Master Thesis Information Sciences

Changeability of ERP Systems

An analysis of accountable factors

behind the capability of ERP systems to support organization changes

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Abstract

Changes are inevitable in any organization and it increased the risk potential for ERP reimplementation. Yet, at the same time, aside from their claims of having a flexible solution, the ability of current ERP systems to answer these changes is still questionable and uncertain. The purpose of this research is to identify accountable factors behind the changeability of ERP system in handling changes. The anticipated outcome of this research is to find the best practices in managing changes in ERP system. The additional outcome could be found in a form of a model for technical evaluation of changeability in ERP systems This model may be useful for prospective ERP customer to be able to compare the changeability value of an ERP system towards another.

Keywords: ERP, changeability, flexibility, process change

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Changeability of ERP Systems

Enterprise Resource Planning (ERP) systems are widely known and being used by many big companies to streamline processes and information from various business functions in order to achieve a more efficient work environment. The basic idea of this system is to have a shared database which supports multiple functions used by different business units. Having a synchronized information makes business processes across organization becomes faster, more accurate and well organized.

The current trend in ERP market is to design a cheap, simple and compact package solution which targeting small and medium enterprise (SME) (Castellina, 2011). It is basically a scaled-back system which supposedly offers a pre-configured solution in an easy-to-install framework to satisfy the budget and time constraints that most SME has. Nevertheless, a huge share of the money the big developers gained from ERP systems is coming from their deals with the big companies. Industries like manufactures, retails, constructions, ICT, each of them has uniquely different resources and processes to work with and also produces different types of outputs. Most of the offered ERP solutions for these big companies are designed as a general and complete solution. So, in order to comply with huge variations and complexities of aspects within different types of companies, ERP system has to be tailored so it can properly fulfill the unique needs of those particular company.

The sole purpose of this customization is to make ERP system fit the current (and possibly future) needs. Despite the purpose, this customization might also become a root of other problems in the future (Brehm, Heinzl, & Markus, 2001). While the vision of organizations might still be the same for a longer period of time, their business plans and business processes will always be prone to change from time to time. In order to keep benefiting profits while maintaining business continuity, a company has to adapt to the competitive business environment by carefully analyzing market trends, developing innovative products, and managing their business process workflow in an

effective and efficient way. These unanticipated changes are one of the main risks that need to be handled by ERP system. To answer this challenge, the previously tailored ERP system would have to be modified to fit the new requirements. It may seem simple, but, even changing "just" a couple of parts in the system might have an implication to the integrity of the related data structure or dependencies to other modules. Some changes might also involve parts of the system that are hard-coded or maybe modify the way ERP communicates to other systems that might affect the compatibility. These are some reasons of why in some cases modifications or adjustments are not enough or simply cannot answer the needs, and the system needs to undergo a reimplementation. The combination of system limitation, complexity and the high cost of reimplementation process gives challenges to the user whenever a system modification is needed and also for the vendor of ERP system to be able to tackle this problem and to provide a better solution with a more adaptive (towards changes) environment.

1.1 Problem statement

While it is true that changes are inevitable in an organization and the risk potential on reimplementation is real, the ability of current ERP system to answer these changes is still questionable and uncertain. This is supported by the lack of literature on ERP changeability in particular (Esteves & Pastor, 2001). It makes the closest field related to ERP changeability topic to be ERP flexibility and information system (IS) flexibility.

ERP reimplementation can be seen a series of a change event. Ross, Rhodes, & Hastings (2007) mentioned three aspects of a change event: the agent of change, the mechanism of change, and the effect of change. The mechanism of change defines the path that needs to be taken in order to reach the goal state from the former state. This mechanism drives the change of the system to the desired state. In an ERP system, this mechanism reflects the ability of how the system "adapts" in response to the change

instigated by the “agent of change”. A change agent is the force instigator for the mechanism to occur. In connection with the focus of this thesis, a change in business processes or business strategies become the agent of change in triggering ERP reimplementation. The location of this change agent can help us understand the terms used in this thesis. When the change agent is external to the system then it is flexible-type change. If the change agent is internal to the system, it is an adaptable-type change. Flexible-type change is the closest type of change to the focus of study in this thesis. The degree of this particular characteristic is varied between IS products and a measurement can be done to get the value that reflects the quality of an ERP system in terms of change.

Reimplementation of an ERP system is infamously known as risky, time-consuming, and very costly. License fee, maintenance fee, hardware related fee, training and implementation fee and also development fee, there are a lot of costs components to consider in the implementation and reimplementation. There are reasons of why ERP reimplementation is as expensive or even more expensive than a new, clean slate implementation; first it is due to the higher level of complexity and scalability; second, the possibility of increased number of user; third, demand for higher functionalities; and the last one is data migration and compatibility (Elragal & Haddara, 2010; Haddara & Elragal, 2013). An ERP system that has been used for years will always have problems with their data structure or conflicting business processes in some part. That is why the process of reimplementation could take a long time, reaching an average of 2 up to 3 years (Blegind Jensen & Svejvig, 2013), and a long-time project like this always mean a big cost will be spent. It proves that changeability is an important characteristic among other quality traits in overall ERP system (Alrawashdeh, Muhairat, & Althunibat, 2013). It is also supported by Esteves & Pastor (2001) which claimed that there are unanswered issues which should be solved in ERP, especially in areas like complexity, integration, and flexibility.

Regardless of this high reimplementation cost, organizational changes due to the nature of business management make reimplementation of ERP system become

unavoidable. Trying to overcome the risk of future high costs due to ERP reimplementation, some ERP vendors claimed that their system is easily adjustable or maintainable to face the scenario when system changes could not be avoided. But, still, there is no certainty about the credibility of such claim, because it is hard to know how "flexible" or "adaptive" their system is compared to other similar products. Hence, by knowing the value of ERP's changeability, a better assessment can be done to help prospective ERP user to find a more suitable ERP product which will be implemented in the organization; the one that has a low possibility of having a recurring expenditure in the future in the form of reimplementation.

1.2. Research goal and question

ERP system is available in the market in various categories, designed to serve various company types and scale, they also developed by different vendors. In order to understand what kind of factors accountable for an ERP system in numerous variety of products, it is necessary to investigate it by gathering information from ERP expert, and also compliment it by generating a model that will objectively show the importance of certain technical aspect within the system of those different ERP categories. The model could also be used to represent the capability of the respective ERP system, whether the system can easily adapt to changes or not. This value is supposed to stand inversely proportional to the risk of future expenses from having an ERP reimplementation. The changeability value as a result of the proposed measurement model could be used to provide insights to the decision maker in assessing and determining the most suitable product to be implemented in their organization. By having a better insight of the overall capability of an ERP system, it will be easier for a consultant to narrow down prospective products from the list, and it is also easier for the prospective customer to comprehend and to compare the quality value of each product.

To achieve that goal, a measurement model is needed to be able to measure the value of changeability of ERP systems in response to changes within an organization from a scientific and practical perspective which currently none is existing. Creating of such model would answer the following research question:

" What factors are accountable for achieving a changeable ERP system? "

Before answering the question, the following sub-questions need to be answered:

- What is ERP?
- What is flexibility and changeability in an information system?
- What are the determining factors to a changeability of an information system?

1.3. Research structure

The research will be described in this thesis using the following structure:

1. Introduction
2. Literature review
3. Research Methodology
4. Results
5. Conclusion and discussion

Literature Review

The purpose of this chapter is to find important literature in ERP reimplementation, including research on the changeability of ERP in particular and information system (IS) in general. A broad search on the net was performed for terms such as “ERP changeability” and “Information system flexibility” with additional keywords like “evaluation”, “adaptability”, and “measurement” to find existing relevant works related to the research question. Further related articles were found by snowballing the collection of relevant articles which meets the inclusion criteria for the scope of this thesis (Wohlin, 2014).

The literature used in this thesis were mainly found from Google Scholar’s aggregated database, SpringerLink, ScienceDirect, and Radboud University library repository. Unfortunately, very little amount of literature on ERP reimplementation was found. Most of the literature is focused on ERP selection (Reuther & Chattopadhyay, 2004) and ERP implementation (Ağaoğlu, Yurtkoru, & Ekmekçi, 2015; Esteves, Pastor-Collado, & Casanovas, 2002; Sun, Ni, & Lam, 2015). On the topic of ERP and IS changeability, literature in a lesser degree was found in fields like Production Management System (Hoogenraad & Wortmann, 2007; Potente, Fuchs, & Hausberg, 2012) and engineering (Fricke & Schulz, 2005; Koh, Caldwell, & Clarkson, 2013). The lack of literature in the targeted field made the search split into two fields, Business Process Reengineering (BPR) and IS which has a similar relation to ERP reimplementation.

Important findings were then collected into two groups in this chapter, starting from the narrative definition of changeability and flexibility in an IS, and finished by comparison of the framework used in the evaluation method for IS flexibility.

2.1. ERP System

This section will briefly explain about ERP system as a particular IS product with some illustration to make a clear reference of the system, which is aimed to help to understand the background of the problem within the scope of this thesis.

2.1.1. History and evolution

The now so-called Enterprise Resource Planning (ERP) is a developed and more advanced version of Material Requirements Planning (MRP) and Manufacturing Resource Planning (MRPII). The main difference between ERP system and its predecessors is that ERP covers the whole business processes and organization functions, not only limited to the production operations. During the 1970s, MRP systems were used to handle production and inventory planning within manufacturing companies. Based on this system, MRPII was developed during the 1980s to cover other business processes like sales planning, capacity management, scheduling and operations in manufacturing companies (Klaus, Rosemann, & Gable, 2000).

The MRPII approach was then expanded in the 1980s towards more technical areas covering product development and production processes. These functions including computer-aided (CA) planning, CA design, CA engineering, CA manufacturing, and CA quality assurance. The whole conceptual framework for the integration of all technical and business administrative functions of a company was named Computer Integrated Manufacturing (CIM). The general integration frameworks were based on MRPII functions, and though the approach was focused on manufacturers, it could be easily generalized. The factor which was improved quite significantly in CIM is the integration issue, especially with the data and process modeling techniques. A major focus of CIM in the 1980s was to design the integrated enterprise-wide data models assuming that an integrated database is the main element of information system infrastructure. Process modeling became the attention when a reference to integration architectures was developed to cover more than the information flow between functions. The entire process was designed to explain typical business

processes. Initially, these models existed because the applications to implement the design not existed yet, in other words, it is due to the existence of enterprise systems that make process management possible (Davenport, 2000). Because of that, data and integration models were extended with a vastly increasing number of process models. Nowadays, data and the referred process models are used as a reference to document ERP systems and the software which support the enterprise modeling of data and processes are widely used in ERP implementation projects.

2.1.2. ERP category

ERP vendors keep developing and improving their products to better match the needs of their market. Nowadays we can find a wide range of industry-specific ERP system available to be used and each of them has been made to suit different needs of each industry. In the recent survey, distribution (35%), manufacturing (29%), and education (23%) are reported as the leading customer in the market compared to other areas like constructions (3%), healthcare (2%), and telecommunication (2%) (Panorama Consulting Solutions, 2017). From the scale of the company to the number of users and also the type of deployment, these variables contribute to the diversities in the available solutions in the market right now.

Based on the size and the complexity, ERP commonly divided into 3 tiers where the first tier is the most complex and the third tier is the simplest one. To have the most advanced and expensive ERP system is not always good for the company, it is about having the right fit, not too complex that the operational cost would be too expensive and also not toao simple that the system does not cover the needs of the company.

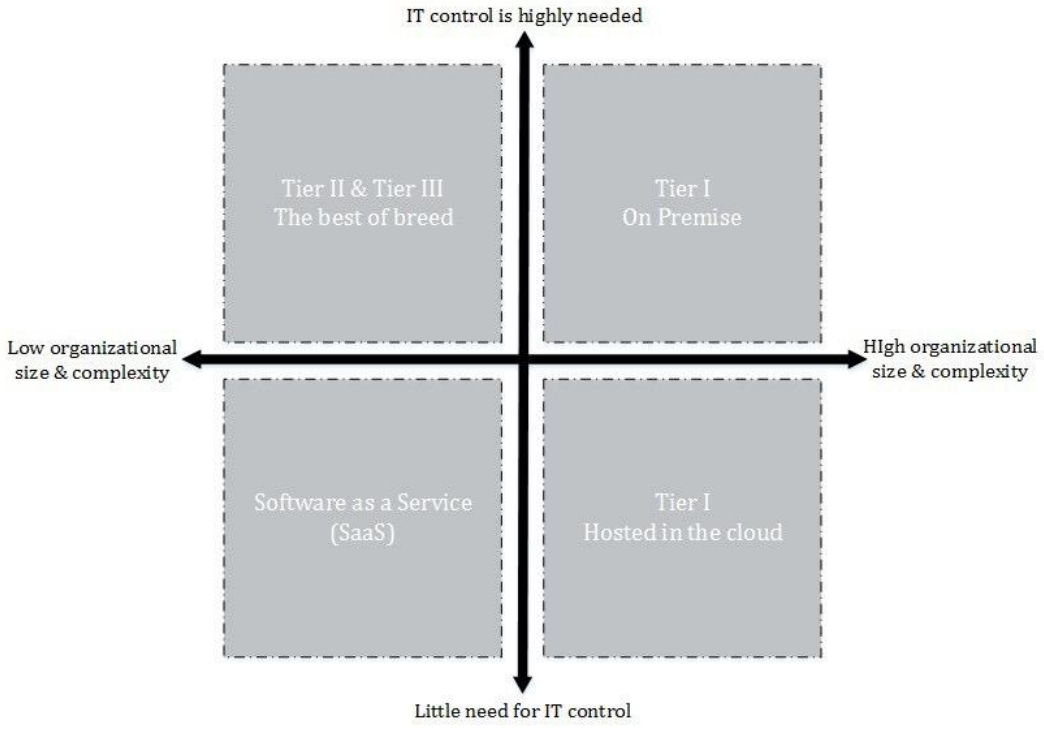

Figure 1: ERP solutions map category

Figure 1 shows four quadrants in which shows the category of ERP systems based on two factors, IT controls and the size of a company which is aligned with the complexity (see Appendix A.1). The bigger the company is, the most complex their business processes will be. Thus, the ERP system which covers their need must be designed to have a wide scope of functionality and must to be tailored well to match the needs of the company. On the other way, smaller businesses with less complexity do not need a solve-them-all solution with many functionalities. They need a solution with an easily operationalized system and a simple implementation. The other factor is the need for IT control or IT support. Mainly it could be divided into two categories based on the data storage placement, on-premise storage, and cloud storage. On-premise storage offers a higher value for data confidentiality, as for the integrity and availability, it varies, depending on the server design and setup. Cloud storage on the other hand, aside from the quality of the internet connection and the quality of service the vendors offered, they mostly serve a better integrity and availability to the customer.

2.1.3. Cost structure of ERP implementation

Based on the previously explained categories of currently existing ERP system, vendors of ERP system have arranged a wide range of pricing plans (according to the type of system deployment, the size of the company, and also the type of license). It is not a surprise because every organization has their own unique needs so they cannot be treated equally. This pricing system also makes sure that the license system will benefit both parties mutually. In general, there are at least 4 key factors which will affect the cost of an ERP system:

- number of users
- applications or modules required
- level of customization
- hosting location

Numbers of users and the required modules correlate closely to the size of the company. A smaller company will require fewer users to access the system and need fewer number of modules and basic functionality. On the opposite side, a high number of users and greater functionalities will contribute to a high cost. Customization has an important part as well because ERP needs to fit nicely with the specialized business process of the company, for example, a company that does custom manufactures might need customization in the modules to add a certain feature so they can have more flexibility in their supply chain management and production planning application. The type of deployment has a vital share in the amount of total cost of the first year (in correlation to the type of license, see Appendix A.2 for details on license cost), which most of it often goes into the implementation.

These aspects make up most of the expenses in the total cost of ownership (TCO) in implementing an ERP system. Implementation of an ERP system is a delicate procedure that needs to be done in a structural and careful manner. Figure 2 shows the general steps it takes to implement an ERP system. From here, it can be seen that there

are several other costs other than the actual ERP software system itself. Below is a list of possible costs elements on the implementation of an ERP system:

1. Licensing fees:
    a) software purchase
    b) user licenses
    c) subscription fee
2. Software maintenance fees:
    a) upgrades
    b) annual maintenance
3. hardware related fees:
    a) server purchase
    b) maintenance
    c) workstations
    d) IT personnel
4. training and implementation fees:
    a) business analysis and consultations
    b) project management
    c) training
5. custom development fees:
    a) consultation
    b) programming

Not all of these costs are applied in every implementation, it varies for every vendor and their solutions (Mukwasi & Seymour, 2014). For example, a cloud-based system would not need to pay for hardware related fees.

The following is a case example of cost structure difference in TCO of both implementation and reimplementation. R company having an on-premise ERP system implemented has 500 employees with a turnover rate of $ 200.000 per employee which make their annual revenue a total of $ 100 million. From the previous estimation, the license will cost roughly 500 x $ 4.000 = $ 2 million. Depending on the security approach taken by a company on this scale, spending on hardware could cost somewhere around $ 50.000 up to $ 200.000. The cost for installation and configuration

is hard to predict because we do not know how long will the process will take, but the rate is at around $ 200. Training at around $ 400.000 and also annual maintenance fee at around 15-20% of the license fee. The cost breakdown for implementation can be pictured in the table below, in an assumption that the project is done in a period of 1 year:

Table 1: Illustration of TCO for new ERP implementation

Fees	Price	Total
License	500 x $ 4000	$ 2.000.000
Maintenance	15 % x License	$ 300.000
Hardware	$ 100.000	$ 100.000
Custom development	2000 (hours) x 200	$ 400.000
Training	$ 400.000	$ 400.000
		$ 3.200.000

This calculation roughly measures the total cost of spending on the first year in which the implementation takes place, reaching 3,2% of the annual revenue. Spending structure on the second year would be way less than the first year because the organization would not need to pay for the license fee (the case is perpetual license), training, and hardware fee.

The cost structure of a reimplementation project is slightly different than implementation. Because the existence of old ERP system, and also there is a possibility that the company added a third-party software in the meantime. Hardware also needs to be replaced because the average rate in renewing the hardware is 3-4 years. The challenge on re-implementation is restructuring current ERP system with the new solution, data migration, and data integration is not an easy task to do. Following the previous case as an example, this R company grew rapidly for the last 5

years. The company now need an addition of 200 licenses for new employees and also adding a few modules and a certain functionality.

Table 2: Illustration of TCO for ERP reimplementation

Fees	Price	Total
License	200 x $ 4000	$ 800.000
Additional modules & services	15 % x total licenses	$ 420.000
3rd party software integration	20 % x total licenses	$ 560.000
Maintenance	15 % x total licenses	$ 420.000
Hardware replacement	$ 100.000	$ 100.000
Custom development	3000 (hours) x 200	$ 600.000
Training	$ 500.000	$ 500.000
		$ 3.400.000

The total cost of reimplementation is 6 % higher than the implementation with an assumption that the project is finished within 1,5 years. This calculation has not counted the fact mentioned by Panorama Consulting Solutions (2017) that 57% of the projects exceeded their initial estimated timeline due to various reason with the average duration for completing the project is at 21 months. Top 3 reasons for the delay are because of data issue, having an expanded scope, and organizational issue. These expenses could grow higher every year. If we use this average exceeded time span for our example combined with 3 reasons of the delay, then it will increase the total cost by at least another $ 500.000 and make it 121% the price of the original implementation.

2.1.4. Implementation and subsequent problem

Every company has unique needs that need unique approaches, this is part of the reason of why we can see so many ERP products in the market now, from a small-

scale ready-to-use solution up to a complex big scale multinational company that integrates many modules and connected to other third-party systems. The introduction of ERP system to a company could lead to obtaining an increased productivity, but it could also bring obstacles if the implementation is not carefully done (Aversano & Tortorella, 2010).

ERP works as a system of modules which are able to communicate to other modules because they are sharing the same data access. by sharing the same data, the problem of classic information system in a complex system like data duplication and information delay would decrease significantly. This is a role which is expected to help to improve the efficiency of data flow and information processes in an enterprise. On the other hand, implementing ERP system is a delicate process which could be very risky if it is not carefully planned and executed. Failures from cancellation and cost or time overrun happened quite often. Data from Panorama Consulting Solutions (2017) shows that 54% of ERP projects are reported to have a cost overrun, 72% exceeded the time limit for the project to be completed, and up to 66% of enterprises received less than 50% of the anticipated benefit of implementing ERP.

Figure 2 shows the lifecycle of ERP systems and the stages that should be properly done in implementing them.

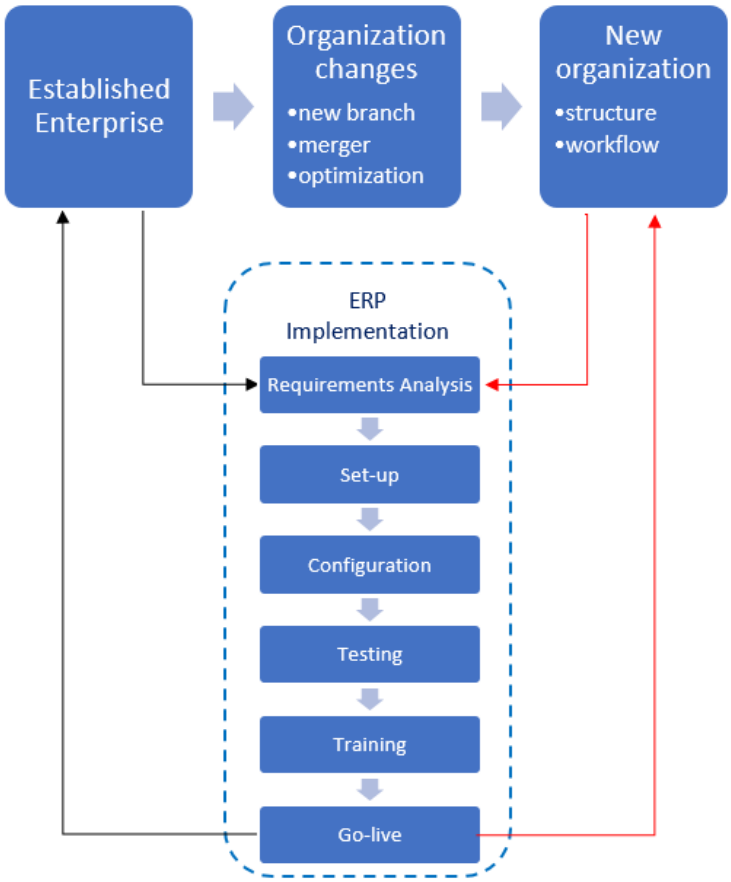

Figure 2: ERP implementation flow

The average time of ERP implementation varied for every solution, Panorama Consulting Solutions report (2016) shows that in large organizations, ERP implementation can take years to complete. To give a clear picture, based on this recent update the top 3 vendors which have the shortest amount of time spent for implementation are: Oracle in an average of 25 months; Infor CLoudsuite in an average of 30 months; and SAP HANA completes the top 3 in an average of 34 months project implementation. A more recent report by the same consulting company (Panorama Consulting Solutions, 2017) stated that the average implementation cost for top 10 ERP systems (most of these solutions serve upper-mid to large organizations) is around 3,6 percent of their annual revenue with 74 percent among them having a budget overrun.

This budget overrun is mostly caused by project delay due to an expanded project scope and also data integration issues.

The technology breakthrough in SaaS and cloud system does not affect much to the market of the on-premise system. Medium and large organizations still choose on-premise system type of deployment by the number of 67%, followed by 27% SaaS penetration rate, and the remaining 6% on the cloud system. At least 88% of the organizations applied customization to the system; 70% of them had to do a moderate amount of customization which is around 11% - 25% of code modifications. The reason for customization could be many things, starting from the type of company and its scope, the number of users, certain business processes, and also the possibility of integration with the irreplaceable existing system. This customization was done to achieve their mission of implementing ERP system in the first place, which is to improve business performance, having better system integration across location, and better customer service. It seems like the customization really does have a positive impact on the organization as 89% of them expressed satisfaction towards the outcome of the ERP system (Panorama Consulting Solutions, 2017).

But even after all those tailoring, there will always be a reason for a change in the system. There are several reasons for this change. First, looking at the fact that systems are being used, it will lead to a desire for more advanced functionality. Second, the nature of changes in business rules when companies develop their product in response to changing market condition, governance and collaboration structure or manufacturing resources. Third, changes also might be caused by technology breakthroughs in ICT, such as upgrades in one of the employed system, either the ERP itself or a third-party system that is working collaboratively with it.

The tailoring process of ERP system could limit the flexibility of the ERP in reacting to those changes because the system is already adjusted to a certain functionality. This statement might or might not be true, but there will be a point where the system cannot afford to be modified anymore because the change is too significant

to be done or the system is too complex, to begin with. When this problem happens, a reimplementation will be the last option to be chosen by any enterprise.

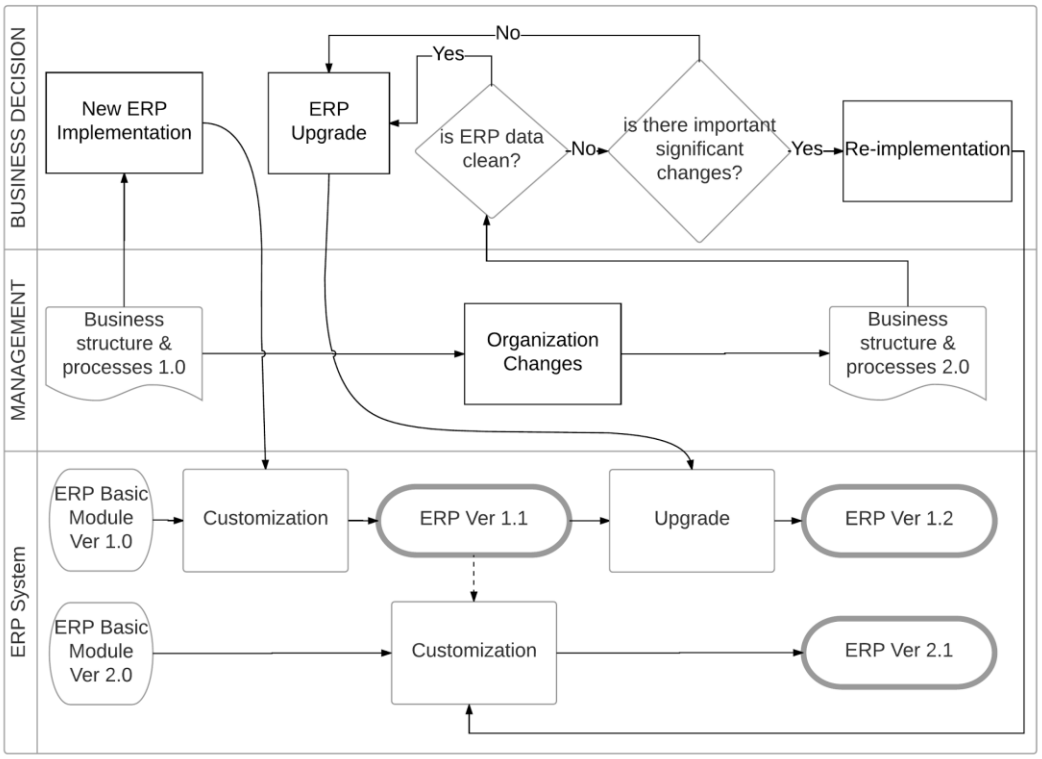

Figure 3: ERP upgrade & reimplementation procedure

Reimplementation process is a costly, risky procedure, and could be a nightmare for large companies, especially if the customized system is very complex. But sometimes, a reimplementation scenario cannot be avoided because the current ERP system and its old customization are no longer reliable, have been heavily modified to a point that is hard to be modified further or it is just simply not relevant to the current business anymore. Research by Gebauer & Schober (2006) also supports this premise, saying that flexibility to change the Information System is essential under high process uncertainty. By meeting the actual requirements and future preferences of stakeholders, a changeable system is expected to improve information revealed over

time, supporting business processes, reducing maintenance cost and gaining more revenue at the same time.

2.2. IS flexibility and changeability

Information system (IS) is an organized system for the collection, organization, storage, and communication to process or interpret information. Another simple definition stated by explains that information system is "a group of components that interact to produce information" (Kroenke, 2011). Being a concept and also a functional solution, ERP system is one form of information system as a whole means of processing and providing information to the user. Thus, ERP system generally follows the basic principle of an information system.

There are different approaches to define flexibility, adaptability, and changeability of an information system mentioned by numerous sources. The following sub-sections try to define a clear distinction between them.

2.2.1. IS flexibility

Various authors (Tompkins, White, Bozer, & Tanchoco, 2010) seem to have the same opinion regarding flexibility as a static character. Possible flexible changes were planned at the moment when a particular system is being developed. This makes flexibility be seen as a pre-defined reaction to predictable changes in a system. Other authors (Palanisamy & Foshay, 2013) see flexibility from user's point of view, claimed that flexibility is an ability where an information system is able to adapt quickly to the user's specific information needs and functional requests. An example of these requests could be a capability of modifying existing reports and generating a new one in a reasonably accepted time period. IEEE Standard Glossary of Software Engineering Terminology (1990) defines flexibility as “the ease with which a system or component can be modified for use in applications or environments other than those for which it was specifically designed”.

IS flexibility can be seen as the capability of an IS that uses a set of resources to respond to the changing needs of the organization. Changes in the working environment are inevitable and could exist in many forms. For example, the decision-making policy (decision making vs decision support), problem-solving approaches, changes in business context either a general or specific one and even the basic information requirements. Flexibility in an IS exist with the help of a user and only when the user is able to adjust or adapt the output based on those changes.

To be able to achieve flexibility in an information system, this particular characteristic is determined and applied as early as in the analysis and design phase of the development stage. Generally, actual users or representative who understands the actual job requirements will provide information required during the IS planning in order to make a functional and usable system. Their participation is needed because they have the knowledge to define the changes that may occur in the business processes, routine tasks, decision making and problem-solving. By carefully analyzing important key functions and the likelihood of changes from the information acquired, their participation will help to develop IS flexibility in the system according to the current needs and possible future needs based on their creative and cognitive knowledge and abilities.

2.2.2. IS changeability

(Potente et al., 2012) stated that publications have different terms for different areas of focus in changeability; some of them see it from technological aspects and called it reconfigurability, others who see it from organizational aspects called it agility. Hoogenraad & Wortmann (2007) see changeability in two perspectives: from vendor's perspective it is called flexibility and from customer's point of view it is referred as adaptability. Regardless of the nonexistent clear line of definition between changeability and flexibility, he states that flexibility is representing the capability to react to predictable changes within a predefined reaction. Changeability, on the other

hand, allows leaving this pre-defined scenario without requiring a significant financial and time-wise effort.

Changeability is also regarded as going beyond flexibility but at the same time they are also interdependent (Potente et al., 2012). Looking at the terms from a managerial point of view, the difference can be seen on the change processes with the user/employee as the main driver to the process, because at some point the system is not purely technical but more of a socio-technical system (Grabot, Mayère, & Bazet, 2008). Authors with a background in engineering see changeability as a potential for change. It represents performance potential and not the level of performance itself (Blecker & Graf, 2004).

For the purpose of this thesis, the definition of changeability will be focused on the changeability of ERP as an information system. Based on various definition mentioned earlier, ERP changeability could be seen as the capability of an ERP system to change / adapt / respond / adjust to new conditions with minimum cost and effort.

The fact that changeability underlies the principle of diminishing marginal utility also lacks proper attention (Schuh, Lenders, Nussbaum, & Kupke, 2009). Relative advantage obtained decreases as the level of changeability increases, when at the same time the cost to provide that level of changeability increases exponentially (Schober & Gebauer, 2011). Therefore, it is possible that the goal of ERP vendors is not to aim for the highest possible level of changeability, but for the highest degree of net utility of changeability. In other words, it is possible that at a certain level it is sufficient enough for ERP system to have the ability to adapt to the practical changes that occur in small-scale individual functions, instead of having to prepare for all possible changes which will increase the cost of development. But then, these “practical changes” are not always predictable up front for them to be able to be anticipated in advance. Once again, it may be true that the actual goal for the ERP vendor is to achieve a certain degree of changeability by applying sufficient realistic probabilities from both

the customer and the developer side to reduce the cost and the complexity of the project in general.

2.3. IS flexibility evaluation models

There are several existing models for IS evaluation, including the evaluation of specific quality details within an IS. For the purpose of this thesis, the focus would be on the flexibility feature. Table 3 shows the list of works of literature in IS flexibility and their approach in determining the factors accountable for the grade of flexibility.

Table 3: Index comparison in various ERP / IS flexibility evaluation approach

Authors	**Flexibility factors considered**	
	First-level index	**Second-level index**
Zhou, Lv, & Lu (2013)	• Architecture flexibility • Function flexibility • Transaction processing flexibility • Client flexibility • Responsiveness flexibility	See Appendix A.3.1
Li & Yin (2007)	• Business changes • IT changes	See Appendix A.3.2
Lu, Liao, & Lu (2010)	• Data flexibility • Process flexibility • System flexibility	See Appendix A.3.3
Wang & Liu (2010)	• Design flexibility of data tier • Interaction flexibility of presentation tier • Process flexibility of business tier	See Appendix A.3.4

2.4. Proposed model

Based on the literature review on ERP system and information system flexibility, a model is proposed following on a general three-layer architecture in ERP system as the main contributor for ERP's changeability. Although various new system designs were introduced (Bahssas, Albar, & Hoque, 2015), a three-layer architecture is still the most suitable as this research is not targeting specific segment. The three layers together make a set of three criteria (denoted as the first-level index) followed by a set of sub-criteria (denoted as the second-level index) beneath each criterion. This structure follows the base construction of analytic hierarchical process (AHP) hierarchy. In AHP, the structure of the criteria represents a hierarchy, the goal makes the top of the pyramid, and sub-criteria lays at the bottom.

Presentation criteria are responsible for the I/O of the system. Graphical User Interface (GUI) is set as one of the sub-criteria because there are differences in the fluidity of UI. A desktop app based UI will be harder to be modified compared to the web app based UI. The simple explanation would be the desktop window has to be compiled/generated from the project file before deploying a modified UI, and even after the deployment, they still need to be installed on each client. A web app that does not need to be compiled prior to the deployment and the change is simultaneous because the scripts reside in the server. Device type is also important because a computer-based app have different design and versatility than the one in a mobile app.

Next criteria on the list are an application or the back-end part of the system where all the rules, logic, and calculations are set. The degree of modularity is one of the concerns in these criteria. The system architecture of most ERP nowadays are modular, consist of modules which are connected or synchronized to each other. It means, if there was a change in one module, we have to make sure that the process in other module is aligned with the changes in the modified module. The more modular and the less synchronized the system is, the less changeable it is.

Table 4: Proposed changeability model for ERP system

Evaluation objective	First-level index	Second-level index
ERP System Changeability	Presentation (Front end)	GUI
		Device
	Application (Back end)	Modularity
		Content Management System
		Source code access
	Database (Data structure)	Server location
		Data compatibility
		Scalability

The change of procedures and business processes in the system could be managed by setting the provided parameters in the desktop-based app. In a web-based app this parameter could be grouped into one Content Management System (CMS), the variety of this setting and management system will also contribute to the changeability value. This criterion has the closest definition of IS flexibility as defined by Potente et al., (2012) because possible changes made available in the CMS is planned beforehand during the development cycle.

The last criterion for the Application section is the availability of access to the source code. The farthest we can go in having a changeable system is only as far as the parameter setting and CMS goes if we do not have access to the source code to modify the system. Having a well-documented source code will definitely help the system to be more changeable. This criterion, however, has a close relation with the type of license used. A perpetual license has a different level of control over the system compared to a license based on subscription. Subscription-based license normally used

by SaaS type ERP system which does not have a lot of IT control (see figure 1). Due to the nature of the system in SME segment that was designed as a moderately cheaper and ready-to-use solution, it is very unlikely for them to get their hands on the source code of the system. The simplicity of SaaS makes it more rigid compared to the other type of solution in another quadrant.

The last index in the first level is the database, this is where all the information is stored and retrieved. Having an on-premise deployment is supposedly friendlier for the change process rather than having all the information hosted and processed in the cloud. Data compatibility is rather an important factor as well because most of the companies tend to have a third-party software employed. We have to make sure that all the data that goes through this exchange of two or more system is compatible to each other. Last but not least is how scalable the system is. A scalable system will not have difficulty when the system grows bigger and needs a bigger storage, or when the number of user is increasing exponentially. A scalable system also means that it has to be able to serve multiple platforms, in correlation with compatibility.

2.4.1. Evaluation model

In order to quantify the changeability of ERP system, we need to find out the objective weight for each of the criteria and sub-criteria. The result of the evaluation process will give weight to the first-level and second-level index in the model proposed. This will be done by pairwise-comparing between criterion in the first level index and also between criterion under the second-level index which shares the same first-level index. After the option is made, next step would be to give them a scale of importance over the pairwise preference. The score used for the pairwise comparison is in the range of 1 to 9. The following table 5 explains the scale used for this pairwise comparison. The final score for the value is in the range of 0 to 1. An ERP system with “perfect” changeability value will have the point 1, and the system that considered has no value in changeability will get 0 point.

Table 5: Scale for pairwise comparison

Intensity of importance	Definition	Explanation
1	Equally important	Two elements contribute equally to the objective
3	Moderate importance	Experience and judgment slightly favor one element over another
5	Strong importance	Experience and judgment strongly favor one element over another
7	Very strong importance	One element is favored very strongly over another; its dominance is demonstrated in practice
9	Extreme importance	The evidence favoring one element over another is of the highest possible order of affirmation

All of the criteria mentioned in table 4 could be found in any ERP system. So the choice of the intensity of importance is purely based on experts' knowledge, experience, and personal preferences. Their expertise and experiences will objectively weigh the structure of the proposed model to get a clear picture of the most important factors accountable for changeability in an ERP system.

The result of the model evaluation using the AHP will produce the weighted model which will become the framework which could be used to quantify the actual changeability value of ERP systems from the technical perspective.

Methodology

This chapter will outline the strategy as well as the approach taken within this research, the method of data collection, the selection of the sample, the research process, the ethical considerations, and the research limitations of the project.

3.1. Research strategy

The research held with respect to this thesis was done with the intention to bridge the gap between theoretical knowledge and practical problems. Previous research in ERP system was mainly done in areas like organizational knowledge, and business models. Although product development is also one of the main issues, currently none are trying to address the reimplementation issue. As such, this research tries to answer the problem at hand by combining existing theoretical knowledge and the practical insights from ERP experts.

3.2. Research method

To satisfy the objective of this thesis, a qualitative approach was held. The combination of extensive literature review and interview of ERP experts is hoped to be able to produce a model for ERP changeability.

The basic advantage of qualitative research is that it offers a complete description and analysis of a research subject. However, the effectiveness of qualitative research is heavily based on the skills and abilities of researchers, so the outcomes may not be perceived as reliable due to the personal interpretations and judgments (Cho & Trent, 2006).

3.3. Research approach

The research approach that was followed for the purpose of this thesis was the inductive one. In this approach, research was started with a general idea which is then followed by data collection. Patterns emerged from the data collections is analyzed and then generalizations are constructed to develop working theory and conclusions (Wilmont, 2016). Inductive approach is most suitable for small samples that produce qualitative data. However there also lies the weakness of the approach, the generalized theories and conclusions are based on limited number of observations, therefore the reliability of the research results could be under questions (Denzin, Lincoln, & Giardina, 2006).

3.4. Data collection method and tools

For the purpose of this research, both systematic literature review and in-depth interviews are used. Zotero is used to gather and organize literature from various sources. The collected literature is then filtered and coded in Atlas.ti to help analyze the connection between sources in the same code groups.

In-depth interviews are personal and aimed to identify the participant's emotions, feelings, and opinions regarding the research subject which will help to validate the result of the interview. The interview is guided by a structured list of questions to satisfy the need for data collection, but still leaving rooms for more detailed follow-up questions based on the answer given by the participants (see Appendix B). The results of the interview were collected, coded and analyzed in Atlas.ti.

When the interview is finished, each participant is asked to weight the indexes in the proposed evaluation model by cross-comparing them. The evaluation of this weighing process will involve Analytic Hierarchical Process (AHP)

3.5. Sample selection

Sample members are chosen on the basis of their experience, relationships, knowledge, relationship, and expertise. For this research, the sample criteria would be a person who has sufficient and relevant work experience in the field of ERP system but not exclusively affiliated to a certain ERP vendor at the moment of sampling. This was done in order to make sure that the participants have a full understanding of the concerning field and also to avoid bias in the data collections.

3.6. Ethical consideration

The respondents have been informed regarding the objective of the study, the scope and also the length of the interview. When a participant was willing to cooperate, he or she should be informed about the potential effects of their involvement and aware that they have the freedom to withdraw from the interview at any time.

At the beginning of the interview, respondents were also assured that their answers are fully confidential which will be used for academic purposes and for the purposes of this thesis only. By offering the options for quotation and anonymity agreement in the consent form, it is hoped to make sure that the respondents are comfortable in expressing their ideas during the interview and be able to talk freely in the case of sensitive issues coming up or opposing interest to a certain side comes into the topic. Respondents are agreed on the way the information in the transcript is processed, by signing the interview consent form.

3.7. Data analysis

The result of personal interviews is analyzed based on the structure of the provided questions. Key comments found during the interview which was outside the structure of the questions were labeled in vivo coding in Atlas.ti. The end result will then be combined to the weighted proposed model to get the conclusions.

3.8. Research limitation

This thesis has the following limitations:

- The scope of this research is limited to the changeability of ERP as a software system in general, not aimed to a certain ERP vendor or category.
- Due to the vast amount of ERP products and limited resources available for this research, this thesis does not count and compare the actual changeability value of each product, but rather to construct a weighted model as a base framework to quantify the technical changeability value and best practices of achieve that goal.
- A small size of sample (8 experts) is chosen due to the limited amount of time provided in the schedule of the research project.

Results

While it is true that making a wide scope for this research are supposed to make it make it easier to find competent respondents as a source of information, it turns out that the specific sample criteria makes it hard to find the suitable experts to be contacted. No less than 80 suitable experts have been contacted, and only a handful of around 10 prospective respondents who responded positively, in which only 7 of them who managed to have time to be interviewed within the planned schedule. It is because most of the people with these criteria are normally in the middle to top management position and have limited amount of free time on their schedule. This chapter will discuss the result of the gathered data from both interviews and questionnaires for the technical model for ERP changeability.

4.1. Interviews

The interview was held using the structure in Appendix B. The results then transcribed, and coded based on important findings and also based on the key questions planned in the designed structure.

There were 10 ERP experts agreed to be interviewed but in the end, only 7 of them who managed to spare some time to be interviewed within the time frame. The interview was done face to face with 4 of the respondents and the remaining was done via video call. Unfortunately, it turned out that 1 of the interview video recordings failed to capture the audio and no transcription could be produced from that interview. Hence there are a total of 6 valid interviews that can be processed, excluding the interview with respondent I3.

The respondents have numerous amount of experience of ERP implementation, reimplementation and upgrade in various organization size and with various vendors. Some of them tend to be more technical and the others are more leaned towards project and change management. Nevertheless, all of them are fully knowledgeable in ERP system due to the years of professional experiences. A couple of them has even more

than 25 years of experience, since the earlier years of ERP system. All of the respondents agreed to be quoted, in which four of them specifically requested to be anonymized. For the sake of anonymity, the respondents respectively use pseudonym I1, I2, I4, I5, I6, and I7. The following table shows short details of the background for each respondent and the details of interviews:

Table 6: Respondent's background and interview details

Respondent	Roles [organization]	Experiences [years]	Time of interview	Recording duration	Information treatment
I1	Team Manager Oracle Finance [Government of The Netherlands]	Oracle, SAP [15+ years]	12:00 – 14:00 28th November, 2017	60 m 9 s	Quotes allowed, anonymized
I2	Project leader & implementation consultant [SME manufacture ERP consultancy]	Microsoft Navision, Infor [9+ years]	17:30 – 18:30 29th November, 2017	59 m 46 s	Quotes allowed, anonymized
I4	Senior application consultant [Government of The Netherlands]	Oracle, SAP [6+ years]	12:30 – 13:30 5th December, 2017	45 m 4 s	Quotes allowed, anonymized
I5 (Jan van der Vis)	Project Manager, Change Manager [Life Fitness]	SAP, Peoplesoft, Microsoft Dynamics, Exact [15+]	15:00 – 16:00 7th December, 2017	47 m 26 s	Quotes allowed
I6 (Paul Lemmen)	Team Lead Financial Application [Nexperia]	SAP, Oracle, Workforce, Salesforce, various vendors [20+]	13:30 – 14:30 14th December, 2017	34 m 4 s	Quotes allowed
I7	Team Lead Enterprise Application for Finance [Maritime Service]	SAP, IFS, Oracle [20+]	10:30 – 11:30 15th December, 2017	37 m 9 s	Quotes allowed, anonymized

The results are explained as a group of quotations with the same code in the following subchapters.

4.1.1. Reason for ERP reimplementation

The root cause of this research is the sheer amount of money spent on the reimplementation of ERP system. Turns out every organization has various reasons on why did they decide to reimplement their system. Every organization is unique, thus, the reason behind the need of reimplementation is also sharing the same trait.

The interesting point shared by I6, that this "uniqueness" is also the root cause that might get organizations into the problem. Because apparently, when an organization thinks that they are unique, they tend to think that the process has to go a certain way, their way. Which is not always supported by the standard functionalities offered by ERP systems and if it was forced, may lead to a customization in the package.

> *"Really, in the core, that's still the same, it hasn't change, the shift is and was that all enterprises think that they are unique."*
>
> *Paul Lemmen (2017), Team Lead Financial Application - Nexperia*

That is not always the case of course, but it is the common perspective that most of the enterprises have when they are implementing an ERP system. Apart from that, the other respondents mentioned other issues as well, reflecting their own experiences. Based on the information gathered from the interviews, some respondents mentioned similar cases but overall there are at least 6 reasons to have a reimplementation:

1. Governmental regulations (applied to government body)

   There are some rules applied to a certain government body that requires them to arrange a new tender at the end of every contract. T1, who worked for one of the government IT service in The Netherlands, mentioned that this tender should be followed by the current contract holder as well if they wanted to continue to serve the organization for the next contract period. It is arranged in such a way so that the level playing field would be the same for every ERP vendor to prevent the contender from having advantages and leverages with their knowledge of the installed system. One of the ways is that all the competing vendors have to offer a proposal to do a clean implementation of the old system.

2. The product reaches the end of its life-cycle

   The vendor decided to stop the support for a certain ERP system, to give room for a new and more developed solution. ERP project manager of Life Fitness, Jan van der Vis mentioned that one of the reasons on why their organization decided to implement a new system was because one of the old systems they used was not receiving future updates and supports anymore from the vendor. The same respondent also mentioned reason number 3 and 6 as a part of his answer.

3. There is a need to utilize a new solution with an improved technology

   For big companies that have many branches all over the world, it will be useful to have a more centralized data that could be filtered and extracted for business analysis. For example, a company wants to equip a Business Intelligence tool for better insights on the performance of the enterprise, but it does not integrate well with the old system as the previous system was a scattered implementation on many branches all over the world and they are not fully integrated to each other. If the BI tool was to be applied then it cannot properly access all the data from the system.

4. The system in use is not relevant to current business

   Respondent I7 and I5 mentioned another particular reason that the old system merely does not support the business process in the organization anymore. It was mainly due to process changes in the organization that is demanding new processes and new entities with faster processes and these needs could not be supported by the system.

5. Major organization (structure) changes

   Splits, acquisition or mergers, and growth of the organization could play a tricky part in the organizations involved. T6 mentioned a case that the company he is working, for now, was a split off from other company and that it would be a different story if the split off deal regarding the licensing of the ERP system and the ownership of the data were not going into their favor. It may also be the

main reason to reimplement an ERP system if the wind was going in other direction.

6. Overwhelming amount of enhancement and customization
   Customizing an ERP system means more work in the future upgrade because there is a very high chance that the customization will not work on the new patch. Sometimes an organization tweaked the system too much to the point that the system is full of customization in many areas that the organization cannot follow any upgrade anymore.

If we see it clearly, most of the reasons happened because of changes. Organizational change occurs and promotes a chain reaction that demands support from the ERP system. So, if one wanted to avoid the need for a reimplementation, there are two things to aim the focus at, either the design of business processes or the capability of ERP system to support changes.

4.1.2. Capabilities of current ERP system

Following the focus at hand, the respondent was asked about the capabilities of current ERP systems in the market. I1 who has experience with a couple of leading ERP vendors highlighted that one vendor is more flexible in generating a report for the user, an ability which just happened that the other vendor cannot do. “It took a developer to make such changes”, he said. I4, on the other hand, had mixed answers to question TE2 (Appendix B.1). He claimed that “in general we are shifting towards a more customized ERP system”, and stated that “the current system is very rigid” while seeming to lean towards cloud solution. But then he quickly continued and said that the flexibility the cloud solution has, lies on the easiness in buying or losing a combination of modules in the solution, not necessarily like customizing the interface, for example, which is difficult to do.

Although I4 said that the current systems are rigid, he also said that (in a hypothetical way) if a company did not have any limitation on time and money, current ERP systems should be able to deliver realistically around 70% of customization needs

in an organization. It can be quite expensive because every customization needs to be maintained, especially when there is a roll out of a patch or new version of the system. It is not uncommon for them to have to rewrite the customized program, after having a patch to the system, because the patch could overwrite the customization.

I6 explained that the possibility to customize an ERP system is actually endless; referring to the system used in the company he works for. “The toolbox in itself is not the limit, the limit is process knowledge, and how to transfer business needs to process description to IT tooling.” He further explained that even so the possibility is endless, an organization still need a person who knows what the ERP system can offer, and also knows how the workflow in the company, to better understand the reasoning behind every process change and business decision, to limit the customizations in the system. The very reason he said that is because this process is never-ending, there will always be changes in the organization.

On the same note with other respondents, I7 said that ERP vendors can handle changes good enough. He has an opinion that it is possible that the ERP vendors intentionally make their system a bit straightforward, to aim for bigger customer pool.

Summarizing their answer, they have different opinions on the ability to tweak ERP system to fit their needs. But apparently, the ability to modify the system according to organizational change seems not to be a concern for these experts. Because, if there is a change deemed necessary, it must be coming from a careful consideration which must also foresee the risks; and most of the time it is possible to do as long as the resources needed to execute the customization is fulfilled. What concerns them more, the stressing point was to avoid doing the customization. All of them agreed that having customizations in the ERP system also means dragging a problem to the future.

> *“there's also a major challenge, because if you're gonna do that then basically (it) deviate from the standard solutions. which will mean that for any future upgrades you also have constantly you have to update your enhancements and your customizations”*
>
> *Jan van der Vis (2017), Project Manager - Life Fitness*

It's a tremendous amount of work to do in the future to analyze the patch of an update, and then rewrite the customization that might be overwritten by the patch installed. This is something that must be done, regardless of how flexible the system is.

4.1.3. Important factors for a flexible ERP system

Every ERP system on the market now has different structure and architecture, different pricing models, and has a segmented target for different industry. As previously mentioned, the respondents have different opinions regarding the flexibility of an ERP system in handling changes, some said it's always possible, and other realistically said most of the time it is possible if money is not a concern. This shows that there are actually limitations in ERP system to deliver those changes with a minimum amount of resources.

When I4 was asked about the factors influencing a changeability in an ERP system, he was more focused to the problems at hand, it shows that he really wants to make sure that what they want is really necessary if it's possible to be done to the system without doing a customization. He seemed really concerned about not meddling with the system.

I5 has a more straightforward opinion on this, he clearly mentioned: "for me per se in ERP system is not that flexible." He continued by saying that the organization strives for efficiency and effectiveness. So, when talking about what to strive for and flexibility is sometimes two different worlds.

Another answer given by I6 stated that every ERP system has different strategies, but almost the same abilities. In the end, it comes down to money, as long as the organization has money to facilitate the changes, it is almost possible to do anything. I7 has the same voice to I6 while adding that having somebody who is very good in design and processes, who is not easily accepting any changes.

I2, who is an experienced project leader and implementation consultant who's mostly handling SMEs, has the same note with the other respondents. He clearly said that the flexibility does not depend on the ERP system but more at the decision, and change management. He also said that changing people is more difficult than changing

the system. “when you change from ERP system, it always has to do with the changing in the company in the enterprise, always.” It seems that he tried to stress the point that it is more important to have a well-knowledged staff to build an efficient organization is more important and that ERP is just a tool to reach the organization's goal. It is possible that he said that because most ERP system targeted at SMEs are mostly sold as it is, ready to use, and hard to customize.

None of the respondents mentioned any technical aspect in the system. They are all focused on optimizing the process to follow the standards. It could be because it is cheaper in the short term, as well as the long-time period. Having said that, if they are focused on following the standards of ERP system, it means that there is a possibility that they are sacrificing the most efficient way of the process. The respondents also did not specify whether the cost spent on having a “not the most efficient” process is worth more in the long term compared to if they decide to tweak the system to have the most efficient version of the process, in spite of the future expenditure that might occur.

4.1.4. BPR, change management and relation to ERP system

Following the previous concerns, the focus at hand moved to: is it better for the process to follow the standards functionality to prevent the complexity of managing the system in the long term? Or is it better to customize the system to support the business needs of an organization so that they can work in the most efficient and effective way to gain the best possible result for the organization?

The respondents have different answers to this, I2 answered this question by throwing another point of view at the matter. He said “If you have to change the ERP system, you have to change the processes. If you change the processes, you have to change the ERP system.” This is of course like chicken and egg, but in this case, it is a matter of priority, the consideration becomes which one is more important, is the process more critical or is it the customization that is overall too costly both in risk and expenses.

I5 have a clearer answer by stating that the main goal when implementing ERP system is to have it as standard as possible. In other words, the organization has to adapt their processes to basically what the system is able to provide. If somehow the "to be" process is really crucial and irreplaceable then only then the customization will be done.

I6 said the same thing as I5, added that sometimes it is very tempting from the user perspective and business perspective to tweak the system when there are changes in the process because clearly, the system does not limit it from doing so, though it is in form of a customization.

> *"If you keep to the standards, you will always be able to go to the next version of the system. If you have a lot of changes, that is all in general very difficult to adapt to the new ERP system."*
>
> *I7 (2017), Team Lead Enterprise Application for Finance*

This section gave an insight that even though the system is flexible enough to handle the changes, it is not always the path to be taken. I6 mentioned specific rule in the company he works for, "The policy is ERP standards, unless. But when you see our landscape, still quite a lot of unless." This is pretty much drawing the real condition, where the customizations are strictly controlled, and yet the available tool to tweak with the system is not enough to serve the needs of the "to be" business process. It makes room for other systems that could serve the previously unsupported process to come.

4.1.5. Human factor in a pursue of a changeable system

Palanisamy & Foshay (2013) suggest that the human factor is as important as the actual capability in the system itself in achieving a changeable ERP system. Relating to this statement, I1 in an indirect way, admitted that the most effort is made to make the organization ready to work with the new ERP system. I5 have the same idea by saying that the deciding factor that makes a reimplementation is expensive or not is how well the organization know the system, how familiar and how

knowledgeable are the staff in working with the ERP system. Another point of view explained by I6 that it is also possible that the ERP system is functioning properly, but maybe the people are not; because in big companies, people coming in and going out quite often and not everybody fully understands the system. It will have an impact on the actual capability of the system.

I2 and I7 also have rather a similar idea towards the statement. I2 stressed the point at people with process knowledge, especially those who are in charge of managing the system. A right person who understands the process steps and can analyze it properly to suit the actual functionalities of ERP system is necessary. I2 also mentioned that the resistance to change by the employees might interfere with this process. This resistance also become a concern to I7. A slight modification to a process is done to avoid the need to customize the ERP system, it makes the process a little bit longer. At the same time, the employees are complaining each and every minute, reacting to this change, because the way they have to work now is not the same way as they did. Eventually, it will go up to the top management, and they might order to speed up the process and a customization has to be made. This example shows the importance to have people who have business knowledge and also system knowledge. I6 summed it up by saying "all those big companies are loaded with smart people. But, that doesn't imply that you also have the business knowledge."

> *"Anyone can buy a boat, but not everyone can sail a boat."*
> *Paul Lemmen (2017), Team Lead Financial Application - Nexperia*

4.1.6. Best practices for gaining a flexible system

In retrospect of the focus of the research, the last section tries to dig in for the recipe of having a changeable ERP system. All of the respondents answered with the same approaches.

I4 suggest that the organization needs to be critical to the business and not to push all execute all changes to ERP system. Writing a risk-and-impact analysis document for the business might help the top management in considering their decision.

From a technical point of view, I5 suggesting to have an easily maintainable system. Easy enough to have a certain flexibility but needs to be properly controlled, because control and flexibility can also be two sides of a coin.

I6 suggesting to use the toolbox and the properties to tweak with the system, to stay away from meddling with the source code, and try to stick with the standardized functionalities of the ERP system. He also added his answer by mentioning that the key components: process knowledge, people with experience in the ERP system, and to connect business and process knowledge into IT.

I7 is more focused on from the very beginning, he suggested to carefully choose the ERP system by choosing the system that can solve the requirements right out of the box, without customization. From then on, try to keep the process align with the ERP system, and to be critical when it comes to change of process that needs major customization.

4.2. Questionnaire

The interviews were complimented by questionnaire that will cover the technical aspects of ERP system, based on the method explained in chapter 2.4.1, using analytic hierarchical process (AHP). The structure of the questionnaire form can be seen on Appendix B.3.

The tables below show a glance of the distribution of answers from the respondents.

Table 7: 1st level index counts on preference

1st level index		
Presentation	Application	Database
7	8	3

Table 8: 2nd level index counts on preference

2nd level index					
Presentation		Application		Database	
GUI type	4	Modularity	9	Server location	1
Device type	3	Source code Access	5	Data compatibility	10
		CMS	7	Scalability	8

The tables above do not reflect the actual weight and priorities of each index, it only counts on how many times an index was chosen over the other index in comparison. When two indexes got the same intensity of importance (scale 1), both indexes got one point.

The counts on table 7 show that having flexibilities in both Presentation and Application plays more role in achieving a changeable ERP system. The database seems not to be that much of a concern for the respondents. The reason may be because most of the changes are in the functionality part, which is in the Presentation and Application layer and not in the data structure.

The final AHP counts from 6 respondents on the model resulting weight for each criterion and global priorities for each end nodes as shown below

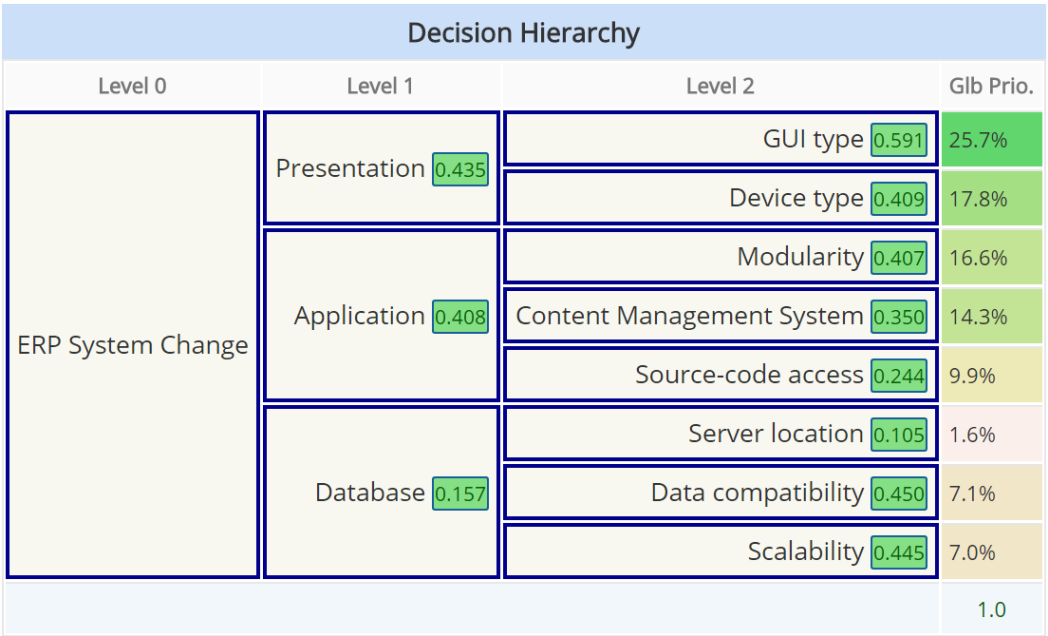

Figure 4: Final weight and global priorities

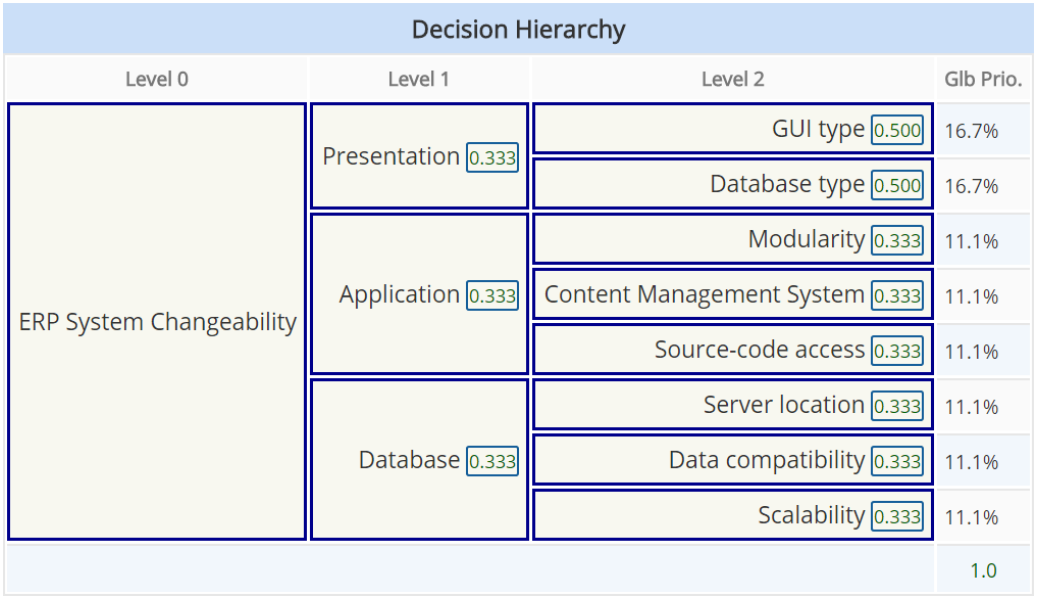

Figure 5: Base weight and priorities

In the final result shown in Figure 4, it is clear that even though on the normal counts Application has been chosen more than Presentation (Table 7), but the weight shows that Presentation is seen as more important than Application. Since this result represents the experience of the experts, the reason might be caused by the frequency of customization that is made on the presentation level. User Interface is the surface that the users see and feel directly after all, so there is a high possibility that a lot of customization made to incorporate the most efficient way to work. In this case, the UI could be as a form-based (desktop app) or web-based (browser). Customizing a web-based UI is clearly easier than a desktop-based application which is more rigid.

The global priorities score for GUI type and Device type is expected to be higher than the other end nodes, that is because there are only 2 criteria under Presentation. Unlike the other layer which divides the weight into 3 criteria, Presentation only has 2 criteria under it which make it have the normal weight of 0,5 instead of 0,33 like other criteria (Figure 5). Overlooking those two criteria will show that Application layer has actually quite a major role as a deciding factor in the changeability of ERP system.

Interesting that having source code access is not the most deciding factor when it comes to the changeability of a system. Although by having access to source code means that it will be a lot more flexible for the organization to tweak with their system, it sits at the last position in the Application layer. It is somehow aligned with the statement that most of the respondents have given, that they prefer to avoid customization. Totally understandable, because there is no use to have access to the source code if the organization does not have staff who has the ability to tweak the system. Most of them will need to go to the vendor or to a consultant to have their system customized.

Content Management System, on the other hand, sits not far from Modularity. To have access to this tool means the organization can control the flow of information, and to trigger a certain kind of action when a certain data is changed. To have control over basic properties like this, of course, is important in an ERP system.

Modularity of the system sits in the top position under Application layer, and third on the global priorities. The respondents seem to be concern about having a system that is too modular, too many dependencies which might make it difficult especially if these dependencies are set by customization, which might make things complicated in the future.

Server location has the least priority due to the development of server technology that makes it easily accessible and maintainable. Although Database layer itself shares almost a third of the weight of the other two layers, it seems like data compatibility and scalability is quite important too, looking at the gap between them and server location. Both data compatibility and Scalability shares almost the same score on weight and priority, respectively around 0.45 under Database layer and 7% globally. They are needed, but clearly not the most crucial aspect here. The reasoning could be that the ability of the current database used in ERP system is proven satisfying on scalability. For data compatibility, it is possible that it is not really a concern because there are standards used to communicate and transferring data between systems, like XML.

Table 9: Distribution of priorities

Participants	GUI type	Device type	Modularity	Content Management System	Source-code access	Server location	Data compatibility	Scalability
Group result	**25.7%**	**17.8%**	**16.6%**	**14.3%**	**9.9%**	**1.6%**	**7.1%**	**7.0%**
Respondent I4	39.3%	39.3%	7.7%	3.7%	5.3%	0.4%	1.8%	2.4%
Respondent I1	70.8%	7.9%	0.9%	12.9%	3.0%	0.2%	3.4%	0.9%
Respondent I5	10.1%	3.4%	18.6%	26.9%	12.9%	4.0%	12.0%	12.0%
Respondent I7	2.7%	19.0%	46.6%	18.9%	7.7%	0.2%	1.0%	3.8%
Respondent I6	1.5%	4.4%	20.8%	6.0%	43.3%	1.5%	15.2%	7.3%
Respondent I2	61.7%	8.8%	4.3%	1.5%	0.4%	8.4%	6.4%	8.6%

Conclusion and discussion

In this research, it becomes clearer how changeability of ERP system plays a role in supporting businesses in an organization. To gain insights to the focus of the research, a total of six interviews have been conducted with project managers, team leaders, and implementation consultants who have experience with ERP system with various vendors and different kind of organizations on a different scale. In the first part of this chapter, a summary of the result and an answer to the research question is provided. The second part closes the chapter with a discussion about this research, consisting of the elaboration on how the result is interpreted, limitation of the research and also recommendations for future research.

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5.1. Conclusion

ERP system has been widely used by a lot of organizations all over the world. Most, if not all big multinationals utilize this system to make their business more effective and efficient. The development of cloud technology also took part in bringing ERP system closer to the SME, widening the market. The solution is becoming more affordable for them with various licensing scheme provided. Despite all the advantages that ERP vendors promised to their customer, the actual performance of ERP system may not always go as promised. Over the time, process changes in an organization are inevitable, and the fact shows that not every change in the organization could be supported by ERP system. It is proved by the fact that there are quite a lot of companies undergoing a reimplementation of their ERP system. It shows that ERP system is nowhere near perfect. The topic of ERP reimplementation itself does not really show up in literature, although this is a significant process that draws serious attention and a lot of resources to be spent. Altogether, this led to the research question of this research:

“ What factors are accountable in achieving a changeable ERP system? ”

To provide an answer to this question, the research has analyzed two dimensions to really capture how does ERP system work, in response to organizational change. These dimensions cover the management aspect and the technical aspect of ERP systems. Although in the beginning, this research was more focused on investigating the contributing factors that influence the changeability value of ERP system from the technical point of view, a lot of insights have been found from the interviews pointing the significance role of change management. It became evident that based on their experience in practice, the experts clearly judge towards the same idea that ERP system by itself is not per definition "capable" or "flexible" enough in handling changes with minimum efforts and minimum cost for a long term. The best that ERP system can offer now is to serve the changes with minimum amount of resources at the moment, without giving a guarantee that the changes made to the system will not give any problem in the future. In other words, from a technical point of view ERP system might be changeable at this moment, but it might not be the case because the aftermath of the change made is uncertain.

In a sense of risk management perspective, it is safe to say that although ERP system possesses the trait of being flexible, more often than not the risk is too high to utilize this flexibility. The respondents prefer to compromise with the business process to meet the standard functionalities offered by the system, in order to lower the complexity, pushing down the cost, and achieving a maintainable system.

Apart from the organizational point of view, seeing ERP system in a bubble as an information system, also gives another sight to the case. There are actually some factors which contributes to the "current changeability" of an ERP system. The proposed model in table 4 was formed and had been cross-compared by the respondents, to find the global priorities and the weight for each criterion. Aligned with the policy that the respondents have, to go as standard as possible, access to source code only ranks on the 5th on the global priority level. Surprisingly, the consolidated result from AHP shows that modularity is the third top concern for ERP experts when it comes to decide whether an ERP system is easily changeable or not. Somehow, it goes against the existential purpose of ERP system. ERP system is made to centralized data across

organizations. ERP system consists of modules to serve specific part in the organization. These modules can “communicate” to each other because they are using and sharing the same data source. The more modules an organization has the more it will increase the dependencies between processes across modules. The higher the dependencies, the more modular the system is, and the less changeable it becomes. The integration is what ERP system offered and yet the more integrated the system is, the less changeable it is.

In the end, even though ERP system is by nature a product of technology, but in reality, the pursue of being a changeable system is not always about technology. Changeability in an ERP system does not depend on mere technical capabilities of the respectable system, but also to the knowledge of the people who are in charge of managing the system. It is true that having a very flexible system which could easily manage to grant any changes would satisfy a lot of people, but it is also true that the capability of ERP systems at the moment is still quite far from perfect. To have a person who has process knowledge, deep understanding on how the organization works, combined with the skill and experience in the respective ERP system, that will increase the quality of an ERP system.

ERP system should not be seen as a tool on its own, but rather a socio-technical system working together with the user to achieve a certain goal. To implement a system that can fulfill the business needs as it is, and to have people who has process knowledge, deep understanding on how the organization works, combined with the experience and skill to really know what the ERP system can offer. The combination of those is the best practice in achieving a changeable, maintainable system for a longer period of time and avoiding the risk of reimplementation at the same time.

5.2. Discussion

5.2.1. Interpretation of the results

It was expected in this research, to find a relatable causal factor from another perspective besides the technical point of view. The change management aspect here

offers control to the ability to change the system. This ability, however, must be controlled, as suggested by Esteves et al., (2002) that business process redesign (BPR) must be monitored and analyzed with proper measurement before implementing a process in ERP. It also supports the modern socio-technical design that implies a top-down development of the organization structure (follow processes), and a bottom-up development of the necessary control structure (follow ERP standards) (Benders, Hoeken, Batenburg, & Schouteten, 2006). The effort to balance this design makes the scope of responsibility to keep a system sustainably changeable becomes wider to not solely dependent on technical ability of the system, but also to the ability of the people to manage processes efficiently and at the same time minimizing changes in the ERP. Surely at some point, customization is needed to be done. If it is deemed necessary, even implementing another system is also an option to be considered, if the current ERP is not able to support the needed process in the organizations. It is not uncommon for an organization to have more than 1 systems in an organization.

It is quite interesting to look at the word cloud (Appendix B.2) extracted from the interviews shows the important keywords that is hidden under the main keywords of this research. Aside from the main topic at hand, the word “people”, “process”, “business”, “processes”, “knowledge” came second after the main keywords. These set of words show that the respondents are really concerned about the process and the people around it.

Looking at the variety in the distribution of global priorities from the model in this research shows the differences of the respondent’s professional background. They are coming from different industries, utilized different vendors on a different platform. The role they have taken in the ERP project in the past also might affect their answer. Respondent I2 for example, he tends to favor GUI type over the other criteria because his professional background is more focused on SME. In which mostly the solution is sold as it is, with little or no tools to meddle with the system, where the customization performed mostly happened at the presentation level. It could also be seen by looking at them having difficulties in choosing which criteria that is more important when it comes to changeability because it’s clear that the model was based on the important

part of the system and without one of them the system would not be there. In the end, they needed to make a choice and set the priority towards their choice, and those decisions they made must be a reflection of their own personal experience; explaining the wide gap of consensus in the results.

The result of this research could show another perspective to people who have the background in IT. To learn that technical knowledge, to be able to execute and deliver the need is not always the answer. To learn the business language, that is also important, because bridging the gap between these two are one of the keys to having a deeper knowledge to properly manage a sustainable ERP system and the organization that runs on it.

5.2.2. Limitations of the research

In this research, there is no certain category of ERP systems used under observation. All product categories from different vendors are included to have a broader scope and image of ERP system in general.

The size of the sample is relatively small for such a broad scope. A bigger sample with very specific market category would probably offers higher consistency and enhancement to the reliability of the research.

In addition, strict criteria are made towards the selection of respondents in this research. Most of the professionals in ERP system are only specializes in one particular ERP vendor, and that will bring bias to the information gained in the interview.

5.2.3. Recommendations for future research

Recommendation for future research based on this research is linked to the limitations in the previous subchapter. In order to get a more focused and detailed view on a specific aspect of an ERP system, one should explore on a narrower scope, such as ERP system for a specific industry, or ERP system that is based on a certain platform of service. By narrowing the scope, it might be more difficult to gather the source of information but, at the same time, it would also increase the reliability of the data.

Another recommendation would be to investigate the reasoning behind the plan of some big ERP vendors like Oracle and Microsoft Dynamics (365) to move all their solution to the cloud in the near future. This is a big step that will bring implications to the user as a customer who is forced to do the switch. One could also focus on the CIA (confidentiality, integrity, availability) of information in cloud ERP which is still a concern for most of the prospective customers of the cloud solution.

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Appendix A

A.1. ERP quadrants

Cloud computing is known for having three service models:

- Software as a Service (SaaS)
- Platform as a Service (PaaS)
- Infrastructure as a Service (IaaS)

A SaaS type ERP is basically a ready-to-use application. The vendor of a SaaS ERP builds a system which is tightly integrated to the platform and the hardware and they are inseparable. A PaaS type ERP gives access to either the vendor or the customer to move the system to another platform provider. It is possible because in this architecture, the vendor manages the platform layer and application / software layer separately. Unlike the first two, an IaaS type ERP offers the most control. The vendor could decide what kind of operating system would be used as well as the platform they are going to use, which means total control of the application on top of the hardware infrastructure. Offering maximum flexibility, most people simply say that PaaS and IaaS as a hosted service, which has the same capability as in on-premise ERP system, but placed in the cloud. In conclusion, SaaS focused only on providing basic services for the users to be able to access software functionality without worrying on technical things like managing server or customizing ERP modules. When a customer wants more control over the system and the data that they use, they can use the hosted ERP solution in form of either IaaS or PaaS.

On-Premise ERP use a physical server to run the system and could be divided into 3 tiers based on the size and the complexity of the organization. Tier I is considered the most complex and expensive solution than the other tiers. Big vendor names like SAP, Oracle, PeopleSoft, and Microsoft Business Solutions or Microsoft Dynamics are

the main players in this area. Most of their clients are big companies which have a large business with many departments on many locations. This solution is normally being set up with on-premise server and backup server and also would take quite a long time for the implementation due to the complexity of the system. This solution also offers a wide range of functions (modules).

Tier II fits most mid-size companies which have single or multiple locations, but smaller in scale compared to companies in Tier I. Even so, the complexity level will still vary, depends on the situation. Vendors in this tier mostly developed their solution based on a specific industry. Thus, the customization of the solution may very well suit with the company. On the other hand, this product design may not always be good for the vendor as the more vertical an ERP system makes the market smaller, as well as lacking other functionalities. The best fit would be a more horizontal ERP system, which allows integration with local systems to overcome the disadvantages and also reaching a lower total cost.

Tier III solutions reside at the lowest price range compared to the first two. Some may even say that it is not considered ERP system because mainly it does not serve functionalities as in Tier I and Tier II. Solutions that qualifies in this tier is one that offers basic accounting abilities along with small business tools, similar to SaaS.

A.2. ERP license

License is one of the important factors contributing to the overall cost of ERP implementation. There is one significant factor that might differ the most when it comes to ERP licensing, which is the type of deployment, whether the system is going to be deployed on-premise or in the cloud. Both of them has their own pricing structure. Generally, a cloud based system would charge the customer on a subscription basis, and an on-premise system will be sold as a perpetual license (pay once for a lifetime).

Just like the name, licenses in a subscription plan is charged in a timely basis (i.e. annually).

The subscription type license of ERP in a cloud system is considered an ongoing operating expense, that is why most ERP vendors tend to set a competitive price against the similar solution in an on-premise system. This cloud subscription pricing system suits better to a SME market, since they do not have big resources to invest in such expensive system in the beginning. They tend to use their resources to develop their business. Larger companies however, may not have any problem in investing a significant amount of capital expenditure upfront for an on-premise system.

A typical subscription fees for a cloud ERP system over the course of a year, will add up to around 20 to 30 percent of the cost of similar system with a perpetual license. Thus, the choice would be a high cost in the beginning followed by low recurring cost in an on-premise system, or low cost in the beginning followed by the same or even higher recurring cost in a cloud system. Even so, both of this cost option tends to converge at some point over time.

The cost of license also correlates with the number of modules accessed for each user. Solutions sold in a user-based pricing model will require the customer to pay one license fee per user. It includes access to all the modules of the system which can be turned on or off to each user based on their user profile. On the other hand, solutions that is sold in a module-based pricing model will require the customer to buy the specific modules that they need (such as general ledger) on a la carte basis.

From the license alone, we can find a number of options. The one-time license cost for a user-based tier I system costs roughly around $ 4.000 per-user. Tier II system with a module-based pricing model ranges around $ 1.600 to $ 4.000 per-user depends on the number of modules accessible for a certain user. This way, if a company figures that they will only need a certain module to be used for quite a long time, they can save a lot because they do not need to buy full functionalities. For an example, there are a

total of 20 planned users, but only 5 of them needs full access to the system. The remaining others only needs certain access to a module of their responsibility, like viewing data or generating reports of a general ledger. It will be cheaper compared to having full access for all user.

The license also not limited to be registered as a named user, but instead could also be based on concurrent users. Following the example above, the company decided to buy only 15 licenses based on concurrent users and set more than 25 users in the system. When they have 15 concurrent licenses, it means they will only be able to have 15 users logged in to the system at the same time, if there was a 16th account tried to log on, it will be denied.

A.3. Details of the literature on flexibility evaluation approach

ERP system flexibility measurement based on fuzzy analytic network process. (Zhou et al., 2013)

First-level index	Second-level index
Architecture flexibility	• Degree of structuring • Adaptability • Structure expansibility • Kernel stability
Function flexibility	• Module coupling degree • Parametric design • Matching degree • Flexibility of configuration
Transaction processing flexibility	• Component-based business • Business adaptability • Business reconfiguration
Client flexibility	• Redefinition of process documents

First-level index	Second-level index
Responsiveness flexibility	• Redefinition of input and output • Redefinition of interface • Online job response time • Task switching speed • Accuracy

A study on the measurement model of flexibility of information system strategic planning.

(Li & Yin, 2007)

First-level index	Second-level index
Business changes	• Planning objectives • Planning scope • Planning course • Budget • Input data categories • Output data categories • Business rules / processes • Data structure • Business response time • Reliability requirement • User interface
IT changes	• Programming tools / languages • Analysis / design methodologies • TT architecture • Network / telecom environment • Other interfaced systems • Enterprise master data • TT infrastructure

A fuzzy comprehensive decision support model for information system flexibility evaluation.

(Lu et al., 2010)

First-level index	Second-level index
Data flexibility	• Structure flexibility • Relations flexibility • Reports flexibility
Process flexibility	• Actions flexibility • Rules flexibility • Goals flexibility • Synergy flexibility
System flexibility	• Platform flexibility • Technology flexibility • Interface flexibility

A Study on flexibility of ERP system based on grey evaluation model.

(Wang & Liu, 2010)

First-level index	Second-level index
Design flexibility of data tier	• Degree of modularization • Structure's extendability • Module coupling • Development process maturity
Interaction flexibility of presentation tier	• System stability • Ease of operation • Response speed • Customization of user factor
Process flexibility of business tier	• Capability of bill self-definition • Free configuration of business functions

First-level index	Second-level index
	• Synchronization of business flow and capital flow • Connectivity with external systems

Appendix B

B.1. Interview structure

~ Brief description of the study ~

~ Explaining the sampling logic and the purpose of the interview ~

~ Filling consent form ~

~ Preparing recording devices ~

Expertise background [code group: EB]

1. How many ERP vendors have you had an experience with? [EB1]
2. How many ERP implementation and reimplementation projects have you done? [EB2]
3. What is your role at the moment? [EB3]

Thoughts on ERP changeability [code group: TE]

1. What is the reasons behind ERP reimplementation / upgrade? [TE1]
   a) What was the most difficult part?
   b) Issues due to the change of requirements in the middle of the project.
   c) how to resolve these issues?
2. Given the recurring changes within an organization which keeps adding more customization (probably), How long will the system suffice? [TE2]
   a) How capable are current ERP systems in handling significant organizational changes or business changes without the need of a re-implementation?
3. Important factors that contribute to the flexibility of ERP system. (based on experience) [TE3]
4. Importance of BPR & change management in the implementation of ERP system. Which is most likely to happen, the functionalities of ERP system fulfilling the

requirements/BP, or the other way around; requirements/BP that follows ERP's standard? [TE4]

5. One literature (Palanisamy & Foshay, 2013) suggests that we should have a dynamically balanced level of flexibility both strategically and technologically (instead of either-or). It makes user's cognitive accountable for the executing the changeable system is as important as the actual flexibility of the system itself. What is your thought on this statement? [code: TE5]
6. What would be the ideal way of achieving a flexible ERP system? [TE6]

Thoughts on the proposed changeability model [code group: TP]

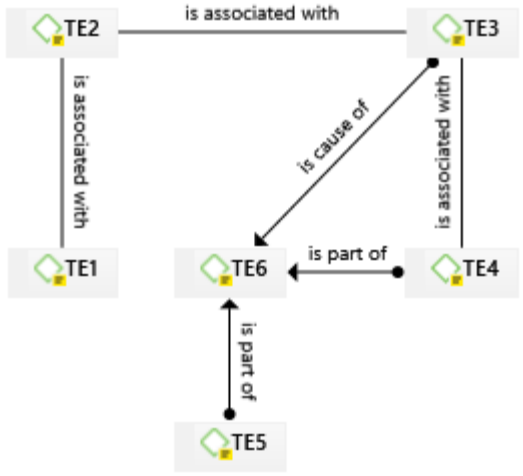
1. What would you highlight from the changeability model proposed in this thesis? [code: TP1]
2. If you could alter the indexes in the model, what would you add or remove? [code: TP2]

B.2. Code Network

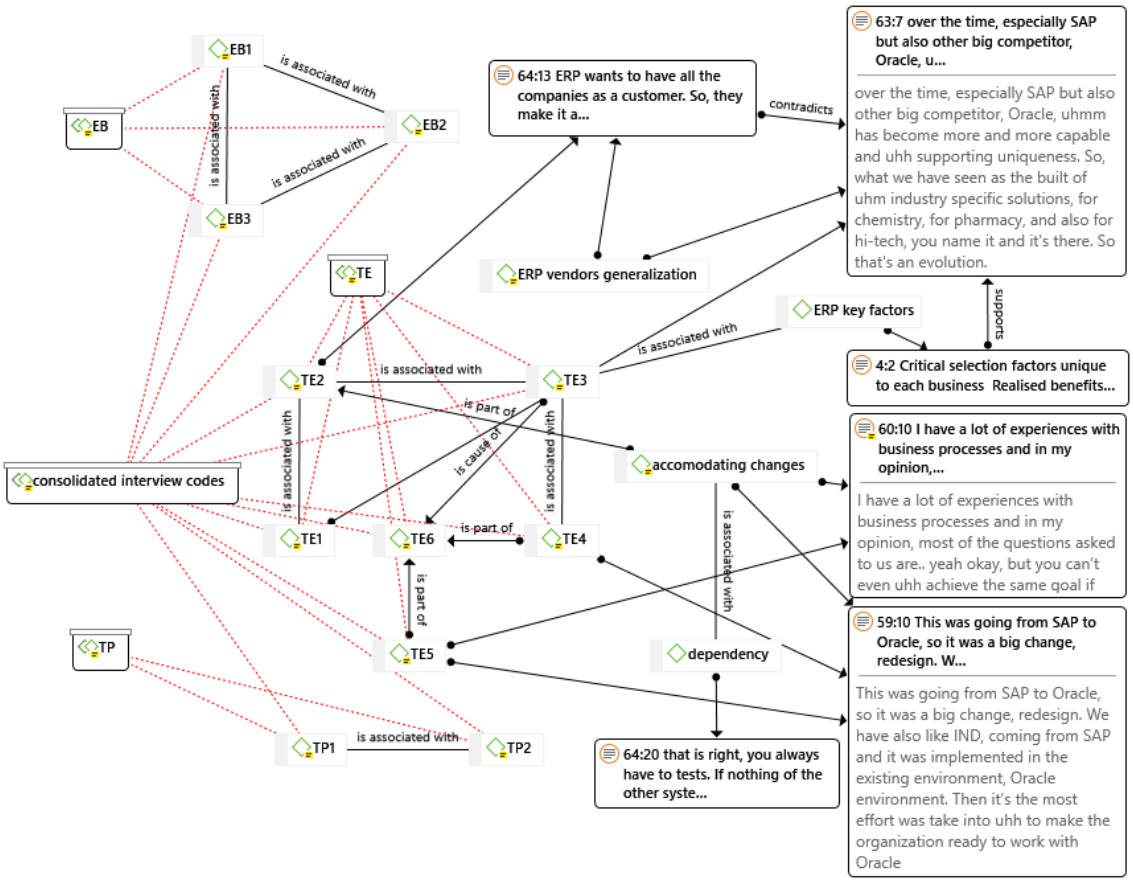
-code group for interview transcripts

Name	Grounded	Density	Groups
TP1~	7	0	[TP]
TP2~	2	0	[TP]
TE1~	25	1	[TE]
TE2~	14	2	[TE]
TE3~	12	3	[TE]
TE4~	13	2	[TE]
TE5~	9	1	[TE]
TE6~	12	3	[TE]
EB1~	7	0	[EB]
EB2~	3	0	[EB]
EB3~	5	0	[EB]

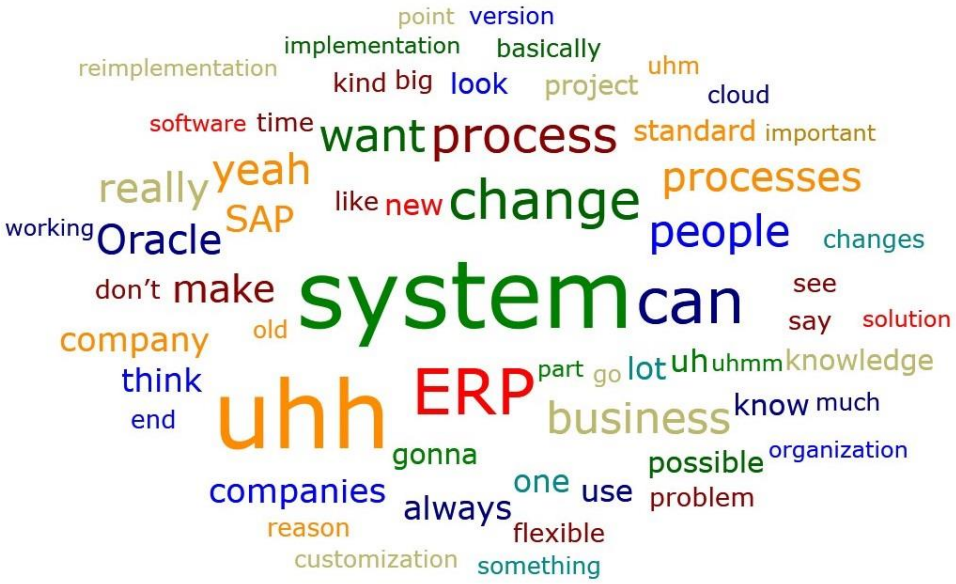
- Code network for TE code group, main topics.



- Consolidated codes for interview transcripts



- Word cloud for TE code group



B.3. Index pairwise comparison for the proposed changeability model

**Tick the preferable index that has more influence to the changeability of ERP system*

1st level index

1. Presentation (front end) ☐ || ☐ Application (back end)
   Intensity of importance = 1 3 5 7 9
2. Presentation (front end) ☐ || ☐ Database (data storage)
   Intensity of importance = 1 3 5 7 9
3. Application (back end) ☐ || ☐ Database (data storage)
   Intensity of importance = 1 3 5 7 9

2nd level index

1. *Presentation*
   - GUI type ☐ || ☐ Device type
     Intensity of importance = 1 3 5 7 9
2. *Application*
   a. Modularity ☐ || ☐ CMS
      Intensity of importance = 1 3 5 7 9
   b. Modularity ☐ || ☐ Source code access
      Intensity of importance = 1 3 5 7 9
   c. Source code access ☐ || ☐ CMS
      Intensity of importance = 1 3 5 7 9
3. *Database*
   a. Server location ☐ || ☐ Data compatibility
      Intensity of importance = 1 3 5 7 9

b. Server location ☐ || ☐ Scalability

Intensity of importance = 1 3 5 7 9

c. Data compatibility ☐ || ☐ Scalability

Intensity of importance = 1 3 5 7 9

B.4. AHP results

Main node

- consolidated priorities

	Category	Priority	Rank
1	Presentation	43.5%	1
2	Application	40.8%	2
3	Database	15.7%	3

- consolidated decision matrix

	1	2	3
1	1	1.18	2.50
2	0.84	1	2.88
3	0.40	0.35	1

- group result and priorities of individual participants

Participants	Presentation	Application	Database	CR_{max}
Group result	**43.5%**	**40.8%**	**15.7%**	**1.1%**
Respondent I4	78.7%	16.7%	4.6%	45.5%
Respondent I1	78.7%	16.7%	4.6%	45.5%
Respondent I5	13.5%	58.4%	28.1%	14.1%
Respondent I7	21.8%	73.2%	5.0%	58.5%
Respondent I6	5.9%	70.1%	24.0%	30.8%
Respondent I2	70.5%	6.1%	23.4%	78.9%

Presentation node

- consolidated priorities

	1	2	3
1	1	1.18	2.50
2	0.84	1	2.88
3	0.40	0.35	1

- consolidated decision matrix

	1	2
1	1	1.44
2	0.69	1

- group result and priorities of individual participants

Participants	GUI type	Device type	CR_{max}
Group result	**59.1%**	**40.9%**	**0.0%**
Respondent I4	50.0%	50.0%	0.0%
Respondent I1	90.0%	10.0%	0.0%
Respondent I5	75.0%	25.0%	0.0%
Respondent I7	12.5%	87.5%	0.0%
Respondent I6	25.0%	75.0%	0.0%
Respondent I2	87.5%	12.5%	0.0%

Application node

- consolidated priorities

	Category	Priority	Rank
1	Modularity	40.7%	1
2	Content Management System	35.0%	2
3	Source-code access	24.4%	3

- consolidated decision matrix

	1	2	3
1	1	1.62	1.20
2	0.62	1	1.99
3	0.83	0.50	1

- group result and priorities of individual participants

Participants	Modularity	Content Management System	Source-code access	CR_{max}
Group result	**40.7%**	**35.0%**	**24.4%**	**11.4%**
Respondent I4	46.0%	22.1%	31.9%	58.5%
Respondent I1	5.3%	76.9%	17.8%	58.7%
Respondent I5	31.9%	46.0%	22.1%	14.1%
Respondent I7	63.7%	25.8%	10.5%	54.3%
Respondent I6	29.7%	8.6%	61.8%	14.1%
Respondent I2	70.1%	24.0%	5.9%	30.8%

Database node

- consolidated priorities

	Category	Priority	Rank
1	Server location	10.5%	3
2	Data compatibility	45.0%	1
3	Scalability	44.5%	2

- consolidated decision matrix

	1	2	3
1	1	0.36	0.15
2	2.76	1	1.57
3	6.61	0.64	1

- group result and priorities of individual participants

Participants	Server location	Data compatibility	Scalability	CR_{max}
Group result	10.5%	45.0%	44.5%	20.7%
Respondent I4	9.7%	38.8%	51.5%	8.4%
Respondent I1	4.4%	75.1%	20.5%	45.5%
Respondent I5	14.3%	42.9%	42.9%	0.0%
Respondent I7	4.8%	19.1%	76.1%	34.2%
Respondent I6	6.3%	63.3%	30.4%	14.1%
Respondent I2	36.0%	27.1%	36.9%	516.7%