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TOWARDS UNDERSTANDING THE ROLE OF MODULARITY IN THE DOMAIN OF ENTERPRISE ENGINEERING AND ENTERPRISE ARCHITECTURE

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Abstract

In order to attain competitive advantage, contemporary organizations are being compelled to develop the capacity to be agile in response to the VUCA environment. Enterprise engineering is a field that employs theories from a diverse array of disciplines in order to design organizations that are both agile and flexible, while also capable of reducing complexity. The concept of modularity is system sciences theory that is highly regarded is this context. Additionally, literature contends that modularity provides organizations with the opportunity to achieve agility and reduce complexity. Since organizations have become increasingly dependent on information technology (IT) to streamline their operations, IT has become a critical element in achieving and sustaining a competitive advantage. This paper posits that in order to achieve agility and reduce complexity, certain organizational design parameters are necessary. Despite the widespread recognition of modularity in the field of software engineering and product development, organizational modularity has received significantly less attention. This study examines four cases through the prism of the modularity concept. According to the findings, the evolvability of enterprise architecture is restricted by various forms of coupling, which was identified as one of the primary factors contributing to the suboptimal outcomes of the IT projects. The results further illustrate that the critical role of modularity and knowledge parameters in facilitating the outsourcing of tasks to achieve economies of scale, thereby enhancing agility, reducing complexity, and conferring a competitive advantage. During visits to the case sites, it has been observed that Belgian organizations are losing valuable knowledge regarding their business processes and IT architecture. In the context of outsourcing, the retention of knowledge of specialized IT professionals within an organization has not been adequately addressed by existing management frameworks and tools; perhaps the literature has not adequately investigated it. This paper presents a theoretically sound conceptual framework that illustrates the correlation between the concepts of modularity, knowledge, outsourcing, agility, and competitive advantage, as evidenced by the results of four case studies. The conclusion drawn from the analyses of four cases suggests that modularity and knowledge parameters are indispensable criteria that must be considered when designing enterprise architecture.

Keywords

Modularity, Knowledge, Outsourcing, Agility, competitive advantage

Introduction

The term VUCA is used to describe the volatile, uncertain, complex, and ambiguous business landscape. The most recent example of VUCA is the global shock and surprise that resulted from the United States' increased tariffs on the majority of countries. The business landscape has started to move fast in order to avoid this new tariff and as we know that 'Apple' has transported 600 tons of iphones or 1.5 million in multiple chartered cargo flights from India to the USA (Reuters, April 10, 2025). The business landscape is moving very fast and facing constant multifaceted challenges. In order to address these unpredictable challenges, organizations should design their business processes, supply chains, and other systems in an agile manner. Recently, financial instabilities increased in intensity, business cycles are becoming shorter, geopolitical turbulence are becoming a norm, and disruptive innovations are emerging on a daily basis. These new challenges are even jeopardizing the existence of the largest multinational corporations. There is a growing complexity to the business landscape and its entire relevant ecosystem. Subsequently, it is challenging to establish sustainable competitive advantages.

Organizational artifacts, including data processes, departments, and decision structures are implemented to enable organizations to prosper in their intricate environments. Consequently, these artifacts need to be able to be adaptable when a strategy changes in response to changes in the environment. Nevertheless, the complexity of these artifacts, as well as their integration exacerbate, rendering them harder to adapt to change. As a result, organizational architectures are often perceived to be rigid instead of flexible. Recently, modularity theory has been used by many authors to provide a scientific foundation for research concerning agile organizations. However, attempts to formulate a general theoretical framework for modular organizations often lead to conflicting results. Moreover, the role of organizational agility in enhancing competitive advantage is not adequately investigated in research (Zitkiene & Deksnys 2018, Corte-Real et al., 2017; Mikalef & Pateli, 2017).

In this research, therefore, a bottom-up perspective has been employed in order to study the application and relevance of modularity theory in real-life IT projects. This paper presents an exploratory and multiple-case study in which four IT outsourcing projects have been examined. The rationale behind selecting IT outsourcing projects is that numerous organizations are pursuing their strategy of offshoring or outsourcing their noncore activities in order to enhance their agility and competitive advantage (Holbeche, 2023). Despite the fact that the examined IT projects were perceived as unable to achieve their intended objectives, it was also challenging to back-source them without substantial costs. This paper endeavors to propose a theoretically sound conceptual framework that illustrates the correlations between the concepts of modularity, knowledge, outsourcing, agility, and competitive advantage, as demonstrated by four case studies. This conceptual framework is proposed from a modularity perspective, and is derived from the 'lessons-learned' that have been gleaned from the examination of four IT projects. This approach enables the acquisition of a more comprehensive understanding of the pertinent application of the concept of modularity in enterprise architecture. Additionally, these lessons can make a significant contribution to the emerging field of Enterprise Engineering. The subject of the case study is to focus on the design parameters of the enterprise architecture projects. The results show that modularity can provide a relevant perspective in such projects. Moreover, it provides insights concerning the usage of enterprise architecture theories and frameworks, such as, "The Open Group Architecture Framework (TOGAF)", "Design and Engineering Methodology for organizations (DEMO)", "Design Structure Matrix (DSM)", and "Normalized Systems Theory (NST)".

In this context, the following examples illustrates why contemporary organizations are increasingly emphasizing the fields of Enterprise Engineering and Enterprise architecture to facilitate agility and manage complexity, which are frequently precipitated by new innovations. This paper posits that the most effective approach to facilitate agility and to manage the complexity that emerges when striving for evolvability in a system is to implement fine-grained modularity as a design principle. Normalized Systems Theory explains how modularity of a system should be designed in order to establish evolvability and facilitate agility in order to accommodate change that often precipitated by new innovations.

A prevalent feature of numerous contemporary organizational issues is the requirement for the integration of new innovative products and services or sometime even adapting to new regulations in a VUCA environment. This frequently leads industry disruptions, in which the most successful organizations are those that can thrive in such contexts. The following examples demonstrate the necessity of adapting to change as a result of new innovations in a variety of industries, and the disruptive impact it can have on the ecosystem:

- In the music industry, the product itself got digitized first with the introduction of the cd. While this led to innovations and changes, the industry leaders remained in charge. However, this enabled a second wave of digitization (i.e., streaming services), which disrupted the market. In this newly emerging situation, tech companies like Apple, Google, Amazon, and Spotify currently hold a significant portion of the market.
- The automotive sector is characterized by the widespread digitization of numerous systems. Automated control was gradually expanded by incorporating features such as cruise control and parking sensors. This allowed tech companies to incorporate supplementary sensors and create sophisticated algorithms which ultimately led to the development of self-driving vehicles. Again, this evolution is primarily influenced by tech companies like Google, rather than the automotive industry's largest players.
- Manufacturer of mechanical ventilation systems must incorporate electronics control systems into their products in response to evolving efficiency regulations. This necessitates significant investments in new production system. Moreover, numerous manufacturers are unable to comprehend such systems, which results in the outsourcing of design activities. This results in a change in the industry's power dynamics.
- The concept of the Internet of Things is to integrate sensors, computation and communication into physical objects. By incorporating intelligence into these objects, they can be remotely monitored and serviced as well as controlled digitally by their owners. Integration is required on a scale that has never been seen before due to the vast number of devices and the numerous incompatible platforms.

One important observation to make from the aforementioned examples is that these diverse industries share a common factor: the intricate, large-scale integration of evolving components or modules. NST is a theory on the evolvability of modular structures, which identifies the root cause of evolvability issues as **"***combinatorial effects"* (Mannaert, Verelst, & De Bruyn, 2016). A combinatorial effect occurs when the effort to apply a certain change to a system is not only dependent on that change itself, but also on the size of the system. In other words: the effect of a change increases in complexity when the system grows, and becomes unmanageable at a large scale. In order to prevent the occurrence of combinatorial effects; NST formulates a set of design principles. In the majority of cases, the effort necessary to implement a specific change is predictable and feasible when these principles are implemented, even when the system becomes exceedingly large.

The rest of this paper is structured as follows. In Section 2, the modularity literature has been introduced which is used in the analysis. Section 3 presents an argument to consider modularity and knowledge as a design parameter. The theoretical framework that was employed during the analysis is further elaborated upon in Section 4. Case introduction is provided in Section 5. Section 6 provides a brief description about the findings and section 7 provides a detail discussion on the identification of the instances of modularity. Based on the findings, a theoretical framework is proposed in Section 8. Finally, conclusions and implications from this case study are discussed in Section 9.

Literature Review

Simon (1962) proposed to decompose a complex system into nearly independent subsystems or modules. Many scholars consider the organization as a complex system and proposed to modularize organizations to achieve agility and flexibility (e.g., Daft & Lewin, 1993; Sanchez & Mahoney, 1996; Sako, 2005). Modularity in organizations refers to the way in which the firm uses its own and other firms' resources through internal or external organizational units (Colfer & Baldwin 2016). Nevertheless, designing organizations as a modular system is a relatively new paradigm which envisages a flexible organization that adapts to the internal and external changing environment and solves the problems through a coordinated process which is self-organizing (Campagnolo & Camuffo, 2010; Daft & Lewin, 1993). Sako (2005, p.235) states that *"An organization is modular if it consists of units with people whose tasks are interdependent within, and independent between, the units, be they teams, departments, or divisions"*. Nadler and Tushman (1999) suggest that the rapidly changing environment will drive the firms to use more of modular organizational forms. Op't Land (2008) investigates the splitting and merging of organizations from enterprise architecture perspective and proposed eleven guidelines which are referred as *'organization construction rules'*. These rules are applied to an organization involving splitting, allying, and post-merger integration undertakings. One such prescribed rule is - which is also considered as one of the basic principles of the concept of modularity - *"keep the organizational actors together when they have high internal cohesion and low external coupling"* (p. 67).

Moreover, Sako (2005) explains that interfaces between modular organization units must be well defined and standardization is one of the several ways in which interfaces can be well defined. Many complex systems are designed in hierarchies so as to reduce complexities by enabling a repeated decomposition into smaller elements or modules (Sako, 2005). Simon (1962, p.468), suggests that in the hierarchic formal organization, each system consists of a set of subsystems (modules), as *"A system that is composed of interrelated subsystems, each of the latter being, in turn, hierarchic in structure until we reach some lowest level of elementary subsystem (fine-grained modularity)"*. In the context of the modular organization, the modular or hierarchical characteristics can be observed within the boundary of an organization and often beyond the boundary of an organization as well. In fact, due to the prevalence of modularity and outsourcing, the boundaries of the organization are becoming obscure and are often redrawn (Sako, 2010). Many scholars suggest that modular organization structure may enhance the opportunity to outsource with ease (e.g., Anand & Daft, 2007; Wu & Park, 2009). Schilling and Steensma (2001, p. 1149) state that,

> "The loosely coupled organizational forms allow organizational components to be flexibly recombined into a variety of configurations, much as a modular product system enables multiple end-product configurations from a given set of components. Common examples occur in the computer and apparel industries, where leaders such as Microsoft, Dell Computers, and Reebok have demonstrated the advantages of gaining access to necessary organizational components through strategic alliances and outsourcing".

Organizational modularity refers to an organizational architecture which allows splitting and recombining parts of the organization to work in a more efficient and agile way. The key lies in the ability to identify efficient and inefficient modules among non-core activities. Efficient modules can be retained in-house and inefficient modules may be considered for outsourcing. Network modularity refers to modularity in relation to the organization's external environment, such as the position of the boundaries of the organization (i.e., make, buy/ally decisions) and the outsourcing networks. Some scholars suggest that modularity in product design leads to modularity in organization design (e.g., Sanchez & Mahoney, 1996). Consequently, it is reasonable to assume that if modularity in product design results in modularity in organization design, then modularity in organization design may contribute to modularity in outsourcing, as outsourcing involves a working relationship between two or more organizations. Campagnolo and Camuffo (2010, p.277) also argued this reasoning by stating that

> "Some of the literature assumes that a relation between product modularity and the outsourcing of modules' production does exist. However, the direction of such a relation is not yet clear: does product modularity determine outsourcing of modules' production, or does outsourcing affect product modularity?"

Moreover, Schilling and Steensma (2001) argue that due to the prevalence of outsourcing among organizations, the organizational structures are becoming increasingly modular and suggest that the firms use three primary ways to establish loose coupling; these are: '*contract manufacturing*' (outsourcing), '*alternative work arrangements*', and '*alliances*'. Many large firms were able to achieve agility and flexibility by splitting their production and business processes, which were subsequently, outsourced to external partners (e.g., Boeing, Toyota, Daimler-Benz, etc.). This integrated strategy of combining modular architecture and outsourcing provided them with a competitive advantage. Moreover, certain scholars contend that outsourcing contract procedures may also be considered modular (e.g., Blair, O'Connor, & Kirchhoefer, 2011; Miguel, 2005). Analyzing seven outsourcing contracts (6 from IT projects and 1 from manufacturing project) in a law firm in the U.S., evidence emerges that all these contracts have modular structures with features designed to reduce interdependencies and mechanisms applied for managing the interface (Blair, O'Connor, & Kirchhoefer, 2011). Miguel (2005, p. 168) asserts that *"Modularity in organization relates to the organizational process, governance structures, and contracting procedures that are adopted or utilized to accommodate modular production at both the intra-firm and inter-firm context"*.

A modular architecture can be described as *"a predefined set of prescriptive rules which all modules of the system need to adhere to"* (Huysmans et al., 2014, p. 4418). As it has been observed that the phenomena of modular architecture are not only limited to the products, production systems, and organizations, but increasingly widening its horizon as it has been observed in outsourcing and in SLA's. Campagnolo and Camuffo (2010, p. 276) assert that *"Organizational design modularity is a relatively new stream of literature" (p. 273*), and they further argue that,*"[….] Modularity in the organizational design context is still seeking its theoretical identity and requires further theoretical and empirical work on organizational design modularity definition, methods and measures"*.

Recently, Colfer and Baldwin (2016) conducted a descriptive study covering varied industries applying the *'mirroring hypothesis'*. The mirroring hypothesis refers to the organizational patterns of a development project, such as communication links, geographic collocation, and team and firm membership, correspond to the technical patterns of dependency in the system under development. The findings suggest that the modular systems with a reduced level of interdependencies are more likely to be outsourced. Similarly, the findings of MacDuffie (2013) suggest that in the automotive industry, the managers tend to outsource those activities for which they have gained enough knowledge through experiences about the interdependencies and about specifying the interfaces.

Modularity as a Design Parameter

Modularity is a concept from systems theory that has been used in several domains. A common theme underlying the concept of modularity in each of these domains is to manage complexity, and enhance agility and flexibility (Sanchez & Mahoney, 1996; Baldwin & Clark, 2000). The idea behind modularity is that a system should be composed in such a manner that all components are loosely coupled. To this end, system elements that must intensively interact with each other should be isolated in a separate module to ensure that changes to this module do not have an influence on the rest of the system. Communication between modules is managed by well-defined interfaces. Modularity, according to Baldwin and Clark (2000), is a design structure, where tasks and parameters are independent between but interdependent within them. The process of modularization entails the division of the design parameters into the parameters of modules, which are manifested as a design rules.

More recently, modularity has also been used with respect to the design of organizations (Tiwana, 2008; Campagnolo & Camuffo, 2010; Sanchez & Mahoney, 1996; te Winkel et al., 2008). This research area investigates how organizations can be constructed using loosely coupled autonomous organizational units that allow organizations to adapt more quickly to changing environments (Sanchez & Mahoney, 1996; te Winkel et al., 2008). Many scholars agree with the idea that a modular organizational structure is composed of autonomous and loosely coupled organizational units (e.g., Campagnolo & Camuffo, 2010; Schilling & Steensma, 2001). Baldwin and Clark (1997) assert that in order to compete in a modular world, frequent redesigning of the internal organization is necessary. Modularity, a cornerstone of organizational design, pertains to the decomposability of tasks within an organization into subtasks with internal interdependence and external independence. (Khodzimatov et. al., 2024). Modularity provides the basis for customization; it yields economies of scale and scope and can be designed in a way that facilitates outsourcing (Voss & Hsuan, 2009).

Knowledge as a Design Parameter

In large organizations, there is an increasing trend towards the outsourcing of IT. There are numerous legitimate explanations for this phenomenon, including the scarcity of skilled domestic labor, the decreasing cost of offshore developers, and the trend toward modular enterprise architecture, which enables outsourcing. However, if all IT-related activities are outsourced, this also means that valuable knowledge leaves the organization, and the absorptive and innovative capacity of the organization decreases. The informants of two Belgian cases have reported that few medium and large organizations in Belgium have between one and three experts in IT and enterprise architecture. It is evident this situation significantly limits the ability of the organization to develop a competitive advantage by leveraging the advantage of IT. In addition, the organization is at a significant risk in the event that this expert departs. In

both scenarios, Organizations either lose their current IT and enterprise architecture knowledge or, at the most, acquire minimal knowledge. The knowledge of adoption and integration of IT systems is vital in order to get advantages from standard services to be delivered cheaply and quickly (Voss & Hsuan, 2009).
IT is becoming increasingly important to support organizations in establishing a competitive advantage, ensuring their sustainability, and fostering innovation (Brynjolfsson & Saunders, 2010). This implies that in order to attain the aforementioned objectives, organizations should endeavor to adopt new IT skills that may present new opportunities. However, it has been shown that the adoption of IT is frequently knowledge-intensive (Sanchez & Mahoney, 2013). In order to adopt knowledge-intensive IT, organizations must engage in a process of organizational learning (Sanchez & Mahoney, 2013). Organizations that posses a greater absorptive capacity will be able to advance more rapidly through the learning process, thereby enabling them to respond more promptly to the VUCA environment. Nevertheless, the two scenarios described above in relation to Belgian organizations imply that the organizations have a low absorptive capacity. This considerably limits their ability to identify, assimilate and exploit emerging technologies and opportunities that becomes available on the market (Wheeler, 2002; Cohen & Levinthal, 1990). Hence, organizations with little internal IT and enterprise architecture knowledge are in this respect rather limited in their ability in establishing a competitive advantage, ensuring their sustainability, and fostering innovation. Consequently, they generally adopt a more reactive approach to new technology, relying on the expertise of service providers rather than proactively exploring the opportunities and potential benefits of new technology. It implies that organizations should prioritize learning from their service provider rather than receiving black-box IT solutions. Such alternative outsourcing models include co-sourcing alliances and transaction exchanges. In comparison to conventional outsourcing arrangements, the literature indicates that the aforementioned alternative outsourcing models have a higher success rate. Nevertheless, the customer organization must possess a higher level of maturity in its modular IT and enterprise architecture (Ross & Beath, 2006). This serves to emphasize that modularity and knowledge are equally critical design parameters that should be taken into account concurrently when designing enterprise architecture.

Theoretical Frameworks

The concept of modularity as a theoretical lens, has been employed in analyzing four cases. Modularity is a concept from systems theory that has already been applied successfully in several domains. A common theme underlying the concept of modularity in each of these domains is managing complexity, achieving agility and flexibility that may lead to competitive advantage (Baldwin & Clark, 2000, Schilling, 2000, Simon, 1962). The rationale behind the application of the modularity lens was triggered by the literature's reports on the high failure rates of IT outsourcing projects. Considering the potential correlation between complexities, modularity, agility, knowledge, competitive advantage, and IT project outsourcing, as well as insights from the literature, the authors regarded the concept of modularity as an ideal theoretical lens. Moreover, research on Normalized Systems, which has shown predominantly at the software level, that the evolvability of modular architecture is limited by a form of coupling called combinatorial effects, which affect not only evolution but many aspects of development of modular structures as well. For instance, some modularity aspects such as 'interface', 'encapsulation' or 'information hiding', 'separation of concerns', and loose coupling, etc., are widely used in IT projects. IT project outsourcing typically entails the collaboration of two or more organizations focusing on the development of software, business applications, and the management of the IT system. The success of such IT projects is contingent upon the mastery enterprise architecture and enterprise engineering.

The idea behind modularity is that a system should be composed in such a manner that all components are loosely coupled. To this end, system elements that must intensively interact with each other should be isolated in a separate module to ensure that changes to this module do not have an influence on other modules in the system. Communication between these modules is managed by well-defined interfaces (Benazeer, Verelst, & Huysmans 2023). The concept of modularity has been used in a variety of disciplines including Information Systems, Management and Organization Sciences, Engineering, Product Design, Production Systems, Psychology, Biology, and Mathematics (Schilling, 2000). Campagnolo and Camuffo (2010) provide a management literature overview which shows increasing attention to modularity in the organizational context. They confirmed research interest in organizational modularity by identifying a large number of publications concerning not only product modularity, but also modularity in production systems and the organizational structure itself. The following section offers a concise summary of the cases that were examined.

An Overview of the Analyzed Cases

In this paper, four IS/IT project outsourcing cases have been analyzed in order to investigate how modularity can be applied to IT outsourcing. The first two cases are international IT outsourcing cases, which have been documented extensively and have been re-analyzed in this study based on secondary data. Additionally, two Belgian IT cases have been analyzed in this study, based on primary data.

The first case concerns the BskyB vs. EDS outsourcing project. This case was of significant scale and complexity and ended in failure. The subsequent court case ended in 2010 and provided an exceptional amount of documentation. The re-analyses and results of this case study have been presented at the "*47th Hawaii International Conference on System Sciences"* (Huysmans et al., 2014) and a further elaborated analysis has been published in the "*International Journal of IT/Business Alignment and Governance"* (Huysmans et al.,2014).

The second case concerns an IT outsourcing project in a public university in a developing country in Asia. In this case, the vendor is as referred to as '*Aries'* and the customer is referred to as '*Taurus*' (fictitious names have been used in order to guarantee anonymity and confidentiality). '*Aries'* was a very competent and well-reputed provider as it was one of the leading independent companies working as a business unit of a large and reputed international company. '*Taurus'* was a big public-sector university in a developing country. The IT project was to create a web-based portal for academic records management. This IT outsourcing project was small in budget and scope, simple and not complex. Nevertheless, also this project encountered significant issues and ended in failure. The findings from the re-analysis have been published as a book chapter in the "*Encyclopedia of Information Science and Technology"* (Benazeer et al., 2018).

In addition to the re-analysis of the first two cases, two additional case studies in Belgium have been conducted using primary data source. The third case focuses on one of the biggest service companies in its sector in Belgium, which is involved in a single-vendor IT outsourcing project. This IT outsourcing project has been selected due to the special nature of outsourcing deal. The outsourcing deal was about 'total outsourcing' which two decades earlier used to be a mainstream outsourcing strategy. The selected case deals with a vendor organization (supplier) referred to as *'Alpha'*, and a customer organization (client) referred to as '*Omega*' (fictitious names have been used in order to guarantee anonymity and confidentiality). '*Alpha*' was regarded as a competent service provider. This IT outsourcing project serves as an exemplary *illustration* of the significant role that a modularization strategy can play in the management of complexity, the reduction of risks, and the enhancing of agility and flexibility.

Finally, the fourth case concerns a Belgian financial institution. The case organization concerns a Belgian banking organization (further referred to as *'AB bank'*, a fictitious name in order to guarantee anonymity and confidentiality). '*AB bank'* focuses on private banking activities, implying that compared to traditional retail bankers; their customer base is smaller but wealthier. Further, the bank's activities include asset management and merchant banking services. Within the Belgian financial services industry, the organization can be considered as medium-sized in terms of the number of employees, number of clients, turnover, etc. While being a private bank in its core, the bank also welcomes investment clients with smaller budgets which can be served via an online investment portal. The IT department of *'AB Bank'* was struggling with systems integration due to multi-vendor IT practice. The informant identifies systems integration as a challenge he was dealing with. Through the lens of modularity, this study aims to gain further insights into the management of multi-vendor IT outsourcing by '*AB Bank'* and the reasons behind the challenging integration issue. The analysis of this case has been presented at the "*Enterprise and organizational Modeling and Simulation" (EOMAS 2017)*-conference and later published in the *"Lecture Notes in Business Information processing: Enterprise and Organizational Modeling and Simulation"* (Benazeer, De Bruyn & Verelst, 2017).

Findings

Table 1 provides a graphic summary of the results of the four cases that were analyzed implying that the instances of modularity have been identified in each case. Modularity has been devised in three categories for the purpose of these four cases, namely, *"organizational modularity"*, *"technical modularity"*, and *"modularity in documents"*. However, this paper will exclusively investigate organizational modularity, and the other two categories will be disregarded as they are irrelevant in the context of this paper.

The first column in Table 1 illustrates the presence of "coupling", an important aspect of modularity, in all four cases. Coupling can develop in many forms and its presence in some modularity aspects, such as, in interface or SLA (service level agreement), modular architecture or modular system, etc. may impacts negatively the performance and the outcome of an IT project. The last four columns in table 1, illustrates the coupling issue found in different aspects (displayed in brackets) of modular systems (displayed in uppercase letters). The modularity literature suggests that within a system modular architecture can be studied at different levels. The identity of any unit as a modular system is not fixed. This identity is determined by the level of analysis chosen within a system (Schilling, 2000; Simon, 1962). If an industry is considered as a system, then an organization can be considered as a module of that system (industry). In the same way, when an organization is perceived as a system, various departments (e.g., production, marketing, human resources, etc.) can be regarded as modules.

A comprehensive list of the primary modularity aspects, including "interface", "encapsulation" or "information hiding", "separation of concerns", "cohesion", "dependencies", "modular architecture" or "modular system", "design rules", "standards", and "low or loose coupling", is provided in the literature (e.g., Benazeer, 2018). These aspects are frequently employed in IT projects. Moreover, Baldwin and Clark (2000) proposed six "modular operators" to accommodate changes that can be applied in a modular system as part of a domain-independent theoretical framework on modularity. These are: *splitting, substituting, augmenting, excluding, inverting, and porting*. A brief description provided below regarding coupling in a modular system.

INSTANCES OF MODULARITY	CASE 1	CASE 2	CASE 3	CASE 4
ORGANIZATIONAL MODULARITY (Coupling)	PROJECT TEAM COMPOSITION (High cohesion)	OUTSOURCING COLLABORATION (Interface/SLA) BUSINESS PROCESS (Design rule) PROJECT TEAM COMPOSITION (Modular operator "substitution")	OUTSOURCING COLLABORATION (Interface/SLA) HIGHLY SKILLED IS/IT TEAM (Modular operator "substitution")	OUTSOURCING COLLABORATION (Interface/SLA)
TECHNICAL MODULARITY (Coupling)	IS/IT APPLICATION PORTFOLIO (Interface - separation of concerns) SYSTEMS INTEGRATION (Modular architecture)		IS/IT SYSTEMS (Low coupling)	IS/IT APPLICATION PORTFOLIO (Interface - high cohesion)
MODULARITY IN DOCUMENTS				INTERFACE/SLA (Modular architecture)

Table 1. Identified instances of modularity in IT project outsourcing cases.
Modular systems are displayed in uppercase letters. Modularity aspects are displayed in brackets

Coupling

Coupling is a measure of the dependencies between modules (van der Linden, Mannaert, & De Bruyn, 2012), in other words, coupling refers to the degree of connection, relationship, and dependencies between modules. Due to interdependence structure, good modular systems are frequently classified as low or loosely coupled systems (Levinthal, 1997; Orton & Weick, 1990; Schilling, 2000).

Example

Figure 1 illustrates two different scenarios. The architectural design on the left-hand side exhibits high or tight coupling between modules (A, B, C, D, and E). For example, a major change to module 'E' might have an impact on all other modules (A, B, C, D) as module 'E' is coupled to all of them. Conversely, the architectural design on the right-hand side exhibits low or loose coupling between modules (A, B, C, D, and E). Introducing a similar change to module 'E' might impact module 'B' only, but not the other modules (A, C and D). The subsequent section provides detailed descriptions of the identified instances of organizational modularity.

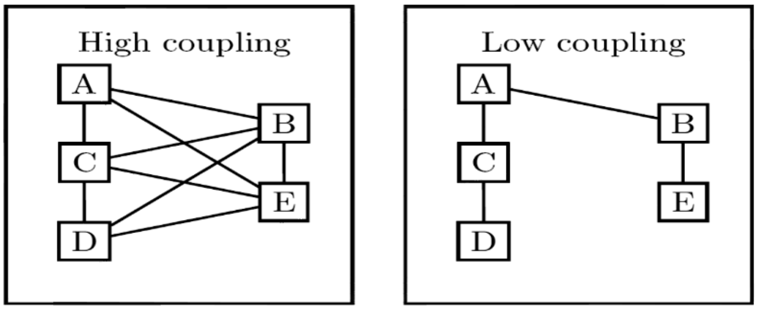

Figure 1. Coupling in a modular architecture.

Identified Instances of Organizational Modularity

The term '*organizational modularity'* refers to the application of modularity not to technical artefacts, but to artefacts like organization structures, departments, projects, teams and others. In this context, an IT outsourcing project can be considered as a modular structure consisting of two (or more) organizations, i.e., the vendor and customer organization, transferring a number of responsibilities for IT-systems under a collaboration defined in an SLA. The SLA can then, in terms of modularity, be considered as the interface of the modules. An interface is one of the most important aspects of the concept of modularity which describes how different modules can interact. Interfaces in services can include people, information, and rules governing the flow of information (Voss & Hsuan, 2009). At the industry level, these interfaces often consist of regulatory frameworks, rules, standards, and technical specifications that allow different players to connect (Jacobides, Knudsen, & Augier, 2006). Even though the importance of an SLA is universally recognized in the literature, the point of view of modularity taken in this study resulted in interesting observations. In cases 2, 3 and 4, issues with incompleteness of the SLA were observed. Moreover, cases 1, 2 and 3 provide instances or examples in these areas, which can be related to modularity and to theories, design principles, and success factors. Following is a brief description of a few examples of identified "instances of organizational modularity" in the cases.

Case 1

In case 1, the role of bid manager was implemented as an interface, with the bid manager relying on underlying workstreams for specialized knowledge needed for decision making. However, this setup of the team, interpreted as a modular structure, and the role of the bid manager required appropriate communication between the bid manager and the workstreams. Regrettably, the communication structures to operationalize the collaboration with these workstreams were not in place, leading to the bid manager providing inaccurate estimates on the IT outsourcing project. Consequently, the London technology and construction court interpreted this as an attempt to deceive the client with malicious intent.

Therefore, it can be concluded that the role of bid manager was not fulfilled as an adequate interface. Rather, the bid manager communicated based on his own (insufficient) knowledge concerning technological matters. The bid manager stated that:

“I certainly did not feel we had a risk here” (High Court of Justice, 2010, para. 1021).

Hence, in case 1, the “instance of organizational modularity” is identified, as it has been demonstrated that a poor modular architecture was in place due to the implementation of a modular design with low cohesion or the reliance on a dysfunctional interface.

Case 2

In case 2, the significance of the knowledge parameter was evident in its direct correlation with the project’s success. The modular architecture of the project’s focal team was subjected to three changes in its composition over the duration of the project. Interestingly, these personnel changes in the project’s focal team led to frequent requirements changes. As requirements can be considered a form of knowledge, these changes in requirements demonstrate a correlation between the modularity parameter and the knowledge parameter because the embedded knowledge of the team members was crucial to the success of this IT project.

In case 2, the first “instance of organizational modularity” is identified through the incompleteness in the SLA, which led to additional financial claims by the vendor organization. The following excerpt shows that the SLA was poorly defined and contained hidden or undefined dependencies.

> “Head of Department of Computer Science started to lead the team to implement the project. However, the project implementation came to a standstill when the client organization desired deputation of full-time experts by the vendor organization to supervise the implementation which included training of the end users to use the system and subsequently adopt it. Vendor expressed their inability to depute an expert without charging a further expenditure to the customer” (Nauman, Aziz, & Ishaq, 2009, p.271).

A second “instance of organizational modularity” in this case is identified through the lack of standardization in business processes and/or operating procedures in the customer organization (lack of design rules in terms of modularity). The project’s failure was attributed to the weaknesses in the design rules. Nauman, Aziz, & Ishaq (2009) also diagnosed ‘*Taurus’* organizational processes to be inadequate to embrace automation and needed re-engineering. The project was delayed due to different operating procedures adopted by different departments for the same task. For instance, following excerpts indicate that the ‘*Taurus’* organization failed to select a design rule from a range of alternative design options.

> “The pattern [i.e., the structure] of student registration numbers varied in different departments. Such anomalies caused some requirements changes, even at the later phases, and delayed the implementation” (Nauman, Aziz, & Ishaq, 2009, p. 271).

Additionally, a third “instance of organizational modularity” is identified in this case through Baldwin and Clark’s (2000) modular operator “*substituting*”. Whenever another version of the *‘focal team of Taurus’* was put in place, already established agreements between both parties (i.e., requirements specification was developed and agreed upon by the customer and the vendor) tended to change. Substituting sub-module *‘focal team of Taurus’* with newer versions was negatively affecting the efficiency of the project which can be observed by the following excerpts:

> “Changes at the organizational level [….] led to some new requirements emerging from nowhere and caused frequent changes in the old requirements [….]”(Nauman, Aziz, & Ishaq, 2009, p. 270).

The above excerpt illustrates that applying the modular operator *‘substitution’* resulted in significant problems to the project. Whereas following modularity literature suggests that there should be no problem. Baldwin and Clark (2000, p. 262) suggest that

> “The substitution operator allows a designer (or user) to swap one module of the system for a better version of the same module”. Furthermore, Terlouw (2011, p. viii) asserts that “the modular operators are the actions that may change existing structures in a well-defined way in order to enhance the efficiency of the system”.

Case 3

Case 3 provided the most explicit illustration of the correlation between modularity parameter and knowledge parameter. In case 3, on a '*total IT outsourcing*' (complete hiving-off) by a Belgian service organization, the replacement of formerly in-house IT staff by new hiring's, led to a loss of knowledge.

In case 3, a team of in-house IT staff assigned to the project is interpreted as a module in a modular architecture. A loss of technical knowledge regarding the intricate IT systems utilized in the project resulted from the replacement of former IT personnel with new hires. Change of people or a team is a recurring event in many IT outsourcing projects. There is a potential concern that the vendor organizations place their highly skilled people at the frontline during the negotiation or at the start of the project. Later, they can potentially replace those highly skilled people by less experienced and low skilled people. This could happen for two reasons: firstly, as those highly skilled people are few in numbers, so the vendor organization needs to assign them again at the frontline to get another new project. Secondly, less experienced and low skilled people are cost effective. In this case, as a part of the outsourcing deal, almost all of the highly skilled people of customer organization *'Omega'* were transferred to the vendor organization *'Alpha'* with job guarantees for a certain period. As a consequence, the customer organization was frequently compelled to request additional services from the vendor organization. This action prompted the vendor organization to claim additional fees.

Therefore, in the emerging situation in customer organization *'Omega'*, which is hollow in terms of knowledge, two "instances of organization modularity" have been identified. The first "instance of organizational modularity" has been identified through the incompleteness or flaws in the SLA. Incongruent with modularity, the SLA contained "hidden dependencies" as the customer organization asking for supposedly additional services from the vendor organization which led to additional financial claims. Moreover, certain executives from the customer organization were required to frequently visit the site of the vendor organization in order to resolve uncertainties regarding the priorities and to expedite the setup of the project.

A second "instance of organizational modularity" has been identified through Baldwin and Clark's (2000) modular operator "*substituting*" because the replacement of formerly in-house IT staff by new hiring's led to the negative impacts on the project's performance. Baldwin and Clark (2000, p. 262) suggest that *"The substitution operator allows a designer (or user) to swap one module of the system for a better version of the same module"*. Furthermore, Terlouw (2011, p. viii) asserts that *"the modular operators are the actions that may change existing structures in a well-defined way in order to enhance the efficiency of the system"*. The substitution modular operator can be applied successfully and relatively easily if all module versions adhere to the same interface and no undocumented or hidden inter-modular dependencies are present.

Case 4

In case 4, on '*selective IT outsourcing*' (partial) by a Belgian financial institution, the outsourcing agreement was seen to be based mostly on values like professionalism and trust, whereas the SLA was considered mainly a legal necessity. The "instance of organizational modularity" has been identified through the incompleteness of the SLA, which resulted in disagreements regarding which services are included in the contract and which are not. It is evident from the following excerpts that the description embedded within the SLA was by no means exhaustive, explicit, unambiguous, and well defined which modularity recommends.

> "(For instance) when we see a problem in a particular process and ask 'S' (pseudonym of a vendor)'why is this problem not noticed by you?', the answer given was that they were not monitoring the process. We suggest the 'S' people that being a professional you should have monitored that problem. The 'S' people will reply that they have not been asked (by the SLA of'AB Bank') to monitor that problem. [….] Both parties have done what is stated in the contract. Yes, but was that enough? No, probably not. It is not stated in the contract that we should make the design as to how the architecture (of the application) should look like and define it. But we expect them to operate the platform that runs the application*"*.

Reflection

The issues with incompleteness in the SLA's and lack of standardization in business processes are not new. In general, many sources stress the importance of completeness of an SLA and the advantages of standardization. Nevertheless, it is intriguing that these recommendations can be associated with 'technical' or 'systems theoretic concept, such as modularity, which mandates that interfaces should not contain hidden dependencies, thereby implying completeness. The fact that the insights based on modularity correlate with insights from other sources, constitutes an indication of the relevance of the role of modularity in the context of enterprise engineering and enterprise architecture. Organizational modularity can also be relevant to a variety of issues related to team composition and people, such as communication and knowledge issues, which are perhaps less apparent than the forms of organizational modularity described above. The team's composition can be interpreted and explained in terms of modular structures as well (Huysmans et al., 2014). Furthermore, Terlouw (2011, p. viii) states that, *"modules can comprise humans and/or software systems"*. Dietz (2006, p. 81) proposed a method to identify modular actor role structures and thereby asserts that *"an enterprise is constituted by the activities of actor roles, which are elementary chunks of authority and responsibility, fulfilled by subjects"*.

Although it is not new that knowledge of specific employees and teams play important roles in IT outsourcing projects. Nevertheless, the correlation between modularity, agility, outsourcing, knowledge, and competitive advantage is intriguing in numerous aspects. A first observation is that the importance of keeping certain knowledge at the customer organization (including on requirements and quality assurance) is generally recognized in literature and practice. However, modularity explains why this may be difficult to achieve in practice. More specifically, considering that the SLA constitutes an interface which hides the complexity of the IT outsourcing project at the vendor's side, this implies a loss of knowledge at the client's side. The highly-qualified employees that the customer organization is attempting to persuade to remain may find this unappealing, as they may be drawn to complex environments that test their abilities. Additionally, it is worth noting that the role of teams and knowledge, as evidenced by the cases, correlates with modularity.

More specifically, recently, there has been considerable optimism in the software engineering world that recent technological advances such as service-oriented architectures and micro-services have resulted in 'plug-and-play' like IT landscapes in enterprises. This rather unproblematic view of software engineering can be complemented by a view of traditional project management which considers employees as homogeneous resources which can be quantitatively aggregated in (large) teams. The issues observed in the analyzed cases seem to support another point of view. Rather, the knowledge issues observed in the analyzed cases indicate that the IT outsourcing projects are considerably complex, as they necessitate specific knowledge and skills that are associated with a specific group of people. This is evident in the fact that some cases report issues when certain peoples were replaced by others. This correlates with insights on Normalized Systems, in the sense that this research points at the existence of combinatorial effects in current IT architectures causing complexity and limited evolvability. From this point of view, it is not surprising that links exist between modularity and knowledge of specific teams of employees. The subsequent section will present a conceptual theoretical framework that has been gleaned from the analyses of four cases.

The Proposed Theoretical and Conceptual Framework

The literature argues that knowledge plays a key role in order to modularize a system as knowledge about interdependencies is crucial in designing such a system (Tee, 2009). For instance, in-depth knowledge about interdependencies among design parameters of different modules is a requirement in order to map the design structure matrix (DSM). But the requirement of specialized knowledge is significantly reduced once a modular system is perfectly designed and transformed as a *'black box'*. Nevertheless, even in a situation where everything is functioning well, customer organizations always need to keep some people possessing architectural and system integration knowledge in order to increase the ability to more precisely spell out contract terms and to effectively monitor and supervise vendors and at the same time increasing their relative bargaining power (Tiwana & Bush, 2007).

Findings from many empirical studies suggest that despite prevalence of IT project outsourcing, the failure rate is high (Delens et al., 2016; Schmidt, Zoller, & Rosenkranz, 2016; Hastie & Wojewoda, 2015). Premature contract terminations and frequent dissatisfaction with IT outsourcing results are commonly encountered. The high failure rate in IT project outsourcing supports the assertion made by

Mannaert, Verelst, and De Bruyn (2016) that majority of currently in use modular systems exhibit only limited evolvability and are therefore neither truly modular nor reversible.

Moreover, it is imperative to leverage the knowledge of skilled IT professionals in order to successfully and cost-effectively reverse the project (i.e., back-sourcing or switching vendors), given the significantly higher failure rate in IT project outsourcing. The term 'reversible' or 'back-sourcing' denotes the possibility of a customer organization (in any unanticipated situation), to transfer back the operations in-house from the vendor. Sako (2005) argues that in a '*pure modular*' project, interfaces are standardized and the project is reversible. Hence, a truly modular outsourcing practice is conceived as being reversible has the potential to enhance flexibility, agility, and competitive advantage (Cohen & Young, 2006). Figure 2 presents a theoretical and conceptual framework that has been gleaned from the findings of the four cases that were examined. This framework may serve as a fundamental guideline in designing enterprise architecture that may yield enhanced level of agility and competitive advantage through the use of modularity and outsourcing. The framework posits that it is indispensable for any contemporary organization to possess in-house, the architectural and the system integration knowledge of IT systems in order to gain competitive advantages from modularization and outsourcing. An organization with in-house knowledge and expertise is capable of designing the IT systems in a modular way (i.e., respecting the rules prescribed by the concept of modularity). Once the entire IT system is modularized in fine-grained modules (as smaller modules as possible), this gives greater agility and flexibility to the customer organization either to keep some or all the modules in-house or outsource to a single or multiple vendor. Moreover, if a vendor fails to deliver as promised, back-sourcing can be done with ease. Smooth, successful and painless reversibility is only possible when a customer organization possesses some skilled people with architectural and integration knowledge. Otherwise, the customer organization will have to face the same situation as *'Omega'* (case 3) and will find itself to a certain degree in a *'vendor lock-in'* situation.

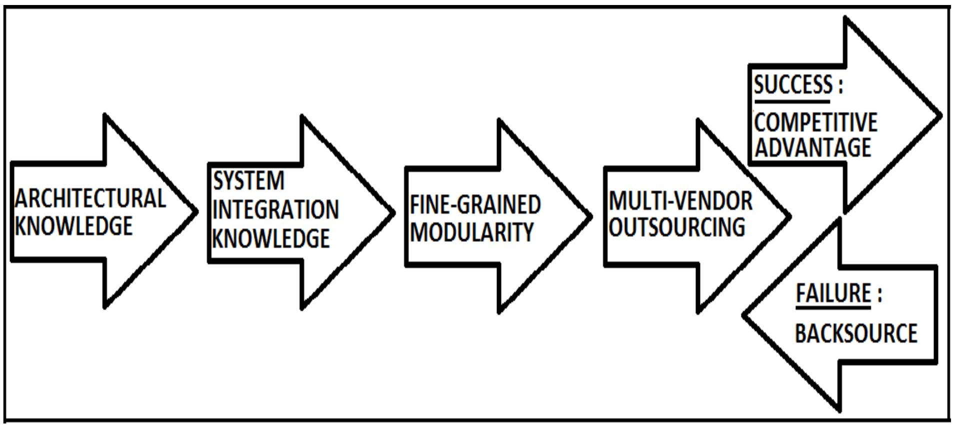

Figure 2. A theoretical framework proposed by the authors in the context of enterprise architecture.

In the context of these cases, it can also be argued that by possessing in-house architectural and integration knowledge, an organization is able to achieve a higher level of absorptive capacity as well (Benazeer et al., 2012). One of the main motivations of IT project outsourcing is to concentrate more on the core competency and outsource the noncore activities. But by outsourcing the noncore activities, organizations intend to forget those activities and anticipate that those noncore activities should work as '*black box*' or *'plug and play'* with minimum interventions. When a system is commoditized as a result of good modular architecture, a few skilled people are required to run or maintain it. Moreover, it is possible to avoid the risk of *'vendor lock-in'* when a system is commoditized, and it gives greater agility and flexibility in choosing or switching vendors. Otherwise when the system is like '*usine à gaz*' (The informant in case 3 employed this term to characterize the IT systems of his organization), or a *'white box'*, the organization becomes dependent on skilled peoples to run or maintain it. This implies the correlation underlying between the concept of modularity, agility, knowledge, outsourcing, and competitive advantage. For instance, in case 3, the main purpose of IT project outsourcing was to reduce cost. But in order to provide services at low cost, the vendor *'Alpha'* needs to replace knowledgeable (who had good knowledge about the system in use) and expensive people who were inherited from the customer organization '*Omega*'. As the system was not commoditized, remained as '*usine à gaz*', replacing those knowledgeable and expensive people was not possible. Since '*Alpha*' (vendor) replaced those highly skilled people by under-qualified persons, everything went wrong. Following the reasoning from the modularity point of view, in this case, there was a contradiction in the initial setup. The goal is to cut cost which is directly associated with commoditization, but this was never possible in the first place because the underline products/services were not commoditized. The following excerpts from the informant confirm this assertion:

"Although the purpose was cost reduction but at the end, it is becoming very expensive".

As many skilled people left the new organization ('*Alpha'*) after transferring from '*Omega*', the organization '*Omega*' became an empty company in terms of knowledge. In this emerging situation organization, '*Omega*' finds itself in a *'vendor lock-in'* scenario where reversibility or back-sourcing was no more possible. The following excerpts from the informant confirm this assessment:

"We cannot do a rollback (vendor lock-in)".

Conclusion

In this paper, a comprehensive framework has been developed that integrates the results from the analyzed cases and that provides a better understanding of the various correlations between modularity, agility, knowledge, outsourcing, and competitive advantage (Figure 2). This framework provides one possible explanation for the conflicting evidence with respect to the impact of modularity on competitive advantage. Outsourcing may have a detrimental impact on the organization's knowledge base, despite the apparent positive correlation between modularity and outsourcing. A suboptimal enterprise architecture design may have a detrimental effect on the agility of the organization and its ability to innovate and endure. The extent of negative or positive impact on the competitive advantage is contingent upon the design parameters of enterprise architecture that has been implemented, outsourcing strategy that has been adapted, and the retention of knowledge sources. Hence, organizations should take into account both negative and positive impacts when designing enterprise architecture as outsourcing may become necessary at some point in the future. Both modularity and knowledge are therefore important design parameters. Organizations should strive for an optimal strategic decision that accommodates changes in their parameters, thereby enhancing agility and competitive advantage. Evidently, some trade-off will have to be made with respect to both parameters. This study provides a theoretically sound framework that illustrates the correlations between various parameters and elucidates the mechanism by which such evaluation can be conducted in the context of outsourcing. It is noteworthy that the proposed framework does not intend to assign a priority to modularity and knowledge, or agility and outsourcing. Instead, organizations should determine the significance of these parameters in accordance with their strategy and the specific context in which they operate. Based on the goals of the organization, they should find a balance between the design parameters of modularity and knowledge in order to enhance agility and competitive advantage through outsourcing.

Findings from this study have important practical implications. It is commonly known that European organizations are, on average, smaller than US organizations. Eurostat statistics (2022) show that 99% of European organizations have less than 50 employees (upto 49 employees); medium-sized enterprises (50-249 persons employed) represented 0.8% of all enterprises while large enterprises (more than 249 persons employed) represented only 0.2% of the total number of enterprises. The informants in Belgian organizations (Cases 3 and 4) stated that majority of these organizations lack an internal knowledgeable skilled professional, with the exception of a single individual who is responsible for making IT-related decisions. As a result, all activities related to IT are outsourced to a service provider or vendor. In the absence of internal resources, this service provider will establish an IT architecture for the customer organization and will continue to maintain it, without any knowledge transfer between the two organizations.

Hence, the customer organization does not learn about the opportunities IT could offer to the organization, and its ability to innovate with IT remains limited. Traditionally, literature has suggested a positive link between organization size and innovation, due to the fact that large organizations have more resources that can be used to innovate (Rogers, 2003). However, it has also been argued that smaller organizations may be more agile and better able to react to changes in the environment (te Winkel et al., 2008). When organizations grow, they may adopt a bureaucratic organizational structure. This structure may slow down their ability to change, or even kill innovative ideas that arise within the organization and that are not in line with the strategy of the organization.

This paper concludes by asserting that the findings of this study have substantiated the notion that engineering concepts, including modularity and the proposed framework can be applied with significant relevance to research domains that are predominantly viewed from an IT management-perspective. Perhaps the implementation of the same concept, modularity, at the enterprise engineering, enterprise architecture, and management levels will establish a shared vocabulary and potentially lead to improved alignment between the these fields of study. This would constitute a contribution to the new and emerging research area focusing on applying engineering concepts to the design of enterprises, coined Enterprise Engineering.

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