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REINVENTING THE HOSPITAL – A STUDY OF LOST SYNERGIES IN DANISH HEALTHCARE

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ABSTRACT

The purpose of this study is to identify the effects of inter organizational relationships in construction projects by investigating how complexities are manifested in variance and repetitions across projects. The case is a set of 27 hospital projects in Denmark including new buildings as well as extensions of existing hospitals. The key empirical material consists of detailed drawings of each of the projects along with information of the participating organizations. The implications of the inter organizational relationships is studied thorough a theoretical framework of modularity by looking for variance and repetition. The analysis shows that the projects are designed for each specific location (region) with unsystematic and limited use of processual, organizational and technical repetitions. Overall, the projects are executed in parallel and follow the same phases with a high degree of user involvement in each of the projects; here inputs are gathered for the specific project that subsequently is designed by a unique team of architects and consultants. Although some of the participating companies are involved in several projects (especially as the client consultant), there is a high degree of variance in the project teams. Despite the variance of the project teams the overall and detailed design of the hospitals look remarkably the same. However, a detailed analysis of the patient rooms reveals that although 70% of the projects use the same architype (the L-type) they are different from each project. This lead us to the conclusion that the hospital is reinvented in each project leaving behind unrealized potential for leveraging similarity across the projects. This could have been achieved by a stronger central coordination, thinking of super hospitals as programs and portfolios rather than individual projects.

KEYWORDS: Hospital construction, interdependencies in project network, modularity, complexity, standard solutions.

BACKGROUND

The completion of any task requiring more than a single individual introduces interdependencies (Chinowsky, 2011). "Project-based organizations revolve around the concept that a group of individuals or firms join together with the explicit purpose of producing a tangible set of outputs that can be physical (e.g. a building), logical (e.g. software code) or social (e.g. a marketing or public relations campaign)" (Chinowsky, 2011).

A large variety of heterogeneous participants has to collaborate temporally in order to realize new, unique projects (Schreyögg & Sydow, 2010). The main characteristics of projects such as temporariness, uniqueness, heterogeneity of participants, variety of disciplines involved, and lacking organizational routines results in complexity challenging managers (Hanisch & Wald, 2011; Geraldi et al., 2011). Moreover, the size of the projects, the number and the degree of interdependence of its elements add to the structural complexity as all this elements need to be coordinated (Sommer & Loch, 2004).

A hospital construction project is highly complex in terms of task interdependencies, the newness of tasks and the heterogeneity of the actors involved (Pauget, 2013). The planned numbers of people to use the hospital together with all the professionals who work in the hospital make the place really densely populated. The aging population and need for specialization increase the demand on health-care services. Therefore, the construction of new hospitals imposes a heavy burden on society as both the central and the regional governments are struggling with budget-deficits and imposed austerity measures (Pauget, 2013)

RESEARCH AMBITION

The purpose of this study is to identify the effects of inter organizational relationships in a program of Danish hospital construction projects. More specifically, we want to investigate how the complexities of the projects are manifested in variance and repetitions across the projects.

THEORETICAL FRAMEWORK

The research is based on an analytical framework combining theories of complexity, and modularity.

Complexities

Complexity is not a new science but rather a new way of looking upon systems. Ever since the seventies, as Simon (1962) points at; "multiple levels of hierarchy and a wide range of architectural choices in system specification characterize the architecture of complex systems" (Simon, 1962). Following this statement the variety product and multiple organizations will add significantly to the magnitude of complexity in a given production system. Hofer and Halman supports this argument; "We argue that the deliberate restriction of architectural choices (i.e., through a layout platform) is a powerful means to reducing engineering complexity and risk" (Hofer & Halman, 2005). They further argue that efficiently reducing complexity will create a competitive advantage (Hofer & Halman, 2005, s. 56).

In a large research program on project complexities Geraldi et al., (2011) describe complexity in five different dimensions as a result of an extensive literature review. These dimensions are structural, uncertainty, dynamics, pace and socio-political complexity. As a result, managers have to cope with challenges presented by each of these dimensions of complexity both in individual level and organizational level (Geraldi et al., 2011). The theoretical categories was subsequent simplified based on extensive empirical research to three types of complexities structural (e.g. product), emergent (e.g. process) and socio-political (e.g. organizational).

In addition to the root causes of complexity, a large literature exists aiming to describe where the complexity hides. Many researchers (Aspinall & Gottfredson, 2006, Hansen et al., 2012) focus on the product complexity and defend that process and organizational dimensions are direct result of product variety and therefore complexity. While some others (Sivadasan et al. (2002) trace organizations passing each other operating in supply chains exporting or acquiring complexity. Wilson & Perumal (2009) argue that analyzing either process or product by themselves still does not address the problem of complexity hindering organizational efficiency. The product, process and organization are integrated and they all have their own role of complexity and by managing each subject alone will not provide much improvement compared to a combined approach as illustrated in Figure 1 (Wilson & Perumal, 2015).

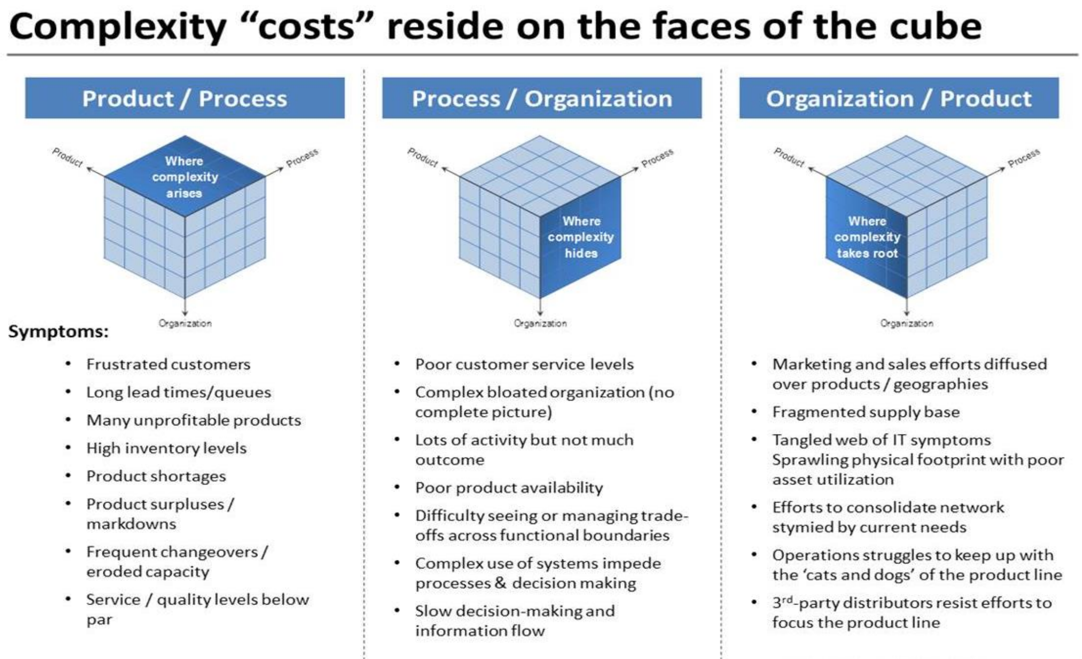

Figure 1: Illustration of the cost of complexity and how the Product, Process & Organization affect one another (Wilson & Perumal, Complexity Cube, 2015)

Modularity

In the journey to manage complexity, modularity appears as a crucial strategy enabling organizations to create products and services meeting individual customers' needs while still leveraging the benefits of similarity and standardization (Oehmen et al., 2015)

A module is an element of a complex system. Modularity is considered a design of production systems or parts of a production system, that attempts to "minimize interdependence between modules and maximize interdependence within them" (Campagnolo & Camuffo, 2009, p. 259). The individual modules are assumed to follow Ulrich & Tung's (1991) application of swapping and sharing of modules, so they can be applied in different systems and be interchanged. In order to apply modularity as a design principle for production systems the concepts of architecture, interfaces and standards from Baldwin & Clark (1997) also are applied. The architecture provides the basic platform for how the hierarchy is structured while the interfaces define relations between the modules and prescribed standards.

The rising complexity of production practices leveraging the benefits of similarity and standardization while at the same time enables the production of individualized products and services (see e.g. Ulrich & Tung, 1991; Ericsson & Erixon, 1999; and Sosa et al., 2004). In particular, the concept of modularity is used to explore different types of production-related structures such as computer, automotive industries within products, processes, organizations and supply chains (Salvador, 2007 and Campagnolo & Camuffo 2009).

In Campagnolo & Camuffo's (2009) review of the concept of modularity, they identify three streams of literature clustered around three different units of analysis: (a) product design modularity, (b) production system modularity; and (c) organizational design modularity (p. 260). In the following, these categories are referred to as product, process and organizational modularity.

Product modularity (product design modularity)

Among the different units of analysis Campagnolo & Camuffo (2009) find that the product design modularity has received the greatest attention from scholars and practitioners probably because it's primarily technically, material and normative orientation.

With the outset in platforms thinking, Meyer & Lehnerd (1997) describe the architecture of a product as being the combination of subsystems and interfaces. They argue that every product is modular and that the goal is to make that architecture common across many variants. Ulrich (1995) believes that product modularity is the scheme by which the functions of the product are mapped towards the physical components, thus defining the product architecture as the arrangement of functional elements, the mapping from functional elements to physical components and the specification of interfaces between these.

The use of product architecture with well-defined modules has in several cases proved to contribute to significant increases in industrial productivity, since implementation of product architecture with well-defined interfaces maintained over many years, makes it possible to develop production processes that are more productive. One reason is that the well-defined interfaces make it considerably simpler to coordinate the individual sub-processes that are typically carried out by different organizational groups.

Process modularity (production system modularity)

Building on the insights from platform thinking and product architectures Baldwin and Clark (1997) defines modularity as a strategy for organizing products and processes efficiently (p. 86). According to Campagnolo & Camuffo's (2009) this type of modularity "within and among organizations mirrors the degree of product modularity, with the main consequence that independent companies (e.g. suppliers) may develop, produce and deliver self-contained modules consistent with the scope and depth of their core competences." (p. 269)

Thereby modularity not only is a characteristic of a product but also the processes / task / activities for producing it. One of the consequences of focusing on modular processes is that the end product might be intangible like a service or experience (Pine & Gilmore 1999).

Organizational modularity (organizational design modularity)

Organizational modularity might be referred to as the way organizations are structured. Since the seminal work by Daft and Levin (1993) where they first coin the concept of the modular organization, several scholars have devoted much effort to develop new organizational paradigms "characterized by flatter hierarchies, decentralized decision-making, greater capacity for tolerance of ambiguity, permeable internal and external boundaries, empowerment of employees, capacity renewal, self-organizing units, and self-integrating co-ordination mechanisms" (Campagnolo & Camuffo 2009, p 274).

A strand of these scholars is particularly interested in the relation between product and organizational modularity identifying the following relation: "Integral products should be developed by integral organizations (tightly connected organizational units to maximize ease of communication and minimize the risk of opportunism). Modular products should be developed by autonomous, loosely coupled, easily reconfigurable organizations. Indeed, the adoption of standards reduces the level of asset specificity (Argyres, 1999) and, in turn, the need to exercise managerial authority. Product modularity also reduces the need for communication due to information hiding, whereby knowledge about the 'interior' of each module does not need to be shared." (Campagnolo & Camuffo 2009, p 274).

The above mentioned theoretical approach will be applied to the nationwide hospitals design and construction case in the context of Denmark. Although the complexity and modularity references are from many braches of the engineering management practices they appear to be consistent explaining the complexities from product, process and organizational perspectives in hospital construction. Finally, modularity theory reflects possibilities to create new still unique design solutions based on the reconfiguration of the repeatable standard solutions.

METHODOLOGY

The analysis is based on three perspectives complexity and modularity the physical, processual and organizational. Each of these perspectives is guided by three questions. What is being built? How is it realized? And who is doing it? In doing so we are looking for patterns of repetition.

Our focus is to investigate the way new super hospitals constructions organization has been designed in a complex temporary setting. It is important to understand the context in which the new hospital construction projects were thought, planned and organized. More than 30 hospital projects have been studied across Denmark in terms of main actors; such as the client, investor, architect, consultant, contractor (organizational perspective), current project phases (process perspective), and design outcomes (product perspective). In the end, 27 Hospital projects in Denmark are chosen for further analysis as the others were not suitable for a comparative study in terms of size (they were to small) or scope (they were renovation projects only).

The empirical material covers project material from each project including drawing floorplans and overviews, information about the participating companies, reports and articles on the specific hospitals as well as general information about the program. The research process was based on three phases: 1. Gathering of material from each of the projects specifically focusing on drawings and organizational design. 2. Analysis and review of the material. Here the material was analyzed by two PhD students with a background with architecture and construction. 3. Presentation and review of finding at different meetings and workshops involving researchers, practitioners and civil servants.

The main perspective is to search for the repetitions and variance and the effects of these within and across the projects. Because of such an investigation, a network of project participants was obtained enabling, the results of participants network positions generates in terms of particular design patterns. As a project requirement, all hospital projects have patient rooms involved in the design material. To compare the different project's patient room design across the projects made it possible to observe the influence of particular project actors on the design outcomes.

Results of the organizational repetitions and interdependencies in design outcomes will be presented with network perspective. Project networks present the concept of intra and inter organizational relationships between individuals and organizations that interact within the scope of one or several projects. This concept of networks is particularly significant as temporary organizations are governed through networks of relationships rather than the formal structures (Manning, 2005).

CASES

Similar to the development in other western European countries the Danish healthcare system is facing major of challenges in the coming years. The higher proportion of elderly in the society, continuous development of treatment options, requirements for coordination across levels of government and sectors as well as increased requirements for renewal, just to name a few. In order to meet these challenges one of the central political parties announced before the election in 2007 that they wanted to spend 80-90 billion Danish Kroner (DKK) to modernize the dilapidated hospitals of which 50-60 billion DKK would be used in construction of new hospitals (Martini, 2007). After winning the election the 80-90 billion DKK was reduced to 60 billion DKK and later even to 41.4 billion DKK (Juhl, 2010).

All these projects was initiated as a part of a major reorganization for the Danish healthcare system concentrating the public healthcare in 6 different regions only responsible of delivering healthcare to the citizens. These regions represent a governance structure between local municipalities and the central government with elections every 4 year. Since the regions are the public owner of the healthcare infrastructure, they are also the clients for the new hospital projects. The overall timeline of the projects are illustrated in the table below along with information about the size of the project (in billion DKK) the project type (Green vs Brown field) and patient room type (L or C).

Case	Region	Budget G. DKK	Project type	Room type	2005 2010 2015 2020 2025
NAU	North	4,10	G	L	
DNV	Midt	3,15	G	L	
RV	Midt	1,15	B	L	
DNU	Midt	6,35	B	L	
KS	South	0,90	B	C	
SSA	South	1,25	B	L	
OUH	South	6,30	G	L	
NFA	Zealand	0,30	B	C	
GAPS	Zealand	1,05	G	L	
USK	Zealand	4,00	B	L	
NHN	CPH	3,80	G	L	
NBH	CPH	2,95	B	-	
DNR	CPH	1,85	B	C	
NHE	CPH	2,25	B	L	
NHV	CPH	1,45	B	C	
SHH	CPH	0,55	B	L	

Table 1: Case overview

ANALYSIS

Process perspective

From the central overview of the program, each of the projects was organized into eight phases:

- Phase 0: Concept and nomination of consultants
- Phase 1: Feasibility and Project Planning
- Phase 2: Construction Planning
- Phase 3: Project Modeling
- Phase 4: Detailed Project Design and The Bill of Quantities

- Phase 5: Bidding and Contract Signing
- Phase 6: Construction
- Phase 7: Commissioning and operation

Initially, all hospital projects were launched almost simultaneously, but this was subsequently changed to two main stages (Juhl, 2010) and finally due to various regional / local political reasons, the current organization of the projects is divided into three main phases. Thus, currently 1/3 of the projects are currently under construction (e.g. DNU), 1/3 is in the planning phase (e.g. NAU) and the last 1/3 is in the programming and design phase (e.g. NHN). The table above illustrates the overlapping timelines of the projects.

The concurrent scheduling of the projects has meant that the client organization (regions) and consultancies of the projects started almost simultaneously, without the opportunity to benefit from each other's experiences and expertise. Consequently, the client organizations are uniquely designed for each region with separate user involvement, which potentially has led to sub-optimization. If the projects had been organized in a sequential way, it would be given the opportunity to gather experience along the way and adjust the future design accordingly.

Product perspective

Overall design (whole)

A part of the analysis investigated the overall design of the hospitals specifically focusing on the five green field projects, as the architects in these projects had more or less the same basis to design from while at the same time having fewer design constrains as these construction projects not directly have to take account of existing buildings and urban spaces. The figure 2 below illustrates the overall design of these green field projects.

Figure 2: Overview of green field projects

As the pictures illustrates are there a general trend in the design of the green field projects with the exception of the NHN project (in the bottom left corner). Four of the green field projects share more or less the same rectangular form. The predominance of this architectural principle can be explained by the constraints of packing rooms together, and the flexibility of dimensioning allowed by rectangular arrangements (Steadman, 2007). Completely different is the design of the NHN project. This construction differs from the others with its curved outline and experimental design. One reason for this difference can be ascribed to the main architect not originating from Denmark. The architect Herzog & De Meuron is a Swiss architect, among other known buildings such as the Beijing National Stadium "Bird's Nest", built for the Olympic Games in 2008.

Detailed design (part)

Looking at the details of the projects another pattern emerge, throughout all the projects two different archetypes of patient rooms is used. Due to the different requirements serving different purposes many of the hospital sections is arguably be designed differently. However, patient rooms are the most repetitive building parts in the hospital projects. The patient rooms are designed for more or less same purposes and thus an interesting object of analysis. As technology and patient ergonomic needs do not vary in the projects realized within the same country of a size as small as Denmark, patient rooms appears as an obvious field to standardize. Moreover, through such standardization, accumulated knowledge from one project can be transferred to new hospital projects.

Another reason for choosing patient rooms as the object of analysis is, to have comparability between different hospital projects as all projects includes realization of new patient rooms. The central ministry arranged an expert panel in order to identify the average area requirements and dimensions. Through such efforts, the need to identify the standards is underlined however no specific standard design were made. The areal norm of single patient rooms is described to be approximately 33-35 m^2.

The specific analysis of the patient rooms reveals two architypes: Type L and type C including various variations of these as illustrated below.

Patient Room Type L:

Patient room with architype L is identified with two mirror-symmetrical L-shaped rooms coming together as seen in Figure 3.

Figure 3: Patient room Type-L. Example is from NAU

Patient Room Type C:

Patient room type C is identified with box-shaped rooms having the bathroom unit within the same box. In this design solution two neighboring units are place in a mirror-symmetrical way so toilets of the neighboring rooms share the same wall as seen in the figure 4 given below.

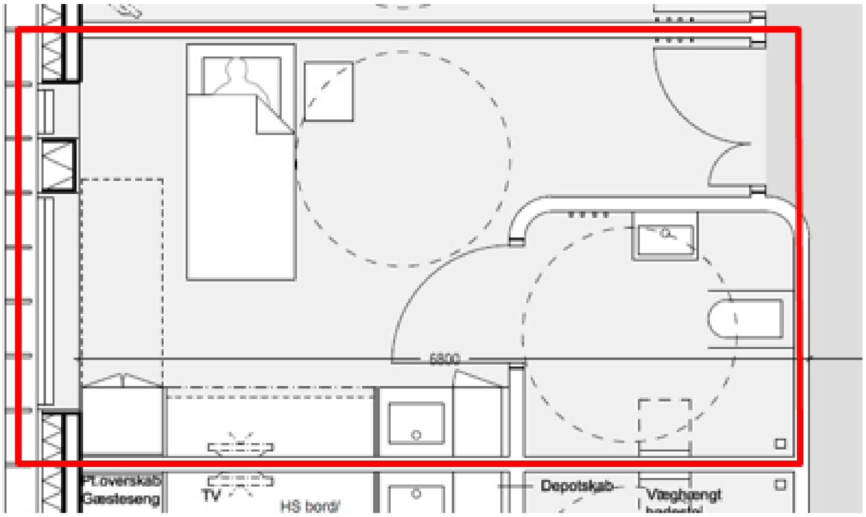

Figure 4: Patient room design Type C. Example is from NHH.

It is seen in Table 1 that all the green field projects uses archetype L as structure for the patient rooms. Even the architecture of NHN uses a variant of the L form where the rooms are tilted making the overall curved design possible. The popularity of the L form is also found in the rest of the projects thus are 70% of the projects using the L type and only 30 % are using the C type. With the existence of the two types of patient rooms, one could expect that is was based on one common standard solution. The analysis however reveals that each of the 27 hospital project have their own specific design, with different dimensions, m2 and interior. Consequently, the patient rooms have been reinvented 27 times - one for each project. In other words, there is no standard solution repeated across the projects missing the opportunity to increase efficiency and productivity of the building process. In order to understand this outcome, we have to look into the actors doing the design – the participating companies.

Organizational perspective

A network map showing the relations between the different regions, projects, and participating companies was developed. The network map as shown in Figure 5 is based on a review of on information about all the participating companies in the hospital projects gathered through the online platform (godtsygehusbyggeri.dk). In total 98 companies are participating in the projects out of which 12 represent foreign countries.

The size of the nodes reflects their relative importance. The size of the projects is defined by their budget. While the regions that projects are located in and companies involved in the projects are defined by their connectedness (degree). The figure shows the centrality of project participants. Here, it can be observed that the company C.F. Møller appears to be the most frequent company as it is described with a large central node. Moreover, C.F. Møller has the most central placement in the network since C.F. Møller has the maximum amount of direct links to projects. Thus, it is possible to reach other participants by minimum required amount connections taking C.F. Møller as a starting point.

Interestingly, in the projects in which C.F. Møller played a central role (mainly as client consultant), the L-shape patient room design architype is observed with minor variations. This observation clearly supports the relation between organization and final product.

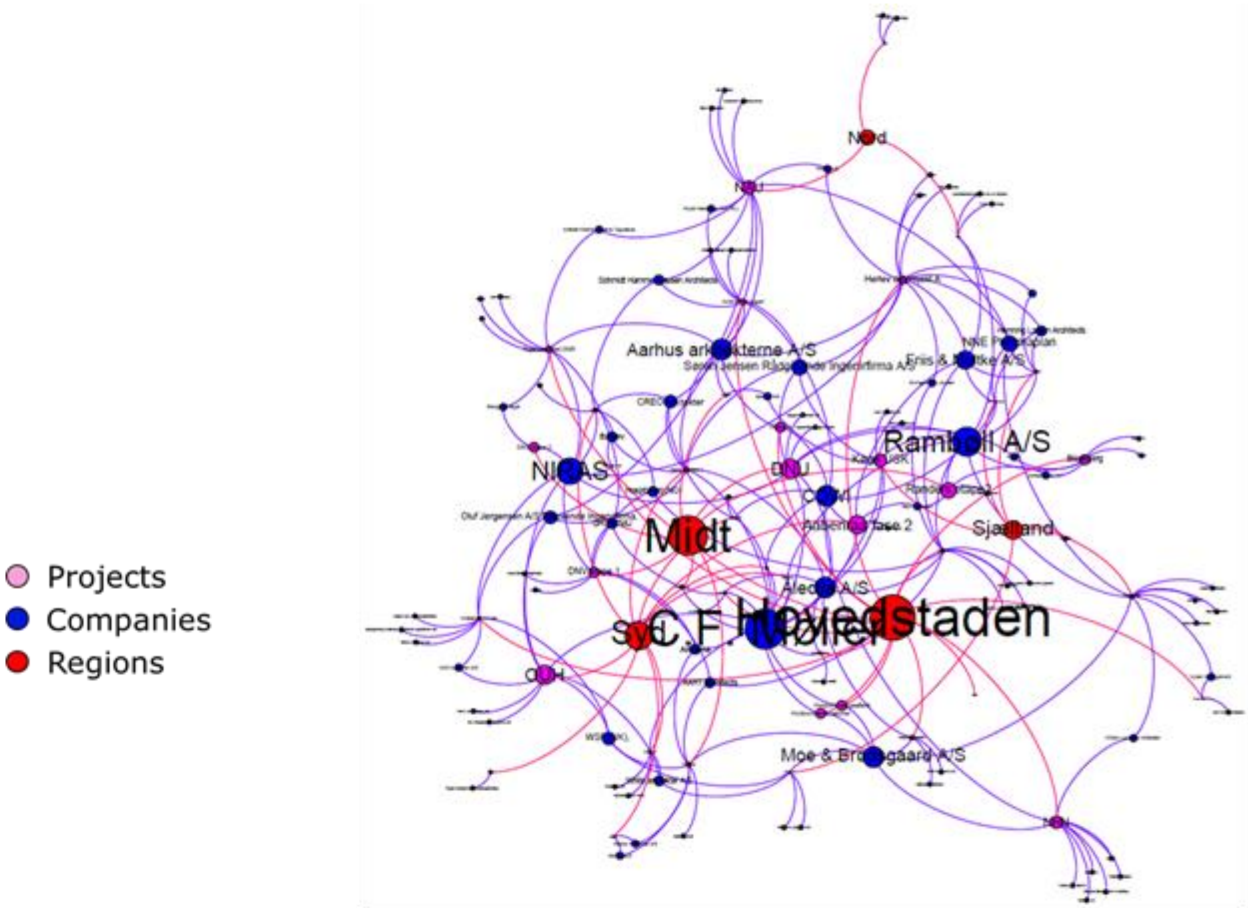

Figure 5: Network map of dependencies between the regions, project and companies

As seen in frequency diagram of companies taking roles in the 27-hospital construction projects in Denmark, presented in Figure 6, most of the companies are only getting involved in these projects only once or twice. This long tail is arguably one of the reasons why there exists no standard solutions observed in the projects. It is a good illustration of the complexity cube presented in the literature section (organizational/product interface). Although variety of companies involved the projects increases the chance to get new inputs and ideas, parties involved in only one or few projects are not able to make use of the experience they gain in one project to other. Therefore, the design processes are run for each project separately and the risk to make the same mistakes increases as there is no or limited learning across the projects. This is particularly the case for the green field projects where the organizational repetition is very limited.

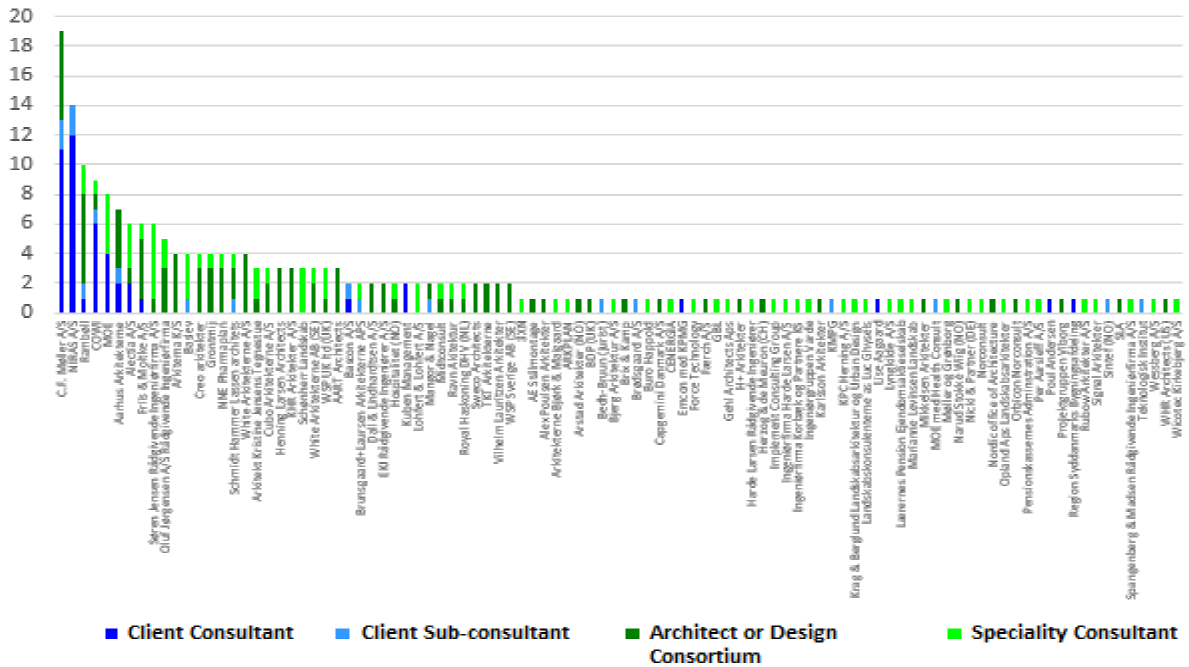

Figure 6: Organizational repetitions: All hospital projects

The frequency diagram also illustrates that it mostly is client consultants that are involved in multiple projects like the companies CF Møller and Niras. This of course creates an infrastructure for informal knowledge sharing between the different projects. However only very limited repetitions within the consortiums exists creating project teams that are unique and thus designing their own super hospitals including unique variants the patient room design.

Besides C.F. Møller playing a central role behind the L shape patient room design there exists no organization-product (design outcome) pattern as illustrated in Figure 7 juxtaposing companies and room types. It can be concluded that there is no central authority making the standard room design through organizational repetition across the projects. Different variants increasing the product complexity designed by different project teams reflecting the organizational complexity.

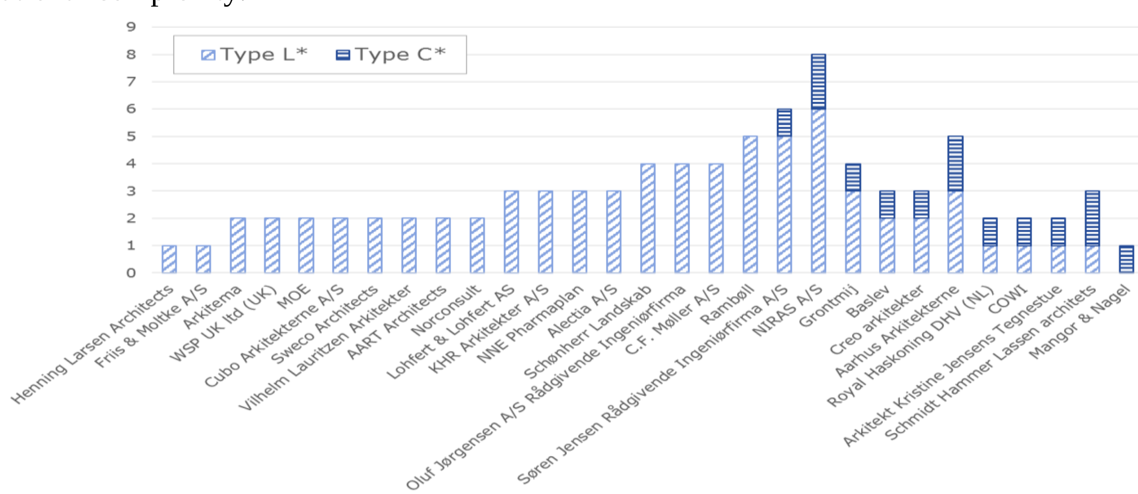

Figure 7: Companies vs room types

DISCUSSION

As the analysis show are all the green field projects designed to be unique pieces in their own way. Each region wants their super hospitals to be the best in the country and a trademark for the region. The observed way of project delivery exemplifies clearly the product/process symptoms described in Figure 1 in literature section. Long lead times in other words delayed projects, unprofitable products in construction terms running over budget and finally frustrated costumers meaning clients and end-users are all the result of the complexity cost (Wilson & Perumal, Complexity Cube, 2015).

Nevertheless, four out of five green field projects shares the same rectangular from structures, despite the fact that it is not the same companies that designed them. When the result in most of the projects overall are of the same nature, it is debatable whether it would be more effective and efficient to design a central model for buildings. In this way design costs could be significantly reduced, since the same process didn't have to be repeated several times.

One of the projects stands out from the others in its design. NHN has a unique architecture. It is debatable whether this is a good or bad solution compared to the other green field projects; if this kind of architecture ensures better treatment and helps to promote healing of the patients, why is the rest of the hospitals projects not designed the same way? Conversely, if it cannot be documented that such kind of architecture creates more value for patients and the employees, the funds could have been used better using the design principle of the other projects. All things being equal it would be cheaper to build a hospital using rectangular building, as this favors the possibility of using standard elements. Thus, the funds could instead be invested in equipment, IT, logistics, etc.

Furthermore, the analysis shows that all the green field projects use the room architype L, or a variation thereof. Almost 70% of all centrally funded projects use the L type of patient rooms. It seems strange that the different design teams use costly resources inventing the same type of patient rooms that overall looks the same but in the details are different. The relation between the organization and product (design outcome) indicated yet again the symptoms described in the complexity cube by Wilson and Perumal presented in Figure 1. Fragmented supply base, many parties involved resisting the efforts to create a standard product that would be cost effective and finally geographical differences and local marketing efforts to shadow the standard design creation. By centralizing the design this project-oriented sub-optimization could have ensured that all buildings are fully optimized for the construction and subsequent operation, while saving money?

Throughout the regions and project user involvement practices among both patients and future staff is widely used. It is puzzling that health care professionals should evaluate and conclude much the same design for each of the projects. Despite the fact that the spatial frame seems quite controlled centrally in our immediate European and particularly Scandinavian neighbors, user processes are repeated on rooms that should be standardized nationwide. There could be guaranteed a greater parity of treatment and staff optimization nationally if the most used rooms (an estimated 85% of the total area required) was standardized. E.g. previous work demonstrates that standardized space reduces errors because of recognition and familiarity in stressful situations. This should be scalable to the majority of the projects.

By implementing standard modular solutions in repeating products such as patient rooms, instead of the creation of the overall architecture over and over again, user involvement processes can have focus on daily usage areas and architectural finishes so that health care professionals, regional client representatives and end-users will feel their touch on the final product.

Another possible side effect of the nationwide standardization of the most obvious space will emerge as new technologies are developed. During the long lifecycle of the projects, new tools and workflows will be developed. By having a nationwide uniformity it will be easier to implement new initiatives. It will only be necessary to conduct pilot projects on individual hospitals and the same module will be repeated nationwide because if the technology works on a standardized hospital, there is a high chance that it also works on another.

CONCLUSION

This study reflects how inter organizational relationships shapes the complexities of construction projects in numerous ways. The analysis shows that even though the different projects are run independently by different project teams not communicating with each other, there are some repeating patterns. The projects are designed for each specific location (region) with unsystematic and limited use of processual, organizational and technical repetitions. Overall, the projects are executed in parallel and follow the same phases with a high degree of user involvement in each of the projects; here inputs are gathered for the specific project that subsequently is designed by a unique team of architects and consultants. Although some of the participating companies are involved in several projects (especially for the client consultancy role), there is a high degree of variance in the project teams. Despite the variance of the project teams the overall and detailed design of the hospitals look remarkably the same. However, a detailed analysis of the patient rooms reveals that although 70% of the projects use the same architype (the L-type) they are all different from each project. In other words there exists no identical patient room design being used in two different hospital projects. This lead us to the conclusion that the hospital is reinvented in each project leaving behind unrealized potential for leveraging similarity across the projects. This could have been achieved by a stronger central coordination, thinking of super hospitals as programs and portfolios making use of modular standard solutions rather than independent individual projects. By reconfiguration of the repeatable modular solutions resources such as time, money and professional health care and design personal can be used more effectively in order to create super hospital projects which are still unique.

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