decision makers with?	.246* .030
How good is the leadership that you practice in the projects?	.241* .033
In a long-term perspective - to what extent does the authority work with the business value realization?	.261* .021
To what extent would you consider that the sponsor understands the intention of the decisions?	289* .010
How do you value your communication with the sponsors?	.247* .029

Table 4. Two-tailed correlations ($p < .05$) (cont.)

Questions	Correlation coefficient Sig. (2-tailed) Is there a PMO? N=78
How do you value your co-operation with the sponsors?	225* .047
Which competence level do you consider the project members to have as regards the IS/IT-sector?	.253* .025
To what extent are different genders represented in the projects?	.240* .034
How important is leadership quality for your work as a project manager?	.224* .049

4.3 Not significant correlations

The remaining correlations (i.e. 63), that did not turn out to be significant, are roughly summarized below. Correlations that are not statistically significant shall not be interpreted. Hence, they are not accounted for in detail, and just broadly outlined. Still, providing some information about these could be illuminating to some point, and should only be seen as an attempt to complement this research about PMO usage in Swedish public authorities.

Whether the authorities applied PMOs or not, did not correlate significantly with the IT project managers' possibilities to influence on the effects of the projects and the business benefits / values, the sponsors' decisions / strategies, staffing of the projects, co-operation, communication and discussions, the users' knowledge, competence and motivation levels. If the IT project managers were certified, how many years the PMOs were used, how the project model worked, and the quality of the support for the project model did not make any difference as regarded correlation with PMO usage.

Nor did PMO usage correlate with the IT project managers' opinions about the users' ability and willingness to increase and maintain their competence (e.g. about project methods) and motivation levels, during and after the projects' results were commissioned. Neither correlated PMO usage and the IT project managers' occupational pride, their intuition, private / occupational experiences, their status, position in the authority, individual gain, private / society's / authorities' norms. There was no significant correlation between PMO existence and auditors' / sponsors' training, the project managers' ability to grasp the whole of the project, the significance of product / project / project charter quality at the initial project phase.

There were no significant correlations between PMOs and the IT project managers' rating of their communication and co-operation with the project staff, external stakeholders, users and auditors, nor as regarded the discussions with sponsors, project workers, external partners, users, and discussions with the auditors. Neither, did the PMO usage, and how consciously the authorities worked with the realization of business values, correlate significantly. When the project's goal fulfillment was followed up on, the sponsors' knowledge level about the IS at the start of the projects, the importance of organizational culture and sector knowledge did not either correlate with PMOs' existence. Further, there were no statistically significant correlations between PMOs and to what extent different ages, and different ethnics were represented in the projects.

The non-existing significant correlations should not be subjected to statistical interpretation but might contribute to an increased understanding of the whole, and to broaden the perspectives on PMOs in public authorities.

4.4 No significant association between usage of PMOs and usage of project models – a hypothesis test

A Chi-square test was performed to test the hypothesis (presented below) concerning the possible distinctions that could appear between public authorities that did apply PMO, or that did not, and to what extent there was an association with establishment of a project model in those authorities.

- H0: There are no distinctions between the public authorities that have an established project model depending on whether there exists a PMO or not.
- H1: There are distinctions between the public authorities that have an established project model depending on whether there exists a PMO or not.

The null hypothesis was assumed [44], [45]. The Chi-square test for independence (with Yates' continuity correction) indicated no significant association between the public authorities' use of PMOs and the authorities' use of project models, $\chi^2(1, n = 77) = 3.47$, $p = .06$, $phi = .25$.

5. Analysis and discussion

This section analyzes and discusses the findings in relation to others' research (5.1), as well as the relatively low application of PMOs at the respondents' workplaces (5.2).

5.1 The findings in the light of other researchers' findings

PMOs are generally apprehended as sufficient and necessary for both successful and efficient handling of projects. A competing view of PMOs as being less significant is available in the literature, and that view was carefully considered when the findings from this research were analyzed. Prior research, questioned PMOs as knowledge brokers [31]; they did not even share knowledge among themselves [30], and repelled project managers because of the heavy administration connected with PMOs [33]. This research's findings, did not clearly reject PMOs' deficiency as knowledge providers but did not support it particularly either; even though there was a weak positive correlation between PMOs and the extent to which the users were trained for their project roles. Issues that the project managers considered, and that they could influence were, with a single exception for user training, not correlated to usage of PMOs. Neither, were there any correlations between how the respondents rated their communication and co-operation with project members, external stakeholders, and auditors. The co-operation and communication with the project sponsors were weakly correlated though. Proportionately few findings showed distinct results in a direction that proposes PMOs to have an important influence for project processes and project outcomes in Swedish public authorities.

Of the 88 correlations that were calculated, seven cases of medium strength and 18 of weak strength were found. Dai and Wells [14] argued that PMOs led to successful projects even though their findings were not statistically significant. Hence, their research presents ambiguous findings, and it would perhaps be more appropriate to play down these findings since there were no statistical significance to indicate the correlation between PMO and project success. When it comes to research, statistical significance should not be ignored. Still, in some cases it might be regarded as relevant to show non-existing correlations for providing a fuller understanding of the whole picture of the current phenomena. Not least, to avoid overestimating the significant correlations that actually exist anyway. That is why the not statistically significant correlations from this research are briefly presented in sub-section 4.3.

Most PMOs in this study (80%) were rather new and at the oldest six years. According to Aubry et al. [23], [24], and Hurt and Thomas [7] it is necessary, and should be expected, that PMOs change, and even are being closed, for the sake of innovation, and adaption to organizational needs. Besides, it is often a part of the assignment to transfer project knowledge/culture so it will be embedded in the organizations; a process in which PMOs are making themselves unnecessary [24]. An organization that had closed one or more PMOs could successfully start new ones. If that would

be the case in these authorities is not be possible to know, because it was not followed up in the survey if there had been PMOs before, or if there were any plans for establishing PMOs.

In the literature, it is raised as a problem that PMOs' tasks are often not recognised in the organization, conveying that PMOs must defend their existence [23]. The findings showed weak correlations between the respondents' opinions about how they considered their employer to appreciate their work and the PMOs. Further, there were no significant correlations between PMOs and the respondents' occupational pride, between PMOs and their intuition, or how his/her individual gain influenced the job. Neither were there any significant correlations between PMOs and influence of norms, or importance of organizational/sector knowledge as concerned the decision foundations.

In the literature [34], there are opinions that implementing PMOs could convey a risk for being increasingly exposed to more scrutiny, than otherwise, just because there is a PMO, which is expected to deal with all project related problems. PMOs should not be judged simply on grounds regarding monetary value, neither should PMOs be established only to give legitimization to the projects [38], and it is not the amount of control, that the PMO exercise, that add to the project performance [37].

5.2 Relatively low PMO usage in Swedish public authorities

Even though the data collection was not as covering as hoped for, the findings still point in a direction that there were a proportionately low application of PMOs in the Swedish public authorities that took part in this research. It was IT PMOs that were studied, and the authorities, in which the IT departments already were outsourced (or should be soon), did not find it meaningful to participate in the survey. That is understandable, but the fact that IT was outsourced in 64 authorities (that did not take part in the survey), makes it still interesting to compare with Martins and Martins [25] research. They argued that outsourcing of PMOs were not recommendable since the organizational culture is too important to let go off. External parts were not considered as being equally good, from a culture preserving perspective. Organizations that want to take advantage of PMOs' benefits should rather keep the PMOs internal, and manage them in-house. This argumentation should be just as applicable on outsourcing of IT, and would probably convey that IT PMOs also were outsourced. The risks connected to external parts dealing with IT issues in a way that are not manifest in the authorities' culture, could be applicable for outsourced IT PMOs as well as for outsourced IT departments. The public authorities' culture probably would differ from private companies [4], [2], [5], [1]. Most respondents (61%) worked in large authorities, with more than 1001 employees, which could be a motivation to keep IT in-house, even for those authorities that did not apply PMOs. There were positive correlations of medium strength between i) project managers that were trained for their project role, ii) between how often the project model was used, iii) between the project managers' competence in the project model, and iv) between the support for the project model and the existence of PMOs. Still, the Chi-square test assumed the null hypothesis (cf. 4.4). The fact that IT project managers' opinions were studied, and that they worked at authorities that had their own IT departments, could possibly partly explain these findings, which however, also could be influenced by the respondents' general project management knowledge and competence. Still, a majority (52.4%) of the respondents' workplaces did not apply PMOs, and the project managers did not hold project management certifications (61%), the latter is however, not regarded as necessary to deliver successful project outcomes [29]; these findings indicate that it is not that significant to adopt PMOs. According to Artto et al. [6] managerial control over projects could be practiced without PMOs; IT project managers with accustomedness to IT projects could be even better equipped for such a commission. Besides, the authorities must be particularly careful with how they spend the taxpayers' money. It would not be accurate to presume that decisions about applying PMO has its origins in anything other than initiated decisions, and weighing of the pros and cons. The IT sector has especially long experience from carrying out projects, since the modern project management era started out from handling technical projects that are closely connected with IT. The IT personnel also show a higher commitment to project management methods than business personnel according to de Carvalho [20]. The research findings indicate that PMOs are not that sufficient, and PMOs are also questioned in the literature. Researchers do not agree about the necessity of PMOs; some found them even to be overrated [15], others stated that organizations could apply managerial control in a way that is principally comparable to what a PMO would have done, and stated that PMOs do not apply project management practices to a higher degree that other organizations [6], [27], [35]. This research showed just a weak, positive

correlation between PMOs and establishment of project models, and no significant association between usage of PMOs and usage of project models. There were no correlations at all with PMOs and the importance of product / project quality, intuition or the projects' effects for the project managers' work, and the sponsors' organization. Neither, were there any correlations between PMOs and the quality of the project charter at the initial project phase, at what time the goals were followed up, the sponsors' ability to grasp the whole / the knowledge level regarding the IS when the project started, and none regarding the respondents' private / occupational experiences. Several issues pointed in the same direction, and the findings are unambiguous when it comes to presenting a picture of the whole about the usage of PMOs in Swedish public authorities.

The fact that a majority of the public authorities did not apply PMOs does not really say anything about the underlying reasons. Well-informed decisions could have been taken in mature project organizations (i.e. the authorities) [7], [8]. There could have been PMOs earlier that have made themselves unnecessary through an "emptying process" [24]. There was no question about earlier / future PMO existence in the survey. Organizations that are running PMOs must accept their presence, and the top management must support them [5]; something that is just as true for projects in general, with or without PMOs. When PMOs are not applied, as is the case in most of the respondents' authorities, it might be a proof of that the projects are manageable without PMOs, and that the projects are explicitly accepted, and supported, by the top management. It could be related to skilled and experienced project managers, and it does not have to be a result of bad judgement or of less initiated decisions about PMO implementations.

6 Concluding remarks and answers to the research question

In this section, the answers to the research question will be summarized, implications for theory and practice will be presented (6.1), and future research will be proposed (6.2).

6.1 Answers to the research question and implications for theory and practice

The research question was: How significant are PMOs for Swedish public authorities? The short answer is that PMOs do not appear as particularly important. There are some partial answers that contribute to a richer understanding of the research question. There was 42.7 percentage of the respondents, who answered that their authority applied PMOs. This figure is however, even lower since some of the respondents work at the same authority (82 respondents appointed in 73 authorities). Concerning what could be statistically proven about PMOs significance for public authorities, there were seven medium strong correlations ($p < .01$), 18 weak correlations ($p < .05$) (cf. 4.2), 63 correlations were tested and found not statistically significant (cf. 4.3), and one Chi-square test was carried out (small effect size) that did assume the null-hypothesis (cf. 4.4). Hence, the findings related to PMOs are not convincing when it comes to validating the PMOs' necessity and sufficiency for Swedish public authorities, rather the opposite.

The most prominent theoretical implications are summarized as follows:

- The findings indicate that PMOs are of less significance for successful projects than they are frequently pointed out to be.
- The fact that there are no PMOs in authorities could be a result of:
    - Earlier instances of PMOs have been exposed to "emptying processes" that actually imply that project management practices have been spread successfully in the organization due to mature PMOs
    - New PMOs that are under development, that should be implemented but are not yet, since PMOs should preferably be regularly renewed.
- IT project managers are often used to carrying out projects, and therefore there could be less need for PMOs when the projects concern IT.

The implications for practice are mainly connected to the importance of acknowledging that PMOs could entail both pros and cons, and that they do not solve all conceivable problems associated with projects and project management. A thorough understanding of these issues is likely to provide a more reliable foundation for substantiated decisions about PMO establishments, and should convey that overestimated expectations are avoided.

6.2 Suggestions for further studies on PMOs in public authorities

Further studies should be carried out in order get a better hold of the factors that influence PMO usage in public authorities. The correlations, and also the non-existing correlations, could give input to follow-up studies that would probably gain from being carried out as case studies [46]. Deep interviews, focus groups combined with surveys, and preferably in a longitudinal study design, which allows for following up on interesting aspects regarding the innovation perspective, and PMOs almost inherent abilities to change, innovate, and to adapt to the organization in a way that make themselves unnecessary whilst embedded in the organization instead [24], [16]. Issues connected to the value for money problem [15], and to the problems with PMOs being entities that project managers in general hesitate to contact because of their reputation as not being interested in knowledge brokering [30] should be further elaborated on.

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Appendix A. Questionnaire

The 89 questions (including the question about if there was a PMO or not) from the questionnaire that were used in this research are listed in sub-section A1. These questions / variables have been calculated with Spearman's correlation, resulting in 88 correlations (7 significant correlations on the 0.01 level, 18 on the 0.05 level, and 63 not significantly correlated). The questions regarding the participants' background data (profile) are excluded below. The participants profile is available in sub-section 3.2.

A.1. Questions

Is there a PMO?
How long have the authority applied PMO?
Is there an established project model in the authority?
How does the project model work?
How often do you use the authority's project model?
Is there any support available in the authority on its project model?
How good do you consider the support on the project model to be?
How would you describe your competence in the authority's project model?
How significant is your occupational pride for your work as a project manager?
How significant is your occupational experience for your work as a project manager?
How significant is your private experience for your work as a project manager?
How significant is project quality for your work as a project manager?
How significant is product quality for your work as a project manager?
How significant is auditor training for those who take on project accountant tasks?
How significant are your private norms for your work as a project manager?
How significant are the authority's norms for your work as a project manager?
How significant are the society's norms for your work as a project manager?
How significant is your status in the authority for your work as a project manager?
How significant is your position in the authority for your work as a project manager?
How significant is your individual gain for your work as a project manager?
How significant is your intuition for your job as a project manager?
To what extent are the authority's managers trained for their project sponsor roles?
How significant do you consider training, for those who take on a sponsor role, to be?
How would you judge the importance of a project's effects for the project sponsor's organization?
To what extent can you influence the projects effects and business benefits?
To what extent can you influence the sponsor's decision-making?

To what extent can you influence the sponsor's strategy?
To what extent can you influence the communication?
To what extent can you influence the co-operation?
To what extent can you influence the discussions?
To what extent can you influence the staffing of the projects?
To what extent can the organization's managers influence the staffing of the projects?
To what extent can the project sponsors influence the staffing of the projects?
To what extent can you influence the users' knowledge level?
To what extent can you influence the users' competence level?
To what extent can you influence the users' motivation level?
How do you value the users' abilities to increase their competence levels?
How do you value the users' willingness to increase their competence levels?
How do you value the users' ability to maintain their competence after the project, and after the products (i.e. the IT systems) have been commissioned?
How do you value the users' competence at the time when the products (i.e. IT systems) are being commissioned?
How do you value the users' willingness to maintain their competence?
How do you value the users' knowledge level during the project?
How do you value the users' motivation level during the project?
How do you value the users' motivation level after the project, when the products (i.e. the IT systems) have been commissioned?
How do you value the project staff's competence regarding the project method / work?
To what extent do you consider that you can take in / grasp the whole of the project?
To what extent do you consider that the sponsor can take in / grasp the whole of the project?
To what extent do you consider that the sponsor can grasp the product of the project?
How complete decision support can you supply the decision makers with?
How understandable decision support can you supply the decision makers with?
How good is (i.e. what quality has) the project charter at the initial project phase?
How important is organizational knowledge (i.e. culture) for the decision foundations?
How important is sector knowledge for the decision foundations?
What is your assessment of your over-view of the product?
What is your assessment of your employer's appreciation for your work?
To what extent are different experiences represented in the projects?
To what extent do the users get any training for their project role?
To what extent can you influence the user training?
To what extent are you and other project managers trained for your roles?
How good is the leadership that you practice in the project?
How important is leadership quality for your work as a project manager?
In a long-term perspective – to what extent does the authority work with the business value realization?
When is the goal fulfillment (i.e. the effects) of the project followed-up on?
To what extent would you consider that the sponsor understands the intention of the decisions?
How do you value your communication with the sponsors?
How do you value your communication with the project staff?
How do you value your communication with the external stakeholders?
How do you value your communication with the users?
How do you value your communication with the auditors?
How do you value your co-operation with the sponsors?
How do you value your co-operation with the project staff?
How do you value your co-operation with the external partners?
How do you value your co-operation with the users?

How do you value your co-operation with the auditor?
How do you value your discussion with the sponsors?
How do you value your discussion with the project staff?
How do you value your discussion with the external partners?
How do you value your discussions with the users?
How do you value your discussions with the auditors?
How do you value the sponsors' work?
Which competence level do you consider the project staff to have as regards the IS/IT-sector?
How important is the IS for the project work?
To what extent do you think that the sponsor is able to distinguish between technical IT-issues and business related issues?
How would you assess the sponsor's knowledge level about the IS when the project starts?
To what extent are different genders represented in the projects?
To what extent are different experiences represented in the projects?
To what extent are different ages represented in the projects?
How structurally does the authority work with the realization of the business value?
How consciously does the authority work with the realization of the business value?

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BPFlexTemplate: A Business Process template generation tool based on similarity and flexibility

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Abstract:
In large organizations with multiple organizational units, process variants emerge due to many aspects, including local management policies, resources or socio-technical limitations. Organizations then struggle to improve a business process which has no longer a single process model to redesign, implement and adjust. In this paper, we propose an approach to tackle these two challenges: decrease the proliferation of process variants in these organizations, and foresee, at the same time, the need of having flexible business processes that allow for a certain degree of adjustment. To validate our approach, we first conducted case studies where we collected six real-world business process variants from two organizational units of the same healthcare organization. We then proposed an algorithm to derive a template process model from all the variants, which includes common and flexible process elements. We implemented our approach in a software tool called BPFlexTemplate, and tested it with the elicited variants.

Keywords:
BPM; Process variants; Template model; Generalisation; Healthcare processes; Similarity metrics.

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1. Introduction

Business processes can be generally described as a set of logically related tasks, behaviors, resources and data that organizations develop over time to produce specific business results [1]. Process models are then designed and evolved to conduct business processes execution, and to have a more or less uniform record of all its executions (instances or process cases). These executions should, in turn, reflect what really happens/is happening in organizations. This way, management is enhanced since metrics and process key performance indicators can be derived from similar recorded cases of a certain process model. Processes can then be improved by redesigning their models to tackle less optimized parts, considering the analysis performed to their recorded cases.

Nevertheless, large organizations often have several organizational units that are managed distinctly, but are also supposed to follow the same process models for similar, cross-organizational business processes and process improvement. Examples of these processes include student enrolment within distinct faculties of the same university, or a medical appointment scheduling across several public hospitals of the same National Health System. Although organizations usually impose uniformity in modeling and executing these processes to offer the same service and to measure performance, many organizational units make several adjustments over time, resulting in a proliferation of process variants. The problem then becomes twofold: 1) organizations loose general business process management ability because measuring, comparing, monitoring and optimizing processes that have many variants is difficult, and 2) organizational units have been improving their process variants overtime, and may not want to adopt/obey to a certain "general" and completely "rigid" process model in all its length.

Therefore, organizations with several organizational units can contain a family of business process model variants. By comparing these variants, we can observe that some of their process elements (tasks, resources, data, decision nodes, and sub-processes) are common, while others may differ, be added or deleted, or simply be in a different order.

Considering the well-known Business Process Management (BPM) lifecycle [2], to redesign, model, implement and maintain each process variant of a process family would be too costly and cumbersome (and therefore difficult to carry or use) for organizations. On the other side, a process variant of a certain organizational unit can enclose valuable good practices and optimization efforts, either to be applied in a local context, or even suitable for the remaining units of the organization.

The challenges that arise from this setup include, on one side, the need to align business processes across all organizational units for better process management, and on the other side, the urge to take advantage of the most succeeded process optimizations made across individual units over time. Accordingly, on the gap between these commonalities (fragments that are shared by all process variants) and to cope with this need for process flexibility, a proper management of these family variants along the entire BPM life cycle has become crucial.

In this paper, we propose an approach to tackle these challenges. The main output of our approach is a template process model that we derive from a certain number of process model variants. This derived template model can then be used seamlessly across all organizational units of a certain organization, reducing variants proliferation. At the same time, it foresees flexibility (the ability to make adjustments) taking into account the adjustments registered in all existing variants. This way, the organization can perform business process management more effectively by assuring the overall use of a single (template) process model which reflects common good practices across all organizational units. Additionally, these organizational units can make use of the template's flexibility features, to reflect their particular adjustments.

Our approach includes the use of good process modeling practices, and an overall algorithm to deal with variants comparison/similarities and derive the flexibility-enabled template process model. We also implemented a software tool to help process engineers to derive this template model. We validate our approach by performing case studies that include the elicitation of six real-world business process variants from the healthcare domain.

This paper is organized as follows: The next section introduces the main background notions including Business Process (BP), BPM, BP variability, BP comparisons and similarity and BP flexibility. Section 3 highlights the related works. This is followed by section 4 where we explain our proposed approach called "BPFlexTemplate". In section 5, we present our case studies that allowed us to validate our approach. Then, in section 6, we describe the BPFlexTemplate software tool. Finally, section 7 renders some conclusions and future work.

2. Background

Besides referring to general concepts of business processes, our proposed approach is based on the combination of three main research topics of Business Process Management (BPM): 1) process variability and the techniques used to deal with it; 2) process model comparison and similarity approaches; 3) process flexibility concepts and techniques. The next subsections provide background on overall BPM as well as in these three topics.

2.1 Business processes and Business Process Management (BPM)

Business processes (BP) can be considered as the arteries of modern organizations. They determine how work is done in the organization. A business process is a collection of related events, activities and decisions that involve a number of actors and resources, and that collectively lead to an outcome that is of value to an organization or its customers [3]. So, a BP may be considered as the set of performed activities in coordination, within an organizational and technical environment. In other words, it defines what shall be done (activities), by whom (organizational and technical environment) and how it shall be done (coordination).

A business process model is the main artifact for representing the respective process. It is described in a graphical way using elements (including activities, gateways, events, sub processes, resources and data) of a specific language or notation like the Business Process Model and Notation (BPMN) [4] or Event-driven Process Chain (EPC) [5]. Business process support is present in several business domains. Examples include the healthcare domain [6], [7], [8], [9], [10], automotive engineering [11], and public administration [12]. In all these domains, business process models are designed and evolved in order to have a more or less uniform record of all instances (cases), in order to reflect what really happen in organizations. This way, management is enhanced since metrics and process key performance indicators can be derived from similar recorded cases of a certain process model.

Business Process Management (BPM) is considered as the science of overseeing how work is performed in an organization. This performance aims to ensure consistent outcomes and to take advantage of improvement opportunities [3]. In this context, the main term "improvement" may take different meanings depending on the objectives of the organization. The powerful interests of the BPM-based approach give rise to many expectations and prospects, including, for instance, the areas of Business Process Reengineering (BPR), or the supervision of Business Activity Monitoring (BAM). Many research works assume that process design/modeling is the core of each of these approaches [13].

Before evolving and improving business processes within organizations, a clear and shared vision of the organization's "as is" business processes is required. The process modeling step is considered as a way to achieve this. Widespread in many domains, process models are used to understand, develop and communicate. A process modeling based approach can serve several objectives, including the identification of tasks to be potentially supported, or the optimization of the already in place Information Systems. Also, it contributes to document the process in order to help writing requirements, making decisions, eliminate confusion and facilitate exchange between involved actors. Therefore, a process design/modeling approach improves collaboration between functional structures within an organization and between organizations. In addition, it provides the reduction or elimination of the dependence of an activity in relation to employees who are assigned to it, and improves the management and knowledge capitalization. Also, it allows checking and improving processes and sub-processes in order to continuously make the processes of the company evolving [14] and [15].

Many works are dealing with the representation of the Business Process Management (BPM) cycle. For instance, in Figure 1 we can observe the proposal of van der Aalst in [2]. It starts by the (re)design phase. In this step, a process model is (re)designed, meaning either the creation of a new process model, or the adjustment of an existing model. Then, in the implementation/configuration phase, the model is configured into a running system usually known as a Business Process Management System (BPMS). In the run and adjust phase, the processes are enacted and adjusted when needed. Also in this phase, the process is not redesigned and no new software is created; only predefined controls are used to adapt or reconfigure the process [2].

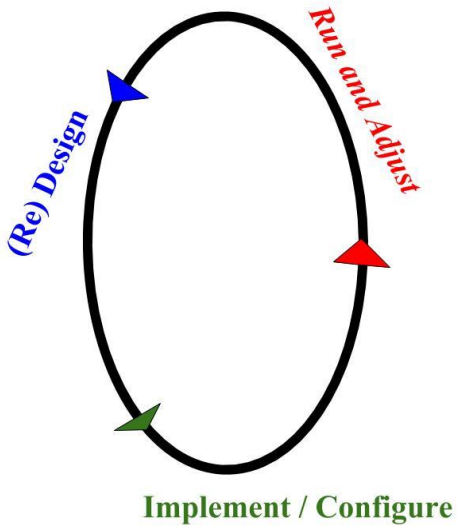

Fig.1. BPM lifecycle (adapted from [2])

2.2 Process variability

For a particular business process, we can have different variants reflecting adjustments made out of a reference process model, taking into account specific requirements of the process context [16]. In fact, the design of processes spans several layers of abstraction, from theoretical lifecycle models, via organizational models of best practice, to the plans of actual process instances [17]. These design efforts usually result in a template model, which can be defined as a generalization of other models, which represent a large number of process model variants [18]. This template model should also be adjustable to get a particular or specific model variant that best suits a certain context. To represent all these specificities, Jorgensen proposed the lifecycle of process model evolution that is illustrated in Figure 2. He divided process models into two categories. The first one is “Particular models”, which aim to support performance of a particular (adjusted) process model. The second one is “General models”, which abstract common properties from a number of actual processes, represent normative standards for the organization, or are templates for reuse and adaptation into particular models.

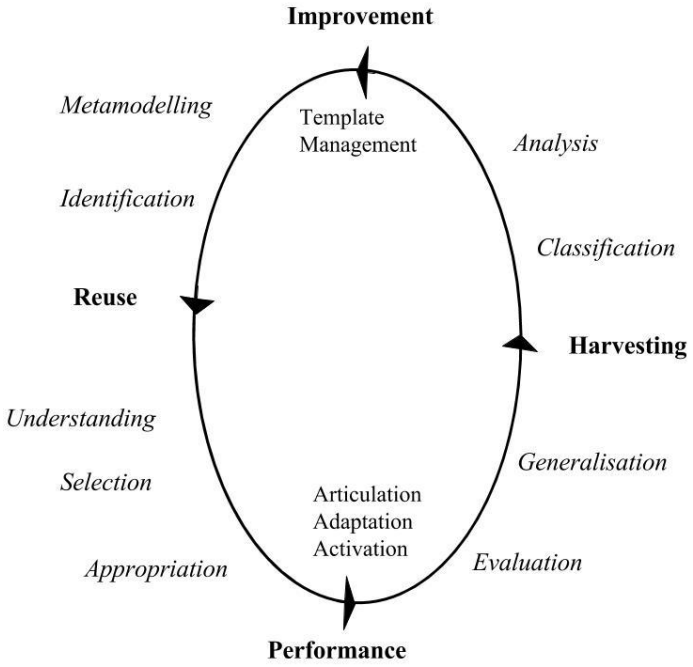

Fig.2. Lifecycle of process model evolution (adapted from [17])

The proposed lifecycle of process model evolution presents four main phases: improvement, reuse, performance and harvesting. Applying a general process model to a particular situation is a case of reuse. The reuse may also refer to copy and paste of a previously developed particular model into a new process. During the performance phase, users need to add new details, remove irrelevant parts etc. of the model.

The process of generalizing one or more particular models is called harvesting. The goal of harvesting is to provide templates that can be reused in the future, and to utilize practical experience as input to assessment and improvement of the general models [17]. Therefore, for a business process, different variants may exist. These constitute, in turn, an adjustment of a general, master process (e.g., a reference process) to meet specific needs of a certain process context [19].

In fact, organizations may need to have a collection of related process variants, which are denoted as a business process family. In practice, a process family may comprise more than one process variant [11] [20]. Take for instance the automotive industry, where we can find a process family dealing with vehicle repair and maintenance, which comprises more than 900 process variants [21]. They have some fragments that are shared by all process variants, but also show vehicle-specific variations. Also, in healthcare, we can find reports on more than 90 process variants for handling medical examinations in a hospital [20] and [22]. In another example, we may refer to the check-in procedures at an airport, which are characterized by a high degree of variability as well. The variability can be caused, for instance, by the type of check-in (if it is online, at the self-service machine or at the counter) [20].

Since a process model can represent several process perspectives such as functional, behavioral, organizational, informational, temporal and operational perspectives, variants can come up from changing any of these perspectives, either individually or in a combined form. The main objective of existing approaches that are dealing with variability is the contribution to avoid model redundancies, foster model reusability, and reduce modeling efforts [23].

2.3 Process comparison and similarity

Over time, many organizations have built many repositories of BP models that serve as a knowledge base for their ongoing BP management efforts [24]. These repositories may contain hundreds or even thousands of models. However, to better manage and improve these large repositories requires effective search or comparison techniques. To search if there is an existing "similar" model or to compare two models is useful to prevent duplication and to have a continuous and effective improvement of the process [25]. A process engineer needs to identify common or similar business processes between, for instance, recently merged companies, in order to analyze their overlap and to identify areas for consolidation. Dijkman et al. in [24] use the term process model similarity query to refer to such search queries over process model repositories.

To answer a similarity based comparison query between BP models involves determining the degree of similarity between one model and another one (or more) [26]. In this context, similarity can be defined from several perspectives, including the following: 1) Node matching similarity which is based on a comparison of the labels that appear in the process models (task labels, event labels, etc.), using either syntactic or semantic similarity metrics (presented in next paragraph), or a combination of both. These metrics start by calculating an optimal matching between the nodes in the process models by comparing their labels. Based on this matching, a similarity score is calculated taking into account the overall size of the models. 2) Structural similarity which is based on the topology of the process models seen as graphs. It is based on the observation that nodes in process models with their relations constitute a mathematical graph. Based on that observation it uses existing techniques for graph comparison based on graph edit distance [27], which is commonly used in information retrieval. 3) Behavioral similarity which is based on the execution semantics of process models. It takes into account the causal relations between tasks in a process model. These causal relations are represented in the form of a causal footprint [28].

Existing approaches for process model elements comparison which is based on similarity metrics can be divided into those based on: 1) Syntactic similarity, where we consider the syntax of labels; 2) Semantic similarity, where we look at the semantics of the words within the labels; 3) Attribute similarity, where we look at the attribute values; 4) Type similarity, where we look at the node types; and 5) Contextual similarity, where we do not only consider the similarity of two nodes, but also the context in which these nodes occur [24].

2.4 Process flexibility

BPM solutions include methods, techniques, and tools to support the design, enactment, management, and analysis of operational business processes of organizations. Accordingly, continuously changing conditions are forcing organizations to rapidly adapt their processes. Then, flexibility requirement has also been following the evolution of BPM, since it reflects the ability to adapt business processes to predicted and unpredicted changing scenarios. Regarding the literature, there are several business process flexibility taxonomies including those proposed by Schonenberg et al. [29] and Regev et al. [30]. We will briefly describe the taxonomy of Regev et al. [30], since it is the one we use in our approach.

This taxonomy focuses on changes that may occur during the lifecycle of a business process. These changes can be of one of three dimensions of change [30]:

- The abstraction level of change which corresponds to the level of application of change in a business process. The change may concern the specification or the process instance;
- The purpose of the change regarding different aspects of the process which are subject to change. The change may concern the process activities (functional), the control flow (behavioral), process the data (informational) or the various protocols used in the process (operational);
- The properties of the change as the degree of change. These concern the extent of change which can be incremental (change a part of the process) or revolutionary in order to create a new process; the duration of

change that can be temporary or permanent; the swiftness of change that can be either immediate or deferred; and the anticipation of change that can be scheduled or ad hoc.

3. Related work

Business process flexibility has been an important research trend for the last two decades, due to the rigidity of process modeling languages and Business Process Management Systems available in the early 1990s. It is often viewed in terms of the ability of an organization's processes and supporting technologies to adapt to changes [42]. Regev et al. [30] observed that a process can only be considered flexible if it is possible to change it without needing to replace it completely, and proposed a business process flexibility taxonomy in [30]. Related works on this matter are aimed at providing process engineers with language extensions and mechanisms (see for instance [33]) to incorporate flexibility in process models and/or instances (by implementing BPMSs that support runtime flexibility).

On the other hand, we can find in literature many examples of algorithms and approaches towards the comparison and consolidation of process models. Notably, the authors in [24,43] propose similarity algorithms to compare process models and elements through their labels, structureand behavior. In [44] the authors present a merging algorithm that takes as input a collection of process models and generates a configurable process model [45]. A similar objective is announced by the authors in [46], where process versions are merged and integrated into a business process model, considering the differences and the change operations history of an initial model. Li et al. [45] take also into consideration the changes/deviations recorded in a Process-Aware Information System (PAIS) regarding a certain business process, and propose to users to decide on the change operations to be applied regarding a newly discovered process variant [47].

Regarding the use of software tools to help process engineers perform these approaches and algorithms, the panorama we found in literature is ratherlimited. In [48], the authors aim for a visual approach to detect significant differences between process variants, based on what was recorded in event logs. They use colored transition systems to model behavior and to highlight the differences, and implement their approach as a Process Comparator plugin of the well known ProM framework [49]. For another aim, Armas et al. [50] proposed the BP-Diff web-based tool that takes pairs of process models in BPMN [4] format and outputs behavioral difference diagnosis in the form of textual statements and graphically overlaid on the process models [50].

In [40], Ivanov et al. propose a Model-View-Controller (MVC) web-based BPMNDiffViz tool, which uses structural matching to compare process models represented in BPMN. Specifically, BPMNDiffViz allows for a colored and quantified visualization of graph differences, stores them, and provides statistics. It calculates the minimum graph edit distance between two process models (number of operations that should be performed to transform one model to another) using an A* algorithm, and also accounts for the string edit distance for each pair of the corresponding graph nodes.

4. The BPFlexTemplate approach

Adopting a BPM based approach may contribute to optimize organizational aspects and the products/services that are delivered when executing the organization's business processes. This way, management is enhanced since metrics and process key performance indicators can be derived from similar recorded cases of a certain process model. Hence, large organizations often have several organizational units that are managed distinctly, but are also supposed to use process models for similar, cross-organizational business processes. As far as we could perceive from literature and from the case studies we conducted, it is common for this kind of organizations to have several variants from a determined business process, due to factors such as local management policies, resource limitations, socio-technical limitations or even culture.

This is the case not only for public governance organizations such as the ones related with education, health or justice, but also for large national or global companies which struggle to streamline their processes along their several organizational units.

For our BPFlexTemplate approach, we adapt the BPM process model lifecycle illustrated before in Figure 2, proposing techniques used in the Evaluation, Generalization, Classification, Analysis and Improvement sub-phases, to obtain a template process model suited to this kind of organizations (cf. Figure 3).

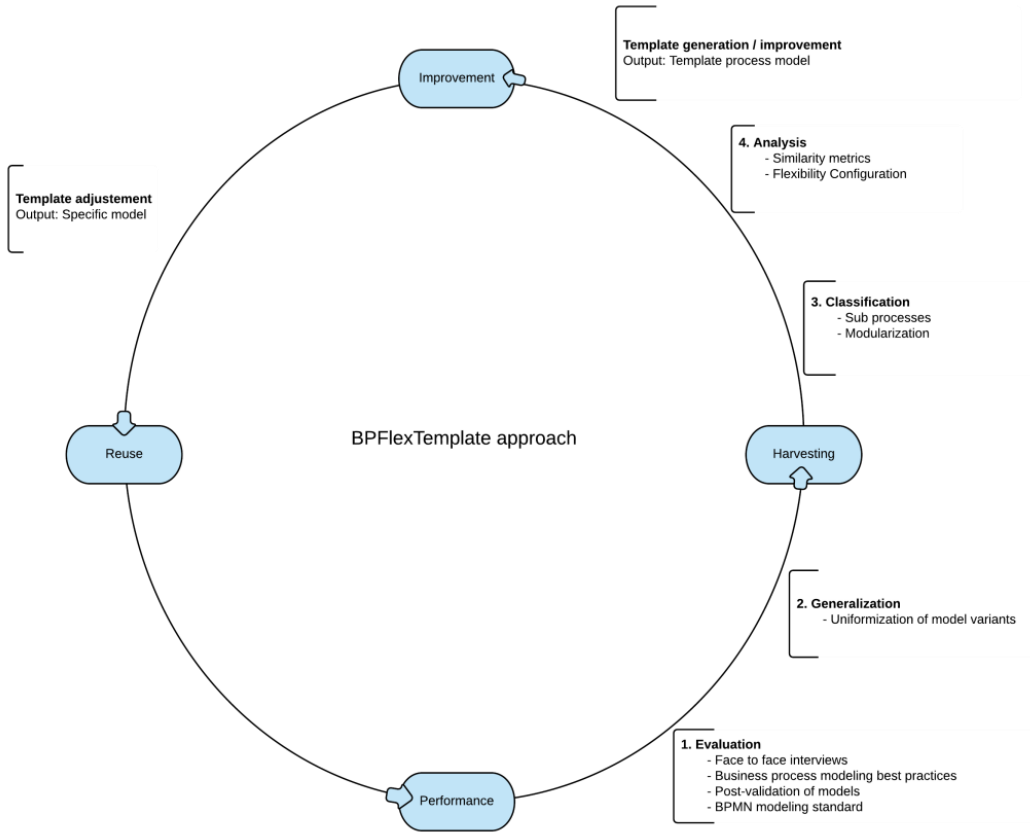

Fig.3. Adaptation of the BPM process model cycle to include our BPFlexTemplate approach

The proposed approach focuses on the right part of the cycle, denoting the techniques used across the Harvesting phase. Harvesting refers to using the models and experience from one or more processes to generate a new template, a variant or a revision of an existing template [17]. It involves manual adaptation of local models to make them suitable for different contexts. Typically, Knowledge Management or methodology experts perform such knowledge capture. The template derived may include both specific language constructs and an initial model.

In the Evaluation sub-phase, we perform process model eliciting by using face to face interviews and best practices regarding business process modeling, based on the works of Mendling et al. in [31] and Pinggera et al. in [32]. Mendling et al. [31] propose a set of seven process modeling guidelines (7PMG). It is a guide to users towards

improving their process models' quality. Concerning Pinggera et al. [32] work, they propose the process of "process modeling", which consists of a cycle of three successive phases: 1) comprehension, 2) modeling and 3) reconciliation. We use these best practices to elicit the different model variants in place within distinct units of a certain organization, taking advantage of the BPMN standard and graphical notation to express these model variants. We then perform a post-validation of these model variants with the interviewees.

Then, in the Generalization sub-phase, uniformisation of process elements is performed by identifying the inputs, processing and outputs of the tasks involved, and labeling them the same in all process model variants, in case they match regarding their overall behavior.

Further ahead, the Classification sub-phase aims to provide a better way to modularize the elicited model variants, by dividing them into more manageable and reusable sub-processes. This will provide a set of sub process templates, which can also be later combined differently according to the specific needs of a certain organizational unit.

Finally, the Analysis sub-phase is performed, where these uniformised and classified process model variants can be compared, in order to derive a single template model. We perform these comparisons using similarity metrics. These comparisons will allow us to derive a single template process model, which will foresee process elements that are either present to most process variants, or specific only to some. We classify these process elements as common and flexible, respectively. This Analysis sub-phase includes also the configuration of the type of flexibility allowed for a certain flexible process model element (such as an activity, a gateway, a document data object or a resource allocation – see, for instance, the work of Domingos et al. in [33]). This flexibility type can be one of those mentioned in the referred taxonomy proposed by Regev et. al. in [30].

Therefore, the overall algorithm for this Analysis sub-phase may be summarized on the following Listing 1 (written based on the pseudo code guidelines presented in [34]):

```
FOR each process model variant
   CALL performSimilarityAnalysis WITH currentTemplateModel, modelVariant,
   similarityType RETURNING similarityResults
   CALL classifyTemplateElements WITH similarityResults, classificationCriteria
   RETURNING classifiedTemplateModel
END FOR

FOR each flexible process element in classifiedTemplateModel
   CALL configureFlexibility WITH processElement, flexibilityType
END FOR
```

Listing 1 – Algorithm for the Analysis sub-phased of the BPFlexTemplate approach

The functions performSimilarityAnalysis, classifyTemplateElements and configureFlexibility may be implemented as components that follow the Template method design pattern from Gamma et. al [35]. This means that they can be invoked with different parameters and then implemented within distinct components (classes) which share the same interface. As an example, and looking forward into our real-world case study, we can apply the following general parameters:

- Function *performSimilarityAnalysis*: invoke with the value of GED (Graph Edit Distance) for the *similarityType* parameter;

- Function *classifyTemplateElements*: invoke with the value of 75% for the *classificationCriteria* parameter, to denote the threshold value for the number of model variants in which a certain element must at least be present to be classified as a common process element;
- Function *configureFlexibility*: invoke with the value of ad-hoc sub process for the *flexibilityType* parameter.

Therefore, the main focus of this algorithm is to reduce model variability for the overall process model template to be used across all organizational units, and allowing for flexibility requirements at the same time that can reflect needed adjustments for a particular organizational unit. In this context, process engineers may control and align 3 parameters in this algorithm: 1) type of similarity metrics to be used to compare the model variants (structural, behavioral, …); 2) level of similarity for each process element (for instance, 75% means that only elements with a similarity of 0.75 or greater will be considered as common, and therefore candidates to be included in the set of common process elements in the template); 3) flexibility mechanism to be applied to process elements that are not similar, and therefore will belong to the flexible set of process elements in the template (for example, an ad-hoc solution means that flexible process elements will be kept and included within an ad-hoc sub process, where they can or cannot be executed, and with no particular order).

5. Case studies

To validate our BPFlexTemplate approach, we elicited six home healthcare process variants from two primary care health centers (organizational units) of the public National Health System (NHS) in Portugal (the main organization). The objectives of our case studies were to validate, on one hand, the assumption that home healthcare processes are not executed the same way within primary care centers of the same organization (the NHS) (and that therefore variants really exist). On the other hand, these case studies allowed us to also validate our global BPFlexTemplate approach presented in Figure 3, including the techniques, best practices and algorithms accordingly.

For the first three sub-phases of Evaluation, Generalization and Classification, we could also benefit from our previous experiences in modeling telemedicine processes [36], [37] and [38] and home healthcare processes in Tunisia [8], [9] and [39]. Regarding these case studies, the home healthcare processes that should be used across all primary care centers is (textually) described in national legislation and overall guidelines provided by the Ministry of Health.

For the Evaluation sub-phase of our BPFlexTemplate approach, we used the 7PMG techniques in the interviews performed with two chief nurses from the primary care health centers of Leiria and Lisbon. Then, we performed an uniformisation of all the process models elicited, and classified them into six process model variants, which were then validated by the same chief nurses. Like in our recent works [8], [9] and [39], we classified these model variants of home healthcare process into three sub-processes, namely: 1) patient admission; 2) organizational care; and 3) patient care.

Figures 4 and 5 show the two validated model variants of the organizational care sub-process (Leiria and Lisbon), after applying to them the techniques of evaluation, generalization and classification described in our BPFlexTemplate approach.

As presented BPMN process models depicted in Figures 4 and 5, these two variants from the organizational care process are noticeably different (even at eye sight). The existence of this variability could also be confirmed within the other four model variants for the patient admission and patient care sub-processes, as can be consulted in [9].

We will use these two depicted variants to illustrate how they are treated throughout the analysis sub-phase of our BPFlexTemplate approach. Regarding this sub-phase, we then performed a similarity comparison for these two model variants, according to our algorithm provided in Listing 1.

This comparison was based on the following similarity metrics: syntactic similarity (Syn sim), type similarity (Type sim) and semantic similarity (Sem sim) between each similar/near element. The values presented in Table 1 are obtained with manual calculations, according to the proposed methods of Dijkman et al. in [24].

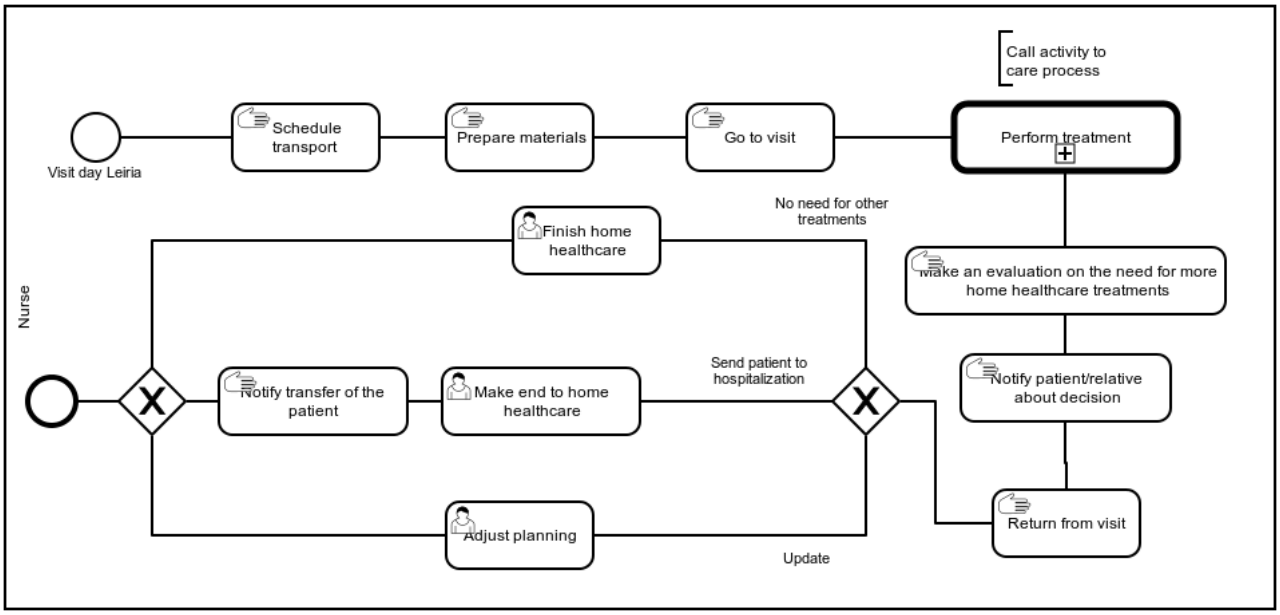

Fig.4. the organizational care sub process model of Leiria primary care health centre according to the BPMN Notation

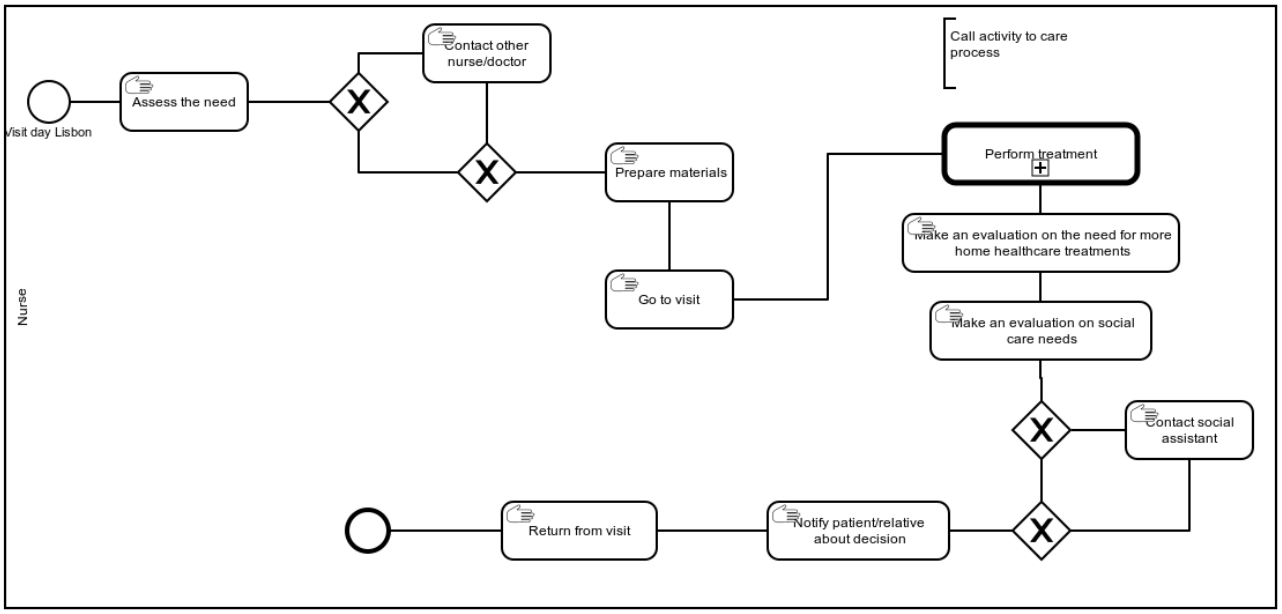

Fig.5. the organizational care sub process model of Lisbon primary care health centre according to BPMN Notation

Table 1 - Similarity results for the 2 model variants of the organizational care home healthcare process

Model variant1	Model variant2	Syn sim	Type sim	Sem sim	N.M sim	G.E.D. Sim
Organizational care of Leiria primary care centre	Organizational care of Lisbon primary care centre	0.53	0.58	0.58	0.80	0.32

Then we calculated the Node Matching Similarity (N.M sim) which is based on pair wise comparisons of node labels or attributes. This is obtained by calculating an optimal equivalence mapping between the nodes of the two model variants being compared. The node matching similarity between two business process graphs representing two process models is:

$$simnm(B1,B2) = \frac{2 \cdot \sum_{(n,m)\in M_{Sim}^{opt}} Sim(n,m)}{|\{n|\in N_1, \tau_1(n) \notin ts\} + |\{n|n \in N_2, \tau_2(n) \notin ts\}|}$$

The node matching similarity score is the sum of the label similarity scores of the matched pairs of nodes. The Graphic Edit Distance (GED) similarity is computed as one minus the average of the fraction of inserted or deleted nodes, the fraction of inserted of deleted edges and the average distance of substituted nodes.

All similarity values presented in Table 1 (all scaled from 0 – non similar, to 1 – similar) denote that there is a significant difference between the two analyzed model variants, proving a certain amount of variability for this process.

As presented in our proposed algorithm in Listing 1, and in order to derive our (flexible) template model from these variants, we can configure three parameters: 1) Type of similarity, 2) Classification criteria and 3) Flexibility mechanism. So, in this case, we chose the following values for these parameters: 1) *Structural Similarity*, 2) 100% and 3) the *ad-hoc sub-process* mechanism for these parameters. These configurations led us to derive the template model presented in Figure 6.

In this derived template model, we marked the common (rigid) process elements with a red contour and the flexible process elements in green. This means that, for this case, the red contoured elements represent the common part of the template, i.e., the one that is really being enforced in all organizational units, according to the configuration parameters for similarity and classification criteria. As for the green contoured elements, they represent the flexible part of the template, to which the ad-hoc sub process mechanism was applied. For instance, for activity Adjust planning, this means that it can be executed in any particular order, or even skipped according to an organizational unit's specific context and needs.

In the next section, we describe and illustrate how we have built a software tool that implements the algorithm presented in Listing 1, in order to enhance the work of a process engineer that wishes to perform this kind of analyses.

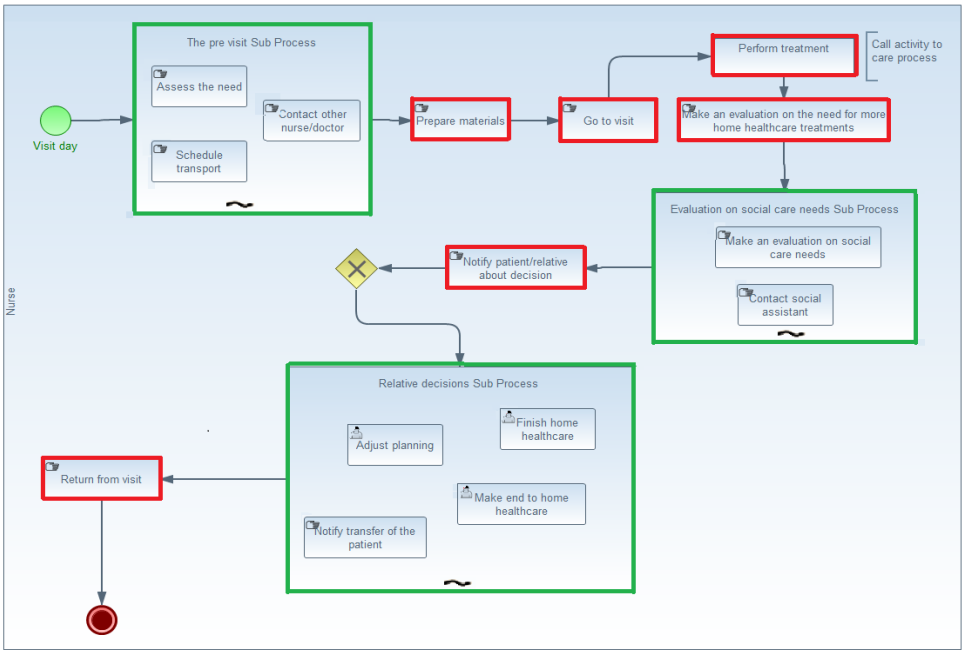

Fig.6. Derived template process model from organizational care of two organizational units [9]

6. BPFlexTemplate software tool

In a previous stage of our work (as in [9]) we could validate our approach by manually executing the Analysis sub-phase of our BPFlexTemplate approach. This implied manual similarity analyses calculations and process model variants comparisons, which revealed to be a cumbersome procedure. In order to automate this procedure, and make it more suitable to be used by organizations' process engineers, we implemented the BPFlexTemplate software tool, which is an extension of the BPMNDiffViz tool from [40]. In the latter, the authors propose a similarity structural matching Web application that compares process models represented in the BPMN 2.0 format. It allows visualizing graph differences, storing them, and providing statistics, assisting in analyzing process model discrepancies. The implemented comparison algorithm finds the minimal graph edit distance between two process models (number of transformations, which should be performed to transform one model to another) using an A* algorithm, and calculates the string edit distance for each pair of the corresponding graph nodes (BPMN process elements of a model). In terms of technology, the BPMNdiffViz tool is a Java-based web application that uses the Spring MVC (Model-View-Controller) framework [41].

6.1 Use cases for the BPFlexTemplate tool

To achieve our BPFlexTemplate software tool, we added to BPMNdiffViz features that concern our purpose of comparing process models and then deriving a template model that is based on our presented algorithm in Listing 1. These template models are also stored in the database and the process engineer can visualize them on the browser. Therefore, in our extended BPFlexTemplate tool, a process engineer can perform these three main features: 1) Select BPMN models from loaded new BPMN models or generated template models; 2) compare two or more BPMN models, produce final graph edit distance, exploit these comparison results and; 3) derive a template model. Figure 7 presents the use case diagram that illustrates these features.

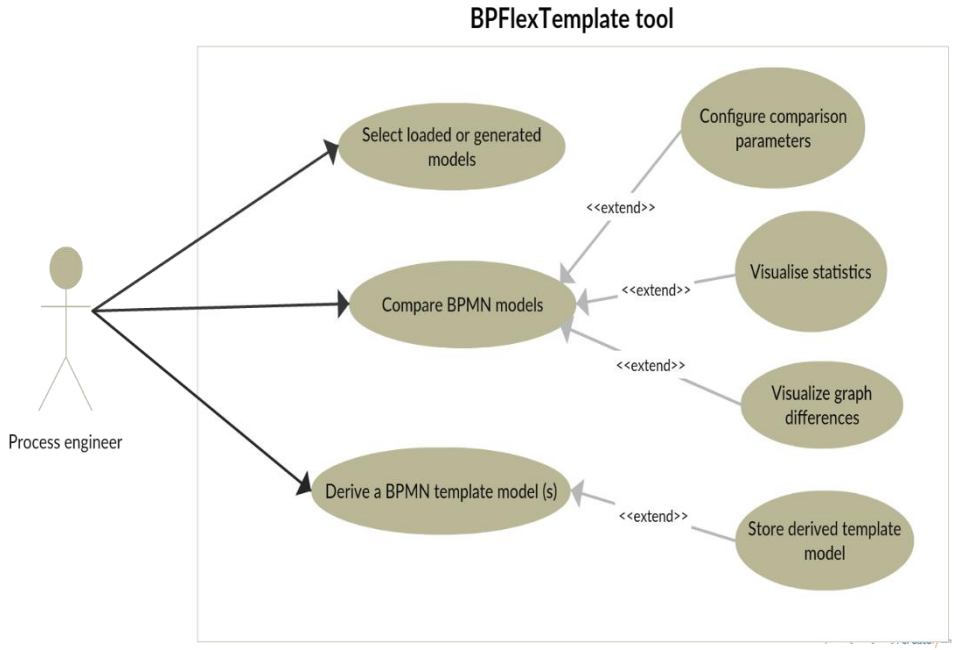

Fig.7. Use case diagram of BPFlexTemplate tool

Thus, based on these main features, it will allow to visualize all derived template models, compare this template with another model variant and generate another template. A process engineer may also choose the type of similarity that should be applied to derive differences and similarities between model variants, as well as the classification criteria (0 to 100%, since similarity scales usually range between 0 – non-similar, and 1 – completely similar). Finally, s/he can also pick the flexibility mechanism to be applied to the identified flexible (non-common) process elements in the template. For instance, s/he may choose between simply deleting them from the template, or including them in an ad-hoc sub process, as illustrated in our example of Figure 6.

To validate our tool, we picked up our elicited model variants from the case studies as input. Our aim is to illustrate that the tool can derive identical results to those presented in section IV where we performed manual similarity calculations and template design.

Figures 8, 9 and 10 show the initial steps where the user can upload or choose the previously loaded process models (variants) to be compared. Derived template models are also stored within the database to which the BPFlexTemplate connects. This means that, for instance, for a process with three variants, the user can first derive a template model by comparing two of them, and then perform a second comparison between this resulting template and the third variant.

As shown in Figures 8 and 9, we loaded the same two model variants analyzed in section IV, elicited within the two primary care health centers of Leiria and Lisbon.

The third step is the configuration of comparison parameters. We may have many combinations: For the similarity type, we can choose between 3 main types (Structural, Node Matching or behavioral) and for each type we can also choose the similarity type between models elements. Then, we may adjust the classification criteria between 0% to 100% (From non similar to exactly the same). Finally, we need to parameter the flexibility mechanism. This means how we want to deal with the flexibility challenge (Replace flexible parts with Ad-hoc sub processes, or delete them, etc.).

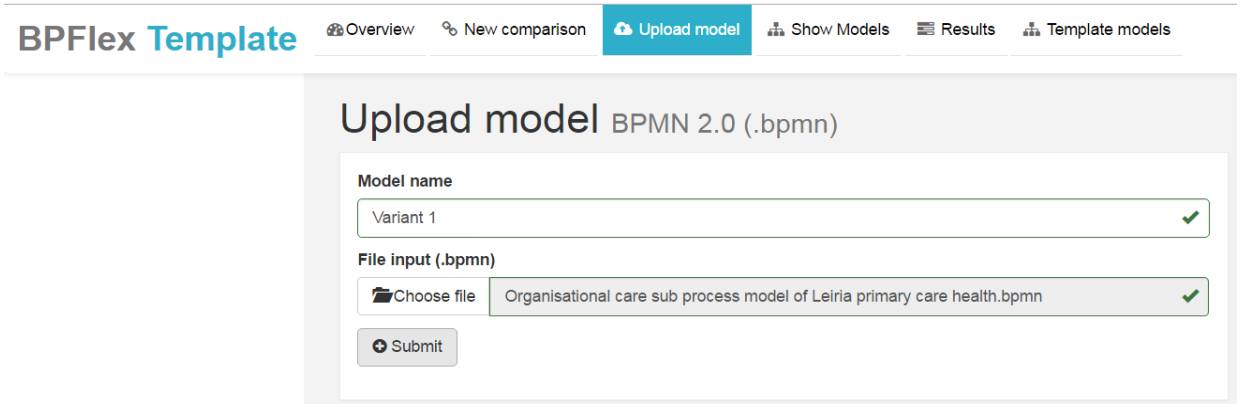

Fig.8.Upload model in the database

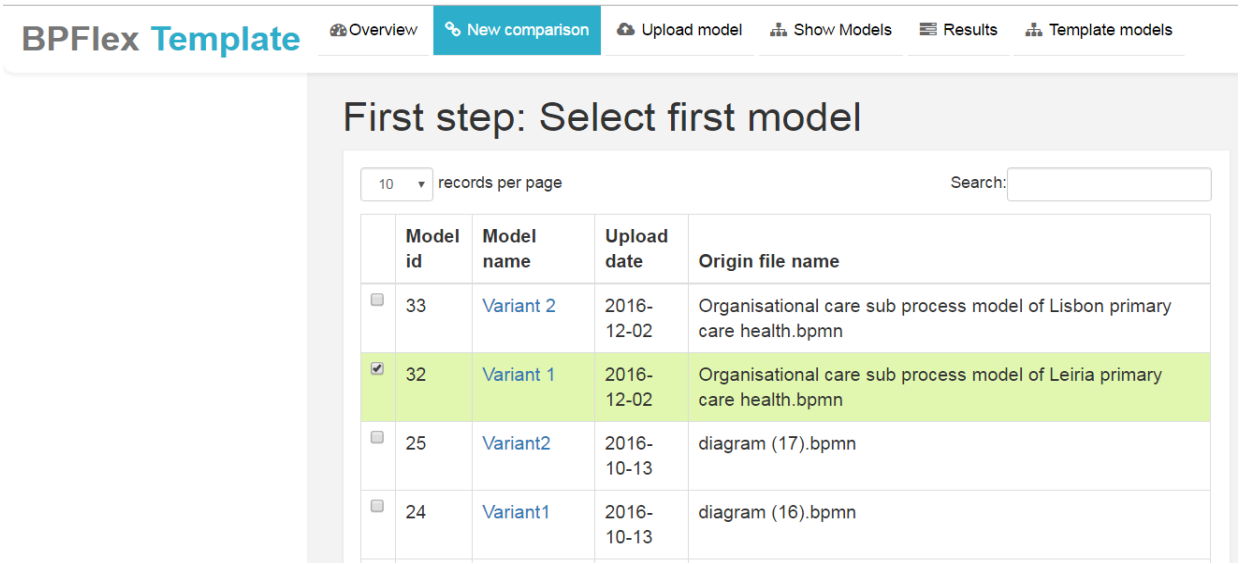

Fig.9. First step: Select the first model to be compared

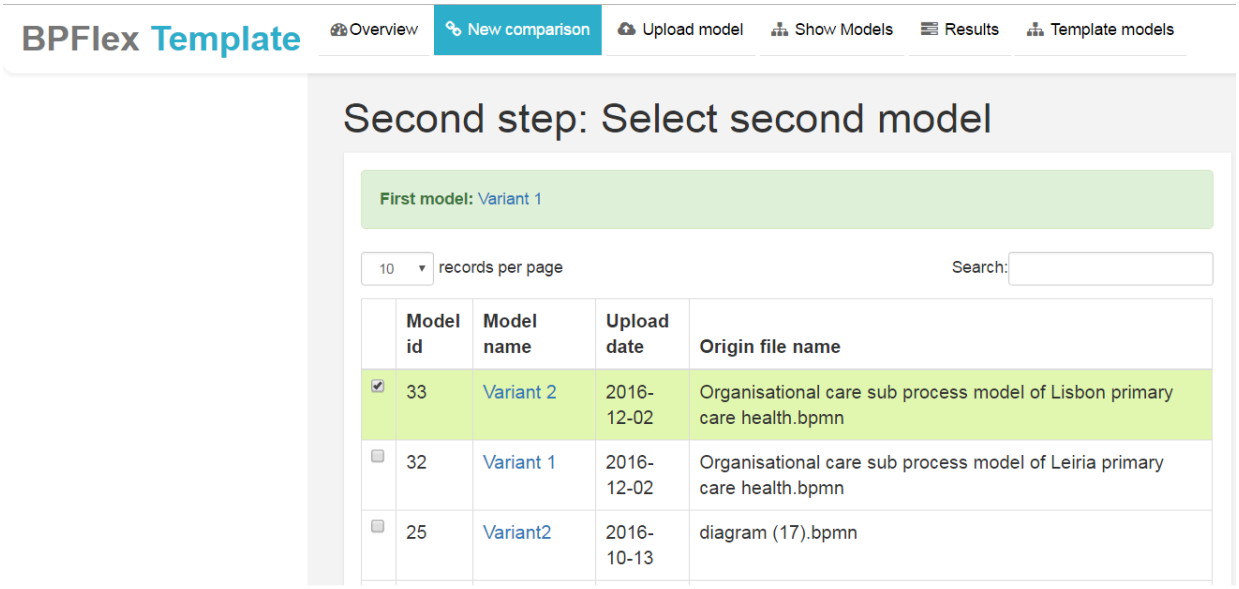

Fig.10. Second step: Select the second model to be compared

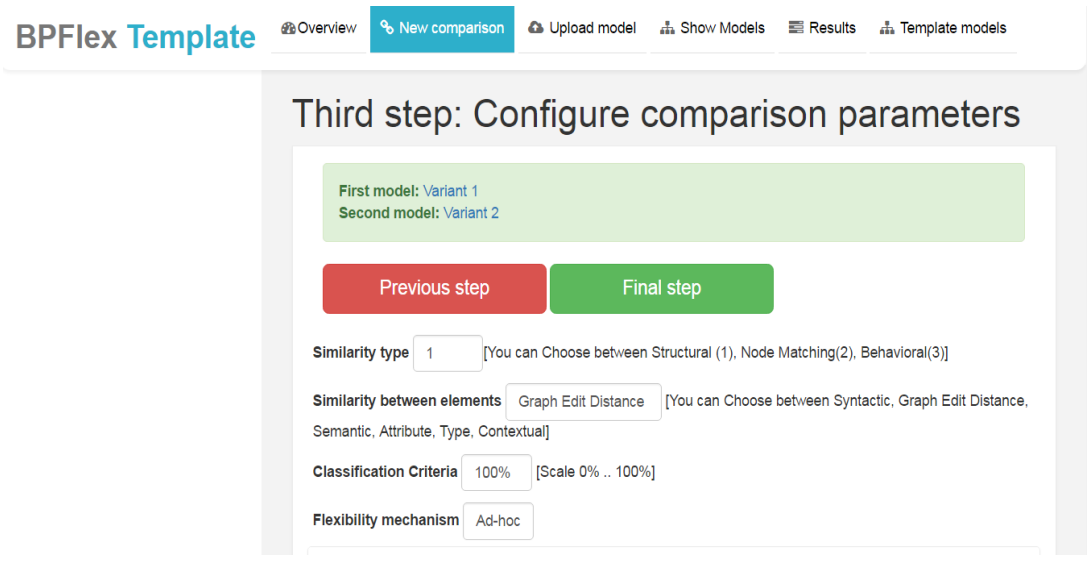

Fig.11. Configuration of the parameters to derive the template model for variants Variant1 and Variant2

Figure 12 presents the derived template model for the parameters configuration presented in Figure 11. We can observe that, although with a different layout, our BPFlexTemplate tool automatically derived an identical template model to that in Figure 6, for the same considered model variants.

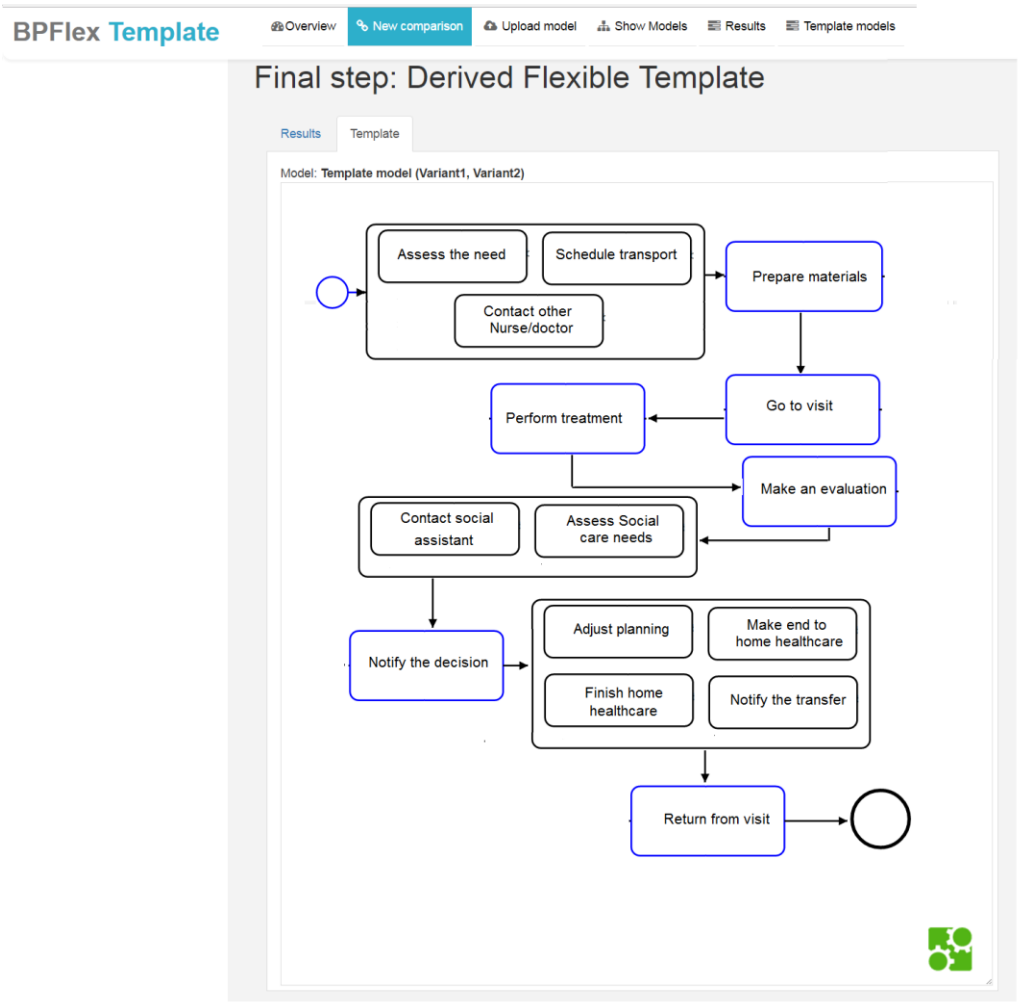

Fig.12. Organizational care derived template model in the BPFlexTemplate tool, with the parameters: Structural, 100%, Ad-hoc sub process

The process elements with a blue contour represent, in this case, the common part of the template, as the black ones illustrate the flexible part, where the ad-hoc sub process flexibility mechanism was applied.

For the same two variants, we also derived a second template model, taking into account different values for the classification criteria (50%) and the flexibility mechanism (Delete), as illustrated in Figure 13.

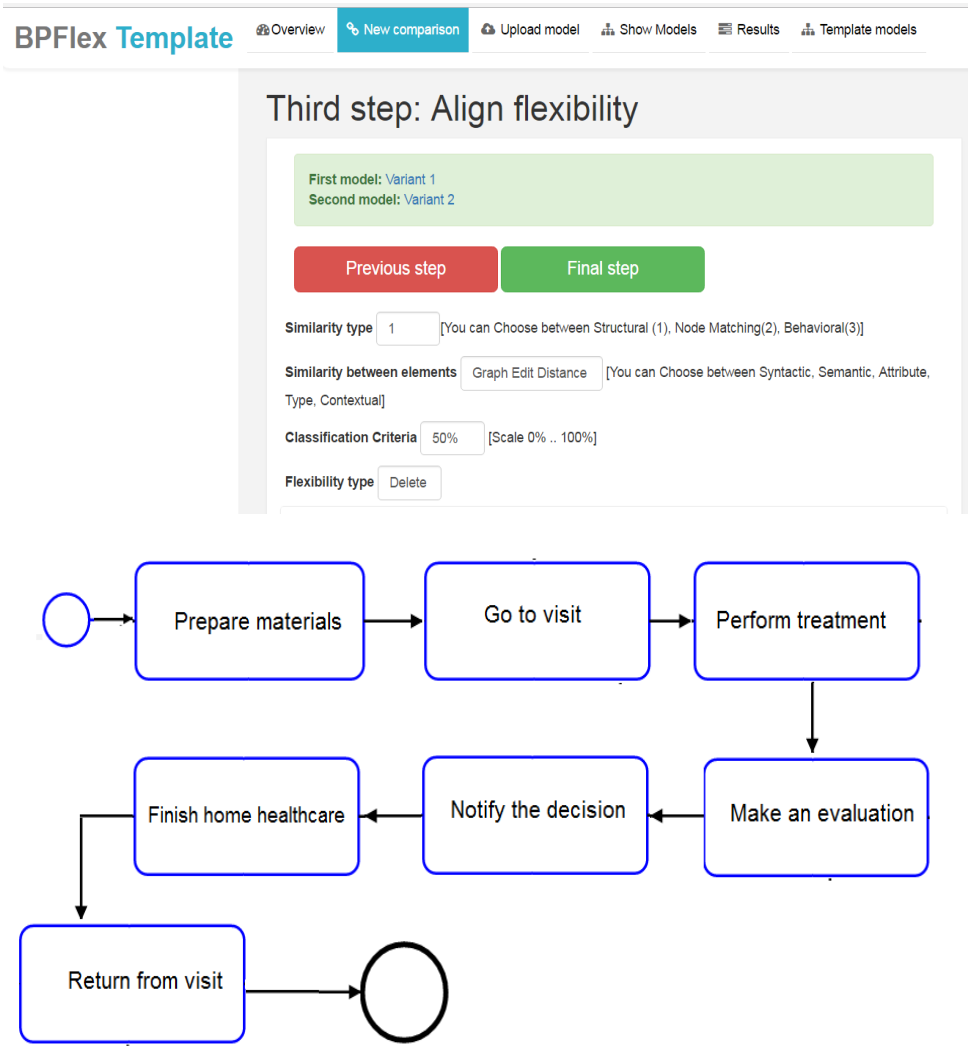

Fig.13. Organizational care template model in the BPFlexTemplate tool, with the parameters: Structural, 75%, Delete

Here, we can observe that by aligning the classification criteria to 50%, some process elements shifted to the *common* part of the template in Figure 13, in comparison to the former template of Figure 12, namely the activities "*Make end to home healthcare*" and "*Finish home healthcare*". Also, and since the *Delete* flexibility mechanism was chosen, this template only kept these *common* process elements, *deleting* the remaining elements from the derived template. This would be suitable, for instance, when a certain organization wishes to enforce a certain process template within its organizational units, which only considers activities that are common, discarding any particular adjustments made to the process in those organizational units.

7. Conclusion and future work

In this paper, we could demonstrate that process variants emerge and can evolve to be quite different in primary care health centers (organizational units) of the Portuguese National Health Service (top regulated organization). For this, we elicited process models for home healthcare in these primary care centers. Assessing the similarity results from the 3 pairs of model variants elicited, we could verify that they present significant differences. This means that the overall management and optimization of these processes may be difficult to achieve, since recorded cases and data differ and can hardly be handled as a coherent set.

Therefore, we proposed the BPFlexTemplate approach to align model variants with significant differences. The overall aim is to reduce the proliferation of process variants that can occur in organizations that are top regulated, but contain several organizational units that often adjust the process models they should follow.

The main output of this approach is a template process model that, based on modeling best practices and similarity results, is composed of two types of process elements: *common* and *flexible*. Common elements should be executed strictly, while *flexible* ones may or may not be executed, according to the organization's flexibility mechanisms allowed. Nevertheless, the purpose is that this template model can fit all organizational units, and enforce them to follow common procedures, as well as allowing them for some flexibility without having to create model variants. This way, recorded cases and data from these processes will all fall into a unique (template) model, enhancing BPM and governance in general for this kind of organizations.

We also present in this paper a software tool to perform similarity studies and derive the template models, according to our proposed algorithm in Listing 1. Process engineers can use this tool to upload, store and compare model variants, and then derive a template model, according to a set of parameters that can be chosen. The tool can automate the calculations regarding similarity comparisons between model variants, as well as model template generation. These tasks can be rather time consuming, cumbersome and error prone when done manually.

In a near future, we are planning to improve our software tool to include more options regarding types of similarity and flexibility mechanisms that can be configured for model template generation. This will allow the template model to foresee a wider range of (different) variants, and to include other flexible process elements that better cover the overall adjustments made to a certain process.

Future work is also pointing us to better explore the term "Business Process Management (BPM) Governance". This will imply, as a first step, to implement a process model repository where organizational units can access, improve and share their model variants. Taking primary care centers and home healthcare processes as our case studies, medical directors or chief nurses can, with this repository in place, access to the latest template models, and actually contribute to their improvement. Directors in the National Health Ministry can, in turn, have a notion of all variants of a certain process, and use the BPFlexTemplate approach to derive template models accordingly.

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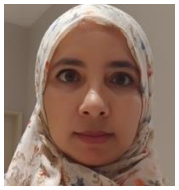

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