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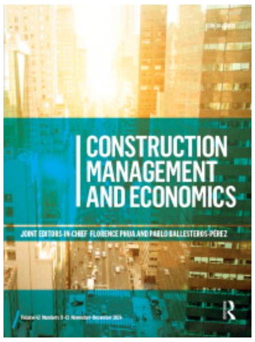

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Making logistics a central core in complex construction projects: a power-dependency analysis

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ABSTRACT

In complex projects, such as hospital constructions, there are large interdependencies between the actors involved, especially relating to the flow of materials and resources. As new hospital buildings are often built on existing blocks and campuses, ongoing hospital operations may hinder logistics and construction operations and vice versa. To handle these issues, it has become increasingly common to implement construction logistics setups (CLSs). The purpose of the paper is to analyse how the centrality of the CLS in the project organization affects the coordination and conflict level in complex construction project management using a power dependency lens. The study is based on case studies of six hospital projects in the Nordic countries. Based on a cross-case analysis it is identified that: 1) from a logistics management perspective we identify three different foci of the CLS; i) security for hospital patients and staff, ii) on-site material flow coordination, and iii) flow coordination to and from site, and 2) from a project management perspective the main findings point towards the importance of centrality of the CLS in the project management organisation in order to ensure enough power to mandate enforcement of coordination.

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Introduction

All construction projects are dependent on materials and resources being delivered to and removed from the construction site in a timely manner (Guerlain *et al*. 2019). Managing these materials and resource flows is known as construction logistics management. In complex project settings, construction logistics can quickly become complicated and if not managed properly it can cause conflict between different project stakeholders. Different subprojects, subcontractors, and suppliers and their respective material and resource flows need to be coordinated so their respective operations as well as external stakeholders are not negatively affecting each other. There is thus a need to minimise negative impacts of construction logistics by taking a more strategic approach on how to coordinate the logistics flows to, on and from construction sites (Dubois *et al*. 2019). Primarily, however, construction logistics is viewed as a daily operations issue in construction projects (Jang *et al*. 2003) and is often approached in an ad hoc manner (Ying *et al*. 2018).

In complex projects, such as hospital construction, there are large interdependencies between the actors involved, especially relating to the flow of materials and resources. The built environment surrounding the complex project can pose challenges for both logistics and construction operations, impacting the timeliness of the project as well as the budget. Hospital projects are often carried out in existing hospital areas where ongoing operations cannot be interrupted. As such, there are risks for bystanders and personnel, and there is a lack of space for material handling, such as (un)loading and storage (Kyrö *et al*. 2019). According to Guerlain *et al*. (2019), a typical construction site receives 2–10 deliveries or 8–10 tons of material per day. Complex construction projects, such as hospitals, are, however, more material intensive, and according to experienced practitioners, there is often twice as many deliveries to hospital projects compared to regular housebuilding (Svensk Bygglogistik Ab 2019). Furthermore, these deliveries must be coordinated in

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a way that they are not competing with other types of transport flows, e.g. goods deliveries, public and private transports, and emergency medical transports (EMTs). The latter is an important issue in hospital projects, where EMTs are always given priority to save lives (Thunberg and Fredriksson 2023). These interdependences among deliveries lead to conflicts between organizations, especially in large and complex projects in contexts with unclear power of using common resources, such as campus roads, parking spaces, and elevators.

In an effort to move away from the short-sightedness of solving logistics day-to-day, construction logistics setups (CLSs) have recently become a popular way of managing logistics (Janné and Fredriksson 2022), and contractors now see large-scale CLSs as a necessity in complex construction projects (Janné and Fredriksson 2019). The increased uncertainty of complex projects in complex environments have resulted in the development of greater efforts to coordinate the use of common resources.

Ekeskär and Rudberg (2020) define CLSs as; *the way that the logistics system, including elements, components, information systems, etc., are designed and arranged to handle logistics in a construction project.* The definition above speaks of the "logistics system" and how it is arranged, suggesting a more strategic approach to logistics. A CLS focuses on coordinating the actors use of material and resource flows, stakeholders, and common resources to ensure efficient projects at the same time as the disturbances to the vicinity are minimised as much as possible. The later implies a continuation of adjacent activities without disruptions due to the commencement of the construction project. A key service is to ensure that the correct information is shared and updated among stakeholders to reduce conflicts between them (Fredriksson *et al*. 2021a). A CLS can combine a few or several logistics services and the two most common alternatives are terminal-based construction logistics centres (CLC) (Hamzeh *et al*. 2007) and just-in-time (JIT) based checkpoints (Dubois *et al*. 2019).

Earlier studies of construction logistics have mainly focused on logistics as a new phenomenon in construction project management (Ekeskär *et al*. 2021) and the design of CLSs, i.e. what services to include (Fredriksson *et al*. 2021a), their initiation (Eriksson *et al*. 2021) and their effects (Sundquist *et al*. 2018). According to Högberg (1997), efficient coordination require concentration of power and decision discretion. However, what remains less studied in relation to construction logistics and CLS in specific, is the relationship between the centralization of power and decision discretion in the construction project and the efficiency and effectiveness of the CLS implementation. Hence, the purpose of the paper is to analyse how the centrality of the CLS in the project organization affects the coordination and conflict level in complex construction projects. The purpose is fulfilled using a power dependency lens as the base for the analysis. The empirical study is based on six cases of CLSs implemented in Nordic hospital projects.

The paper is structured as follows: The following section of the paper presents our theoretical foundation of complexity of large hospital projects and power dependency in construction projects. Thereafter, the research design of the study is presented, followed by a description of the six hospital cases. These are analysed using cross-case analysis and the findings of the cross-case analysis are thereafter discussed. Finally, conclusions and implications of the study are presented.

Theoretical foundation

Complexity of large hospital projects

This research focuses on CLSs of complex and large hospital construction projects in urban environments. Project complexity can be divided into structural and dynamic complexity. The former refers to the arrangement of components and subsystems into one system architecture, while the latter refers to the changing relationships among components within a system and its environment over time (Williams 1999, Brady and Davies 2014).

Regarding the *structural complexity*, large hospital projects are often complex due to their limited time span, integration of multiple equipment and services, and need to coordinate multiple organizations participating in the project (Chakkol *et al*. 2018). The complexity is further increased due to many interest groups, such as nurses, doctors, and patients and their relatives, technical systems and their challenges, and linkages of the project to the existing urban infrastructure (Lahdenperä 2017). Due to the nature of hospital operations, hospitals typically integrate many advanced technologies. In hospital projects, these technologies have to be considered early on in the design process and this has to be carried over to the procurement, delivery and assembly operations as well (Shipton *et al*. 2014). This leads to an intense material flow and according to experienced practitioners, there is often twice as many deliveries to hospital projects compared to regular housebuilding (Svensk

Bygglogistik Ab 2019). Furthermore, the hospital project in most cases is taking place on existing campuses, where the coordination with the surroundings of the project can impact how logistics and construction operations are carried out as ongoing hospital services must not be interrupted (Ekeskär and Rudberg 2016, Kyrö *et al*. 2019). Moreover, the structural complexity of the project increases due to the varying customer groups of e.g. different hospital departments and the addition of public stakeholders. The multitude of decision-making stakeholders leads to confusion of who makes the final decision, furthering the effects of the structural complexity.

Dynamic complexity is another essential characteristic of hospital construction. The healthcare sector is characterised by dynamism and uncertainty, making the management of hospital projects challenging (Bakhshi *et al*. 2016). Lavikka *et al*. (2019) argue that managing the scope and design of hospital projects is difficult due in part to the long lifespan of hospital buildings that need to be "future proof" to cater to changes in future patient profiles and developments in medical technology. The wish to have the best and latest medical technology also leads to late decisions on what technology to include in the project, leading to late design changes. These late design changes impact the planning process of the project, meaning that procurement is performed as late as possible which in turn affects the logistics of the project. As earlier mentioned, hospital projects, at least in the Nordic countries, are primarily carried out as part of refurbishment projects meaning patients, medical staff, medical and non-medical supplies, and EMTs need to have priority affecting the overall complexity further. These large projects also have many different organizations entering and exiting the project at different times throughout the project duration (Lehtinen *et al*. 2019), which adds additional challenges to the management of the project organization and logistics processes (Bakhshi *et al*. 2016). Hospitals are often also located centrally in cities with limited space and infrastructure surrounding the project. Changes in regulation and financing create additional uncertainties.

Together, structural, and dynamic complexities mean that large projects are difficult to manage (Olsson and Hansen 2010, Pauget and Wald 2013). One approach to control for complexity in large hospital projects is to utilize more collaborative project delivery methods (Mesa *et al*. 2016). The goal of such methods is to consider the projects' diverse and changing goals already in the design and planning phases (Sivunen *et al*. 2014). Additionally, these methods propose involving the key actors early on, incentivizing them to innovate solutions for the project throughout its execution (Mesa *et al*. 2016). Such early collaboration between key stakeholders (e.g. customer, designers, and contractors) enhances the development process of CLSs that considers the needs of the project and all its stakeholders (Janné and Fredriksson 2019). On the other hand, Lavikka *et al*. (2019) suggest using design coordinators, robust product design, and process flexibility to manage structural and dynamic complexity of the hospital projects. Peltokorpi *et al*. (2018) suggest that robust design and flexibility can be enabled by employing a modular product architecture that utilizes prefabricated components. This has an effect on the projects' logistics; it requires more thorough delivery planning, but can reduce the need for on-site inventory space (Peltokorpi *et al*. 2018). In summary, the planning, operationalization, and execution of CLSs in hospital projects must take the structural and dynamic complexities of large hospital projects into consideration.

Power dependency in construction projects

Högberg (1997) summarizes the power-dependency theory background by stating that *"uncertainty will result in greater efforts to coordinate, which will require concentration of power and decision discretion"*. According to Cook (1977), organizations establish exchange relationships for reasons of mutual benefits, be it the attainment of objectives for which resources are necessary or the reduction of uncertainty. Producing value requires the combination of resources and the exchange of resources in the interaction between organizations (Hall *et al*. 1977). The exchange of resources creates dependencies. Dependence here refers to situations in which cooperation with other partners is necessary to reach goals and enforce policies (Deep *et al*. 2022). Aiken and Hage (1968) stress that interdependence require coordination which in turn has a cost of resources that must be allocated to the coordination. Coordination is defined as the extent to which organizations attempt to ensure that their activities consider those of other organizations (Hall *et al*. 1977). Coordination can cover both the coordination of activities and strategies towards third parties (Gulati and Singh 1998).

Power differentials between organizations will make it possible to use force and mandating the restriction of freedom of interacting parties making the benefits asymmetrical between organizations (Högberg 1997). Power is about making things happen by influencing the behaviour of another social unit and is a blend of individual person-based factors and structural factors (Loosemore 1999). The location of power in exchange networks and the consequences of that location affects the possibilities of execution of the power (Cook 1977). Variables such as centrality, distance, balance, reachability, and location can be used to determine an actor's dependence/power in a network (Cook 1977), where the level of information received and sent out indicates power (Loosemore 1999). Scarcity of resources in environments characterized by low concentration of power and authority will create conflict between actors (competition), provided that they are interdependent (Pfeffer and Salancik 1978). Scarcity of resources require even more coordination between interdependent organizations to decrease uncertainty of getting hold of necessary resources. When organizations experience conflict, coordination becomes harder as it requires a collaborative atmosphere (Gulati *et al*. 2012). Therefore, organizations are assumed to try to reduce uncertainty by for example creating negotiated environments to clarify how interactions are to take place (Pfeffer and Salancik 1978).

How to successfully coordinate organizations differ depending on the basis of interaction (Hall *et al*. 1977). There are three types of bases for interaction: 1) voluntary, 2) mandated, and 3) standardized (voluntary but formal agreement) (Hall *et al*. 1977). These three types reflect the different kinds of trade-offs between resources received and the autonomy the organizations will have to give up in the interaction (Högberg 1997). The different bases of interaction affect the quality of interactions among organizations (Hall *et al*. 1977). A formal agreement is a step towards coordination, but even if a formal agreement exists negotiations are still carried out during the project as there are always unclarities that have not been regulated (Hall *et al*. 1977). Power struggles develop due to unclarities and different interpretations of responsibilities in contracts, i.e. who should do what and with what resources (Hall *et al*. 1977). Organizations strive to use their bargaining positions to improve their benefits in the interaction (Högberg 1997). Therefore the interdependencies between organizations can be sources of uncertainty in regards to the organizations' ability to acquire needed resources to fulfil their task (Pfeffer and Salancik 1978). Organizations do not engage in power struggles when issues are already decided by external legal mandate (Hall *et al*. 1977). Furthermore, for all types of interactions the level of coordination needed is dependent on the level of trust between the organizations (Aiken and Hage 1968).

The power-dependency theory has in earlier research been applied to the construction context to explain the relations between organizations in a complex project management setting. From a construction project perspective, responsibilities relate to specific events during the project time which require investment of resources to solve (Loosemore 1999). These events vary in their predictability (Loosemore 1999). The uncertain nature of construction project renders unpredictable resource demands which is the risk, and contracts define the responsibilities for these uncertain events (Loosemore 1999). According to Deep *et al*. (2022) the bargaining power and the dependence between actors in a construction project has a significant impact on the level of risk transfer. The client is responsible for setting up a good project management prerequisites and hence by not taking this responsibility the client does not provide support for good project management (Munns and Bjeirmi 1996). The procurement design, i.e. how the CLS is procured by the initiator (client or main contractor) should identify the way to address the emergent uncertainties and manifest collaborations necessary for an efficient implementation of the CLS (Deep *et al*. 2022, Janné and Fredriksson 2022).

The traditional way to manage projects by dividing the tasks into responsibilities to be performed by different subcontractors, i.e. the tasks are interdependent, but the project organisation forces them to be managed independently, often leads to conflicts of shared resources. The most common form of interaction in construction projects is the mandated interaction which is regulated by the contract that binds contributing organizations together. However, the responsibilities in construction projects are not entirely predetermined by contracts (Loosemore 1999), and traditionally logistics has been seen as a voluntary activity, i.e. not included as specific activities whose coordination is regulated by the contract.

However, as can be seen above the centrality of an actor affects its power in a network (Cook 1977), where the level of information received and sent out indicates power (Loosemore 1999). Therefore, a major factor for the successful implementation of project management is that the project manager and team become the central point of responsibility (Munns and Bjeirmi 1996). Furthermore, by resolving responsibilities early in the project, a manager can avoid later conflict, ensuring that the process of resolving a problem takes priority over the process of resolving responsibilities (Loosemore 1999). Here the coordination of the use of the shared resources as part of the logistics activities can be seen as a problem to be solved. To solve this problem a CLS is implemented to improve coordination of resources, such as loading/unloading areas, safety, and limited roads (Fredriksson *et al*. 2021a). However, as presented by Janné and Fredriksson (2022) as well as Eriksson *et al*. (2021), the logistics organization is not always seen as a central part of project management and the risk of bad logistics is transferred from the project management core to be just a sub-supplier of logistics services. This is in line with what Deep *et al*. (2022) identify from their literature review that there is a tendency to transfer risks upstream the value chain or supply chain in construction, which leads to a breach of trust and a lack of reliability and commitment. Furthermore, logistics management is often seen as an increased risk, leading to an increase in project costs from the general contractors and subcontractors perspective (Fredriksson *et al*. 2021b). Therefore, an issue in need of further studies in the context of complex projects is how to integrate CLS management into project organizations so the benefits of CLSs occur.

Research design

The empirical research focuses on using power dependency lenses to explore how the centrality of the CLS in the project organization affects the coordination and conflict level in complex construction project management. The overall objective is to derive conclusions on how construction logistics should be organized and managed.

A multiple case study research design was chosen to learn from past experiences of organizing construction logistics in complex hospital projects. While a single case study can give a deeper understanding of the mechanisms in one particular case (Yin 2014), a multiple case study gives more varied empirical understanding of the mechanisms (Eisenhardt and Graebner 2007). Additionally, multiple cases can, according to Eisenhardt and Graebner (2007), allow for more robust theory-building efforts.

The choice of studying hospital projects is due to these projects being particularly complex with long lifespan of buildings and changing medical technology affecting the design, procurement, and production processes (Lavikka *et al*. 2019). In selecting the cases, it is important to consider what the different cases can contribute to the study (Yin 2014). Eisenhardt and Graebner (2007) highlight that multiple cases in theory building are chosen for replication, contrary replication, extension of theory, and elimination of alternative explanations. In this study, we chose the cases based on a mixture of contrary replication and extension of theory (Eisenhardt 1989). The contrary replication stems from wanting to explore CLSs utilized in multiple complex projects to see whether different organizing strategies affects the conflicts and role of construction logistics in projects. As we have identified two strands of CLS research directions; project-focussed CLS literature aiming to increase productivity, and logistics-focussed literature aiming at presenting the different possible logistics services and their impact, we see a need to a more holistic complexity approach to the CLS area, thus extending theory.

When making the case selection, it was important that the case is; 1) a hospital construction and/or renovation project, 2) utilizing a CLS, and 3) operational within a Nordic context. The focus on the Nordic context was in part due to the structure of the Nordic healthcare sector which is predominantly a public affair and has to abide with public procurement laws, fostering a transparent and open tendering and procurement process. In part the choice was one of convenience as the authors are strongly connected to and familiar with the Nordic context. Through ongoing research projects, we had the opportunity to follow multiple hospital projects, thus allowing for good access to respondents and project documentation to form the basis of the empirical evidence of this study. The case selection process rendered an empirical base of six Nordic hospital projects with four cases from Sweden, one case from Denmark, and one from Finland.

Empirical evidence has been collected through on-site visits, CLC and project observations, archival records, and semi-structured interviews. CLC observations were only undertaken in the cases that utilized the terminal based CLCs. As proposed by Eisenhardt (1989), a research protocol was developed as preparation of the data collection and was used throughout the interviews and observations as an interview and observation guide. The guide focussed on the context and background of the hospital project, the organizing of construction logistics, where in the project organization the CLS was situated, and how the projects' interorganizational relationships were managed. Interview respondents were accessed through the contact persons within each of the studied projects. Primarily, the contact persons were CLS initiators or operators, and depending on their level of centrality, this meant that their suggested respondents covered

Table 1. Data sources and collection.

	Data sources					
Case	Project documents	Interviews with CLS initiator	Interviews with CLS operator	Interviews with CM or GC	Site observations	CLC observations
A	Project plan Project website Site layout plans Logistics model	2h	2 x 2h	2h	1	N/A
B	Project website Site layout plans Logistics plan 2 x master thesis works	–	3 + 2h 2 x 2h	–	1	1
C	Project plan Project website Site layout plans Logistics plan Logistics presentation PhD project	–	2h	–	1	N/A
D	Project website Site layout plans Logistics model	2 + 1h	2h	2h	1	1
E	Project plan Project websites Site layout plans	1h	1h	2h	2	N/A
F	Site layout plans Logistics plan	–	2 x 2h	2h	1	N/A

different actors within the different construction projects, making a 1:1 comparison and matching of respondents within the different projects difficult to achieve. All respondents were, however, experienced in their respective roles and in connection to construction projects and construction logistics and were suggested by the contact persons to allow the researchers the best possible understanding of the introduction and challenges of the CLSs in the different projects. This is in line with the suggestions of Eisenhardt and Graebner (2007) whom highlight the need for respondents to possess some expertise on the subject matter from their respective perspectives. The empirical data was transcribed (interviews), annotated (interviews, documents, and observation notes), and stored electronically (Eisenhardt 1989). Table 1 summarizes the data collection process of the six cases.

It is common practice in theory building research to combine empirical and analytical approaches (Eisenhardt 2021). Combining the two approaches allows researchers to delve deeper into a phenomenon and uncover fresh perspectives (Eisenhardt 2021). The first step of the analysis was thus identifying *how* the CLSs were organized and managed and trying to uncover the rationale for *why* the CLSs were organized the way they were, i.e. to explain any shortcomings or successes the CLS organizing had led to. This was conducted within the different cases as a first step to gain an understanding for the individual cases, building the foundation of the theory extension in accordance with Eisenhardt (1989). Once an understanding of the individual cases were achieved, the encountered challenges of the different hospital projects' logistics setups were compared through a cross-case analysis (Eisenhardt 1989) to search for patterns of what to consider when introducing a CLS in a complex project environment. The cross-case analysis was conducted as a thematic analysis (Flick 2009) in which the themes were originally developed through the iterative in-case analysis approach in which the individual cases were contrasted against the literature presented previously. This allowed for the cross-case analysis to go deeper into the mechanisms behind the introduction of CLSs, such as e.g. the rationale behind introducing CLSs in the cases as well as seeing if the challenges encountered in the cases differ depending on mandate and centrality of the CLSs. This cross-case analysis allows us to suggest how construction logistics can be organized and incorporated into project management and provide more of a holistic approach to project complexities and how to deal with them.

Six Nordic hospital projects

The empirical foundation of this study consists of six Nordic hospital construction projects: four Swedish projects, one Danish project, and one Finish project. To control construction logistics activities and reduce disturbances to hospital operations, all the hospital projects have opted for CLSs. The CLSs have primarily been initiated by the public clients, i.e. regional councils in Sweden (cases A, B, C) and Denmark (case F), and the hospital region in Finland (case E), whom are the owners of the projects. In one of the Swedish projects (case D), the initiative to utilize a CLS came from the general contractor (GC). All six CLSs investigated offered additional services to increase the value-adding experience of the CLS, depending on the aim with which the CLS was initiated. These services could include e.g. booking and planning systems, site establishment, logistics organization, waste management, and regulations.

Case A is a 7-year project in a medium-sized city in southern Sweden. The main hospital building, constructed in 1975, is undergoing a comprehensive renovation where the interior and exterior is rebuilt to align with modern medical needs. New care buildings and a parking garage are being added to the existing hospital campus. The hospital is one of four emergency care hospitals in the region and as such it needs to be operational during the construction project, meaning that the construction project must take hospital operations into consideration. The regional council (client) hired a construction management (CM) company to oversee the site and material deliveries.

Due to the hospital's central location, the CM company implemented a checkpoint system for deliveries outside the city. Their focus is on minimizing disruptions to third parties and maintaining normal hospital operations throughout the duration of the project. While the CM company has authority over project-related logistics issues, challenges arise in coordinating with regional and local council road and construction project activities adjacent to the hospital project.

Case B is a 5-year project near the city centre in a medium-sized city in northern Sweden. The main building, completed in 1965, requires modernization to meet healthcare standards. Additionally, new care units are being constructed on the hospital campus. It is also home to medical university education programs. All in all, the hospital area is a busy area with ongoing hospital and educational operations.

The regional council (client) hired a consultancy company to establish and manage a CLS with the primary goal of avoiding disrupting ambulances and ongoing hospital operations. Collaborating with a leading logistics software company and a major hauler in Sweden, the consultancy company defined the rules for the setup. However, CLS utilization remains voluntary, posing challenges for enforcement of the set regulations. Regulatory recommendations include booking deliveries 24 hours in advance. The haulers' terminal serves as a CLC, and all materials to the project should be routed through it. Deliveries occur via milk runs from the CLS, where the hauler also can pick up materials from local vendors, and materials are carried into the building. While the setup is well-received on-site, only about 10% of materials are delivered via the terminal.

Case C is a 12-year project in the central parts of a medium-sized city in mid Sweden. The main building was completed in 1975 and is undergoing renovations internally and externally with new care units being constructed throughout the project. The hospital is the largest hospital in the region with emergency care and specialist units. It is also home to medical university education programs. All in all, the hospital area is a busy area with ongoing hospital and educational operations.

The regional council (client) recognized the necessity to manage construction logistics effectively. The main goal was to prevent disturbances to ambulance services. To address this, they approached a construction logistics service provider (cLSP). The cLSP established a CLS with a checkpoint located on the outskirts of the hospital area and strict protocols for booking deliveries five days in advance. The cLSP ensures that goods are safely transported after project working hours to the destination within the hospital. Initially, the cLSP was to report to and receive orders from the projects GC. However, this arrangement left the cLSP with limited authority, making the implementation challenging. Over time, the CLS has evolved. Recent years have seen a shift in focus towards measuring logistics improvements, and the cLSP now operates with greater autonomy in relation to the GC.

Case D is a 5-year project to modernize the psychiatric ward, infection clinic, and medical laboratory of a centrally located hospital in a mid-sized Swedish city. The hospital, originally completed in 1983, remains operational during construction. The existing medical laboratory will be demolished once the new one is completed.

The site manager of the GC insisted on implementing a CLS. This system, managed by the GC, includes a terminal with additional services like kitting, on-site materials handling, and a machine resource pool. Deliveries occur based on call-offs and takt production. However, there is no formal material planning system in place in the project. The GC has a dedicated logistics manager in the project. This logistics manager is tasked with being the contact point between the construction project and the logistics service provider, having the responsibility to ensure that materials are ordered and delivered when needed. The logistics service provider owns the terminal, which, while not exclusively for construction, accommodates the materials as needed.

Case E is a 4-year project to construct a new trauma and cancer hospital on the university hospital campus in Helsinki, Finland. The hospital campus is centrally located in Helsinki, and is one of the largest in Europe, encompassing all major medical specialities in its operation as well as medical university education. As such, the campus is a busy area, and the construction project must take the hospitals various operations into consideration to not disturb medical procedures. Additionally, there is an ongoing road renovation adjacent to the hospital project that adds further complexity to the logistics challenge of the project.

The hospital district (client) engaged a GC using the construction management at risk-delivery method. This approach encompasses quality, time, and budget targets. The GC, in turn, enlisted a logistics service provider to handle on-site logistics. To facilitate efficient logistics in the project, a material delivery planning system was set in place, complemented by strict delivery time regulations due to limited crane capacity. The CLS aims to maintain existing service operations on campus, reduce disturbances to EMTs, keep the busy adjacent road open, and avoid disruption to the existing service and maintenance tunnel beneath the new building. As the hospital campus has limited space for storage, a terminal is used for enabling just-in-time (JIT) deliveries. Additionally, the project aims to use prefabricated products and takt production whenever possible.

Case F is a is 9-year project to modernize an all-round hospital located in the central parts of Copenhagen. Originally the hospital was built in 1913 and added to in the 1940s. This means that the hospital needs both internal and external renovations and rebuilding to become modernised.

The regional council (client) issued a tender for a building site management solution that would encompass a multitude of different subprojects. The winning bid, submitted by a CM company, encompasses overall site and logistics management for the entire project. However, logistics for individual contractors' subprojects remain under the contractors' control. Consequently, the project involves multiple CLSs from different contractors, all competing for the same space and infrastructure. The CM company's challenge lies in balancing these CLSs, coordinating time plans, and ensuring material flow across the entire endeavour.

The CM company added their own virtual checkpoint to manage the subprojects and their CLSs, aiming to minimize negative impact on third parties and maintain normal hospital operations. The virtual checkpoint is in essence a delivery booking system, but the CM company is also responsible for the site establishment, the joint site layout plans, and regulatory compliance. There have been issues with rule adherence as the different subprojects do not see the need for the overall CLS when they have their own setups in place.

Table 2 summarizes the six hospital cases and their CLSs.

Cross-case analysis

The investigated projects tackled the challenges of urban settings with several elements of logistics services. The six projects are all located centrally in urban areas and on existing hospital campuses. As such, the material and resource flows to and from the construction sites all impact the urban environment and the transport flows within the city and on the hospital areas. This has led to the CLS designers opting for CLS designs that focuses on controlling traffic. Cases A and C both opted for physical checkpoints with waiting areas outside the city or construction area. This allowed the two projects control of when deliveries arrived. Case F had a similar departure point but utilized planning systems as the main coordination service. The thought behind the CLS service in these three cases was sound; to control when deliveries are allowed on site. However, all three cases show that due to insufficient planning ability and experience from the GCs, the CLSs struggled with rule adherence as the GCs did not see the CLSs as value adding for their operations. Similarly, cases B, D, and E have also seen difficulties in creating value for the contractors. In these cases, the CLSs were built around terminal setups where the aim was to reduce the number of deliveries through consolidation of material. Case B for instance, shows that even though contractors have been positive to the idea of the CLS, only 10% of deliveries utilize it. From the cases we see that client initiated CLSs (A-C, F) mostly defined logistic policies and utilized delivery booking and planning systems to achieve control of material flows to and from the site. GCs on the other hand, often aimed for more sophisticated CLSs (D, E), such as including takt-based deliveries and material kitting to ensure timely deliveries to progress construction works.

Organizing was highly connected to the main goals of the logistic operations. Ensuring the on-going hospital operations was one of the most important goals in all six studied projects. As the patients of the hospital are their customers, the goal to avoid hindering e.g. EMTs or surgeries due to construction or logistics

Table 2. Summary of the hospital cases and their CLSs.

Case	Country	Type of project	Timespan	Localisation	CLS	CLS initiator	Organizational location of CLS	Challenges encountered
A	Sweden	Renovation of main building Construction of new care buildings Construction of parking garage	7 years	Existing hospital campus in city centre	Checkpoint with waiting area outside the city	Regional council	Part of project management organization	Many stakeholders Focus primarily on relationships Limited mandate on adjacent construction projects Additional CLS within project
B	Sweden	Renovation of main buildings Construction of new care units	5 years	Existing hospital campus In vicinity of university campus	Terminal setup	Regional council	Below Regional Council	Complex CLS organization Use of CLS not mandatory Difficult information flows Not always clear delivery routes Even though response has been positive, only 10% of deliveries utilize CLS.
C	Sweden	Renovation of main buildings Construction of new psychiatric care unit	12 years	Existing hospital campus In vicinity of city centre	Checkpoint setup with waiting area nearby	Regional council	Below GC	Difficult to manage rule adherence Low level mandate in the beginning Difficult to create value for contractors
D	Sweden	Renovation of care units and laboratory Construction of new psychiatric care unit	5 years	Existing hospital campus In vicinity of city centre and residential areas	Terminal setup	General contractor	Below GC	Complex CLS organization Unclear mandate Difficult to manage rule adherence Ad-hoc planning No real planning system
E	Finland	Construction of a new trauma and cancer hospital	4 years	Existing hospital campus	Terminal setup with JIT deliveries Takt production	General contractor	Below GC	Unclear CLS organization Difficult project management model Low level of mandate Adjacent projects Coordination of sub-contractors Difficult to find cheap terminal space
F	Denmark	Renovation of existing buildings Construction of new emergency hospital and psychiatry wards	9 years	Existing hospital campus	Joint planning based setup.	Regional council	Part of project management organization	Changes in client organization Multiple CLSs in same project Low understanding and planning ability from contractors Material coordination within project

operations was central in all cases. At the same time, there is an overarching goal for all construction projects to be carried out and finished efficiently and on time. This means that there is a duality in CLS goals, i.e. one goal oriented towards the construction project and one goal oriented towards the hospital ongoing operations, and depending on which goal is the dominant one, this should affect how the CLS is organized.

However, even though the two goals are not necessarily conflicting, the cases show that the hospitals' goals took precedence over the construction projects' goals in the organising of designing the CLSs. In cases A, B, C, E, and F this is manifested in the CLSs being initiated by the regional councils or hospital regions with instructions to ensure that the hospitals could stay operational and that no EMTs were to be hindered. The CLS operator in case A, for instance, was given the brief that the project should be "the most well-functioning hospital project in the Nordic countries, with special emphasis on the people affected by the project", i.e. the patients and medical staff. The starting point was thus to build the CLSs from this goal, meaning that the entire design of the CLS was structured around as few disturbances to ongoing hospital activities as possible. Similar briefs were given in the other cases as well and as such, the main services of the studied CLSs aimed at controlling traffic to avoid clashes with EMT, patient flows and other hospital related deliveries, albeit in different ways (checkpoints, terminal setups, and planning based setups).

All the projects have seen challenges when it comes to enforcing the CLSs, and this stems from the goal not being primarily from the projects' perspective (A-C, F), meaning that the CLS is there for hospital operations and third parties, not for the contractors. Two cases defy this statement (D, E) where the CLS was initiated by the GC, or the GC had control over the CLS that was implemented. If the CLS is initiated from a client perspective, the client must invite construction representatives to get their input on the scope and structure of the CLS. After all, the GCs and subcontractors are the ones who will be utilizing the CLS.

In all six cases, the detailed design of the CLSs were outsourced to external parties (e.g. cLSPs, consultants, and CM companies), and their directives were to set up CLSs to meet the goals of on the on-going hospital operations. However, the different CLSs were given varying levels of mandate in the operational part of the construction logistics system which affected the organisation of CLS as part of the construction project, and the construction logistics flows. This can be illustrated by Case C where the regional council employed the cLSP to develop a setup based on minimizing impact on EMTs and accordingly provided a setup with a checkpoint and a full set of regulations. The council approved this, but hierarchically placed the cLSP under the GC. This left the cLSP restricted in its mandate to enforce the regulations of the CLS. In this case, the GC had not been consulted in the design process and consequently experienced that the CLS did not provide value for the construction project which led to low rule adherence, thus creating unnecessary disturbances to ongoing hospital operations.

In fact, this is a common issue in all the studied cases; the overall vision of the CLS initiator has not been integrated with the needs of the construction projects (GCs). Instead, the CLSs have been designed in ways that has led to GCs introducing their own competing CLSs (A, F) to ensure that their logistics works with the project. This has led to complicated logistics systems in cases A and F while simultaneously undermining the mandate of the CLS operator. Noteworthy is that in both these projects' CLSs were designed by the same CM company, but for different clients and in two different countries.

In five of the cases (A, B, D-F), the CLS organization has been complex with many stakeholders connected to the CLS to coordinate. Having multiple actors influencing the organizing of the CLS leads to low or unclear mandate for the CLS organization (A, B, D, E), and to issues in enforcing rules and regulations and getting connected stakeholders to adhere to these rules and regulations (C, D). A reason for the poor rule adherence seen in cases C and D is that the regulations were set at the initiation of the CLS but at the same time, construction projects typically have dynamic project organization with many subcontractors entering and exiting the project throughout its duration. Finally, we see that four of the projects (B, C, E, F) have had difficulties in creating value for the customers of the CLS, i.e. the GCs and subcontractors. Partly this stems from low planning ability and understanding for the need to manage logistics from contractors, but also from not including the GCs needs in the design of the CLS. Thus, including the contractors in the design process ensures that the CLS operator has the right mandate to enforce and monitor rule adherence. Case C is a prime example of when flexibility in regulations has led to the CLS transitioning from low-level mandate to higher mandate throughout the projects' duration. The GCs role in CLSs is important as they plan for the material deliveries which need to be aligned tightly with work and assembly schedule on site. Clients cannot manage the detailed work schedule. Instead, clients need to give GCs mandate and support to coordinate material deliveries for the benefit of the whole project and its surroundings.

The projects faced challenges in their logistics. Our analysis shows that the impact from adjacent and surrounding projects is often undervalued in the CLS designs (A, E). This is partly because of the overall mandate problem to affect surrounding projects and their organizations. In case A for instance, the city decided to build a bus station next to the access road of the hospital project, something that the hospital construction project had no mandate to control. This led to issues in getting deliveries through, but also increased the safety issue for patients and staff who were already affected by the hospital project. This indicates that more coordination is needed not only to align the logistics with ongoing continuous operations in the site surroundings but also to proactively identify adjacent project initiatives and their similar needs for logistic arrangements.

It was also found that insufficient planning of the CLS (F) and unclear and changing organizations, both among client (F) and actors responsible for CLS (B, D, E), leads to the limited implementation and value of the CLS. This is manifested as ad-hoc planning (D), the use of competing CLSs during the project (A, F), and in the low overall utilization of the CLSs (B). This indicates that in a complex hospital project where organizations and individuals enter and exit the project, specific attention should be paid to the continuity of the CLS implementation and monitoring when deciding on the services of the CLS.

Summary of the themes identified in the cross-case analysis:

1. The CLS is designed by a third actor and the visions of the CLS initiator, and the GC have not been matched during the design phase of the CLS leading to a situation where the CLS operator does not have the mandate to enforce rules due to their position in the organization of the project and due to the GC not being prepared to voluntarily follow the rules due to goal conflicts.
2. The CLS lacking mandate due to organisationally located on the outskirts of the project organisation, even though the CLS need to coordinate a complex construction project organisation, leads to low rule adherence.
3. A limited systems view of the surrounding actors plans and communication with the same meant that logistical challenges outside the hospital campus appeared during project time.
4. Insufficient planning of the CLS design, organisation and, changing actor responsibilities leads to limited utilization of the services and lack of value provided for GCs leading to a vicious circle of increased costs for logistics and low performance of the CLS.

Discussion

The cases show that hospital construction projects are complex, both from an organizational perspective with many stakeholders (Shipton *et al.* 2014), as well as from a logistical perspective with often busy and urban locations of the projects. Introducing a CLS is thus a must in these complex construction projects. However, as seen in the theme 3 of the cross-case analysis neither of the six cases has had the full systems view when deciding on CLS organizing. As highlighted by Eriksson *et al.* (2021), designing CLSs for complex hospital projects, a wider system analysis of flows also covering the surroundings needs to be undertaken. It is not enough with the coordination of the site and supply chain actors, also actors responsible for hospital operations and ongoing urban work needs to be included in the coordination. Instead, the resulting CLSs have not been able to enforce the necessary level of coordination, and the projects had a track record of conflicts related to logistics issues.

Two of the identified themes (1 and 2) highlight the lack of centrality in the location of the CLS organization in the project management. Cases A, B, C, and F are all located under the client and the project management whereas case D and E are under the GC. Similarly to the findings of Ekeskär and Rudberg (2016), we have seen that the higher up in the project hierarchy, the more mandate is potentially given to the CLS. However, what is also seen in the cases is that even if the mandate is given, it does not necessarily mean that rules are adhered to. This can be due to that even though the CLS is located under the client and project management, it is not necessarily seen as a central part of the project management organisation, and that the responsibilities resolving logistics coordination issues is not given priority (Loosemore 1999).

Theme 4 highlight the operational foci regarding logistics coordination among the studied hospital projects which is along the lines of what Ying *et al.* (2018) has noted in other types of construction projects. In the studied cases we identify three different foci: 1) security for hospital patients and staff, 2) on-site material flow coordination, and 3) flow coordination to and from the site. These three foci respond to either the goal of undisturbed ongoing hospital operations (1) or efficient construction project (2 and 3), i.e. theme 1. However, to meet the goals of undisturbed ongoing hospital operations as well as an efficient construction project, a combined view of the flows related to both these goals need to be considered. This requires strategic planning, providing an overview of all simultaneously ongoing works around the project (theme 3).

All the studied CLSs lacked centrality in the project and with rule adherence as an effect (theme 2). However, the complexity of the logistics in a hospital project is even more complex than just the complexity of managing the many actors involved in the project. To manage this level of coordination, the CLS needs to be centrally located with access to information from not only the project, but also from all ongoing operations in vicinity of the project. Preferably, this information also includes information on urban planning and traffic planning close to the hospital project (theme 4).

Furthermore, the CLSs studied were mainly designed from the perspective of their initiator, i.e. the client, by a third-party actor. However, the analysis show that the projects must integrate the contractor perspective with requirements of existing operations and urban settings when organizing the CLS (theme 1). Similar findings were presented by Janné and Fredriksson (2022) who found that contractors who took an active role in their logistics saw more value from the CLS, a challenge that the six cases presented here have all been subject to (theme 4). Allowing contractors to give input on the CLS organizing will also help with rule adherence. At the same time, these complex projects are characterised by different stakeholders entering and exiting the project throughout its duration (Lehtinen *et al*. 2019). The regulations must thus be set on a more general level and allow for development.

Thus, there must be room for the CLS to grow and evolve over time, both in terms of operations but also regulations. A construction project has, as pointed out by Kyrö *et al*. (2019), varying needs throughout the project duration. The CLS can thus not be static but rather it needs to adapt to any changes in the project or surrounding area to better match these evolving needs. To allow for this, the access to information is key. Otherwise, the CLS and the project will face a lack of knowledge of what adaptations are necessary.

Conclusions and implications

The purpose of the paper was to analyse how the centrality of the CLS in the project organization affects the coordination and conflict level in complex construction project management using a power dependency lens. The power dependency lens allowed us to identify four common themes leading to logistical problems;

1. The CLS was designed by a third-party actor, not managing to combine the visions of the client and the GC.
2. The CLS was not given enough power to mandate rule adherence.
3. The lack of systems view made the CLS lack information to effectively coordinate the flows of different actors within and surrounding the project leading to conflicts.
4. The lack of mandate and shared visions regarding services decreased the effectiveness of the coordination (low utilization of services).

This indicates that the higher up in the project hierarchy the easier it is to enforce rule adherence and thereby a better possibility of achieving the goals of initiating a CLS can be reached. This is a contribution to the construction project management theory. We also identify the still operational focus of the implemented CLSs. From a logistics management perspective, we identify three different foci of the CLS: i) security for hospital patients and staff, ii) on-site material flow coordination, and iii) flow coordination to and from site.

The findings have several implications to construction stakeholders (GC, clients, and cTPL). Logistics is about coordination of shared resources and should be dealt with as a strategic issue to reach potential benefits. First, the clients should give CLS a central role in the organization of complex projects, from its initiation to steering and potential conflict management. This impacts not only CLS design, but also how the logistics services are procured as well as the mandatory demands on its use to be included into the project contracts. The designed CLS also need to combine the three foci's taking a systems view of the whole area to be coordinated. Secondly, to improve the rule adherence and utilization of logistics services, the results of the study points towards the importance of including the GC in the design of the CLS. This provides improvements in the internal material flow (foci ii) at the site in addition to a better control of the flows to and from the site (foci i and iii). Involving the GC in the design of the CLS is thus a prerequisite to also reach productivity improvements in the project, not only decreasing disturbances to ongoing operations in vicinity of project. Finally, the study shows that the client and GC should in collaboration steer the CLS throughout the project. This means, that logistics issues and conflicts are actively discussed and solved at project management level, and that the content of CLS and the rules are proactively adapted for changes in the project or its environment.

In this study we have analysed six cases from Sweden, Finland and Denmark. The cases have provided insights from a variety of CLSs and the lessons learned from these cases are transferable to other projects as well. In practice, all hospital construction projects will be different from each other depending on where and how they are being built. However, we believe that the elements identified here are a good step in the right direction of understanding what to consider when organising complex project management organisations.

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Data availability statement

The authors confirm that the data supporting the findings of this study are available within the article.

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