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Supply Chain Management in Construction and Engineer-to-order Industries

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Abstract

The construction industry is a key sector of every country and the application of supply chain-related techniques holds much promise to improve performance of construction firms in many ways. According to an extended view, which encompasses the construction of industrial and residential buildings, of civil engineering and infrastructure projects, there is a number of major actors that must be coordinated in some way to reach ETO decisions, leading to performance outcomes and metrics. The need to co-ordinate information across the supply chain is a persistent and pressing challenge for ETO companies. Procurement helps to establish the conditions for the supply chain to function effectively. New technologies like product configurators or cloud manufacturing are being applied. Planning and decision making is a critical driver. In the future, the challenges of applying supply chain management techniques to a construction environment, will require more quantitative studies, to cast light on some potential gains from better information management and use of digital technologies. Then there is also an opportunity to integrate clear upfront planning and procurement with the project delivery processes, and choose the right configurations, focus and relational types. Finally, there is much potential to harness the innovation potential of SMEs.

Keywords:

supply chain management, engineering-to-order, construction industry

Introduction

We conceived this special issue on Supply Chain Management (SCM) in Construction and Engineering-To-Order (ETO) industries, published in Production Planning & Control, for a number of reasons. Firstly, the current literature on SCM in Construction and ETO industries is scant and scattered over a wide range of publications. Second, the construction industry and complex engineering work is a key sector of every country and the application of SCM techniques holds much promise to improve performance of construction firms and their projects in many ways.

The characteristics of many construction firms allow them to be placed in the domain of 'engineer-to-order' (ETO) situations, where products are designed, engineered and finished after an order has been received (Gosling and Naim 2009). The product design for each order is uniquely tailored to the customer's specification, including the development of order-specific product content, such as Bills of Material, drawings, and manufacturing work instructions. The variety of work

in ETO companies, the customized, complex products and the underlying uncertainties of markets, all indicate that SCM-related processes need to be integrated with other core processes, including tendering and design.

These distinctive features of ETO industries influence the potential application of established Operations Management and SCM techniques, and it is still not clear which approaches can be adopted, need to be adapted, or are not suitable. This journal has been instrumental in developing the discourse related to construction supply chains (e.g. Behera et al. 2015; Tezel et al. 2018), as well as the broader conceptualisation of ETO supply chains (Adrodegari et al. 2015; Birkie and Trucco 2016; Gosling et al. 2015; Pero and Rossi 2014). Such work establishes a good platform for this special issue and make PPC an ideal outlet for building on these debates and synthesising a range of related papers.

In this special issue, we demonstrate the breadth of challenges for construction and ETO situations, spanning procurement, logistics, supplier and supply chain management, innovation and complexity management, as well as adopting new technologies. Issues of lean and performance measurement and management are also prominent. The papers included focus on a range of industrial contexts, including shipbuilding, construction, machinery, as well as 'megaproject' situations.

Papers in this volume focus on the links between supply chain management (SCM) and construction projects. SCM challenges in construction projects are unique because they deal with deliveries for one goal – completion of the overall project. Suppliers play a large role, with engineered to order components that face engineering change orders to balance the project's evolving demands given long project completion times. For megaprojects with significant project complexity, management is often handled by a third-party logistics provider. There are also many choices of decision systems to balance the interests of stakeholders. The papers in this volume frame questions and provide insights for all of these contexts.

The cases discussed range from construction management, to shipbuilding, to rail projects, to university hospitals to aerospace engines and provide a rich variety of problem contexts. This diversity of construction projects highlights the opportunities to use the tools discussed by the authors. These cases characterize project complexity, socio-political issues and the need to understand local authorities' perspectives. Emerging digital tools such as cloud manufacturing are also discussed. The methodologies used include ideas from the SCOR model in SCM, Analytic Network Process, multiple case studies, detailed interviews, and literature surveys. This showcases the diversity of research tools used to understand the problem.

A framework to categorize special issue papers and discuss future research

For the reasons outlined above, in conceiving this special issue, we took an extended view of the Construction industry and ETO supply chains, which encompasses the construction of industrial and residential buildings, of civil engineering and infrastructure projects such as road, railways and bridges. We also included a wide range of ETO products where the execution of engineering activities to complete each order is required.

An overview of the actors and drivers explored in this special issue is shown in the Figure 1. It shows the major actors that must be coordinated in some way to reach ETO decisions, leading to performance outcomes and metrics. At the center, we see crucial decision categories covered in this special issue, including planning decisions, supply chain decisions, project management decisions, and the adoption of technologies to manage information flows.

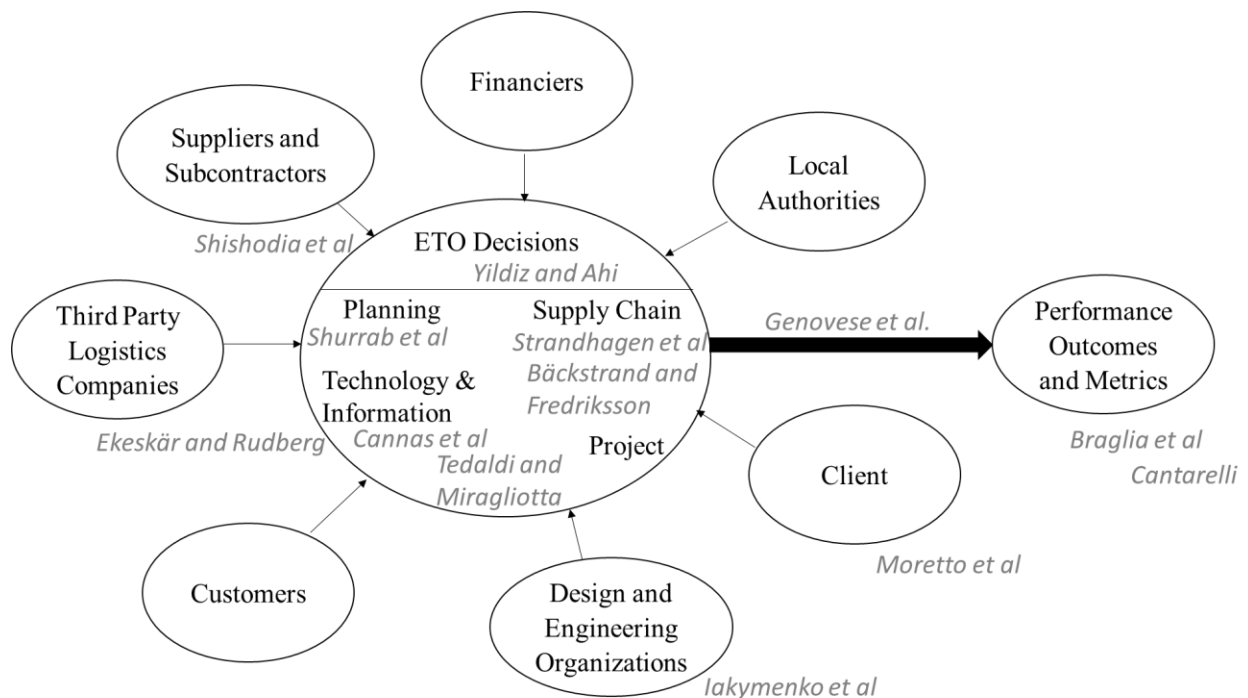


Figure 1: A common framework

Each of the papers, in some way, explores the areas and interactions between the actors and drivers shown in the Figure. Some key themes and clusters of papers are summarized below:

- *The need to co-ordinate information across the supply chain is a persistent and pressing challenge for ETO companies.* Bäckstrand and Fredriksson show the challenges of managing information across the supply chain in the construction sector, while Strandhagen, Buer, Semini, Alfnes, Strandhagen explore how Industry 4.0 technologies can help to co-ordinate information across the supply chain for better outcomes in shipbuilding.
- *Procurement helps to establish the conditions for the supply chain to function effectively.* Genovese, Morris, Acquaye and Koh explore the interface between public procurement organizations and contractors, and the impact of different configurations. Moretto, Patrucco, Walker, Ronchi highlight the need for a contingency based approach in the procurement strategy.

- *New technologies are being developed and applied.* For instance, Cannas, Masi, Pero, Brunø focus on the potential of product configurators to customize products, while Tedaldi and Miragliotta demonstrates an application of cloud manufacturing paradigm.
- *There are possible new logistical patterns and arrangements to consider.* Ekeskär, Rudberg show that it is possible for third party logistics companies to play a role on construction supply chains (where they have not, typically, been widely used), and may help to establish an interface between the supply chain and the construction site.
- *Planning and decision making is a critical driver, and it can be supported by better co-ordination, tools and techniques.* Shurrab, Jonsson, Johansson highlight the need for co-ordination across functions and organizations within the tactical planning horizon. Yildiz and Ahi propose a tool based on the Supply Chain Operations Reference (SCOR) model, and find that the tool has the potential to improve decision quality regarding cash cycle time, return on working capital and perfect order fulfillment. Braglia, Dallasega, Marrazzini develop a framework to identify ETO construction losses and their causes, and propose a metric named Overall Construction Productivity to measure an overall impact of losses. Cantarelli show that complexity and innovation may create additional risk and uncertainty, impacting on project performance. Shishodia, Verma, Jain identify the factors that contribute to the resilience of suppliers and propose a technique to measure supplier resilience which should help companies to select, segment and develop their suppliers.
- *Engineering and design changes are typical in ETO situations, but can be managed.* Iakymenko, Brett, Alfnes, Strandhagen show the scale of the problem of managing engineering change, but provide a range of practices which have the potential to help management them. For instance, design freeze, standard operating procedures and design for manufacture.

Summary of Papers in this Special Issue

This section provides a review note of the papers included in this special issue. According to the presented framework, a significant part of the issue is dedicated to the interaction of different actors of the construction industry and ETO supply chains, the coordination among them, and the configuration and the integration of functions within them.

The paper “*An investigation into design and performance of supply chains for public procurement projects*” by Genovese, Morris, Acquaye, Koh analyzes the role of local authorities in ETO supply chains and their impact on the ETO decisions. The authors motivate their investigation based on public procurement accounting for 16% of total GDP of member states. They investigate how public organizations coordinate and contract firms to deliver local economic benefits from large scale publicly funded projects while accounting for power relations between public and private entities. In particular, they examine how the procurement process can be used by local authorities as a leverage to manage stakeholders and the activities of agents to best achieve a range of economic and social objectives. They analyze 4 different supply chain configurations obtained from an empirical study of procurement practices used by the local authorities across the Yorkshire and Humber region of the United Kingdom to deliver public projects, and study interactions of different stakeholders and the impact of these interactions on different procurement out-

comes. The data consists of over 150 web-based questionnaires, 20 phone interviews with companies, interviews and focus groups with 10 local authorities. Although there is no single configuration that dominates others in the analyzed criteria for local authorities, the authors highlight advantages and disadvantages of each of them and summarize their findings by linking each configuration to local government ideologies and public project deliveries. They emphasize that social and economic benefits arising from public project could be maximized only when the local authorities promote their agenda at all levels of the supply chain. When local authorities make decisions regarding public procurement, their relationship to stakeholders impacts performance. Likewise, when third party logistics providers mediate suppliers to a construction project, their balancing role may be evaluated differentially across supply chain participants.

The role of the third-party logistics providers is studied in the paper "*Third-party logistics in construction: Perspectives from suppliers and transport service providers*" by Ekeskär, Rudberg. Third party logistics providers impact the 60-80% of work accounted by buying materials and service work done by suppliers and subcontractors. Recently, the use of third-party logistics providers in construction industry has increased due to the lack of SCM and logistics knowledge among clients and contractors. However, little is known about the role of third-party logistics (TPL) in construction supply chain. Since employing a TPL provider has a great impact on the structure of the traditional construction supply chain affecting all parties involved, and there is a lack of research on the upstream parties, there is a need for studying the perspectives of upstream tiers on TPL solutions in construction. The authors investigate how suppliers and transport providers, as a part of a TPL solution in construction, are affected by the use of the TPL solution. They provide results from a 2.5 years longitudinal case study of a hospital construction project. For the project, all manufacturers and supplier deliveries were sent to a checkpoint managed by a TPL, with material brought in by the TPL between 4 pm and midnight to reduce disturbance to hospital activities. Data consisted of surveys of manufacturers, wholesalers, building merchants and transport providers about the TPL's role. They conclude that consistent with findings from a literature review, suppliers and transport providers are positive towards TPL solutions since it helps to establish an interface between the supply chain and the construction side, however the suppliers perceive that the contractors benefit more from TPL solutions. Nonetheless, it is found that both the suppliers and transport providers have a willingness to address the necessary issues needed to realize SCM. They emphasize that with the further use of TPL in construction industry upstream tiers should be included more in determining the delivery process, policies and regulation to benefit fully from TPL solutions.

Given that firms rely on suppliers to obtain 80% of their materials and components in many contexts, the procurement configuration impacts the performance as well. The paper "*Procurement organization in project-based setting: a multiple case study of engineering-to-order companies*" by Moretto, Patrucco, Walker, Ronchi studies a procurement organization in project-based companies, in particular, focusing on large-scale construction and ETO projects. The authors investigate how the procurement organization can be designed and how it can be made flexible and adaptable to changes in a project context. They study how project features, customer features and company features impact project performance. They apply contingency theory which sug-

gests that organizational design characteristics should match external and internal factors affecting the organization to achieve strong performance. A multiple case study approach involving 11 companies is used to derive the results. The analyzed case studies showed that there are two extreme typologies for procurement in project-based companies: the “procurement-focused organization” and the “project-focused organization”, with a hybrid approach in-between, which implements some of the features of the two topologies. Project strength, time pressure and level of customization are found to be critical factors for project-based companies that would push toward the adoption of a project-focused configuration. The size of the company is important as well, it has been found that big companies would more likely adopt a procurement-focused organization.

Multiple suppliers involved in the procurement process of ETO projects, e.g. construction project, often face a low information availability among themselves, which leads to the lack of coordination among actors in the supply chain and impacts the supply chain performance. Inability to coordinate actions of supply chain parties results in less than 40 % of construction projects delivered successfully. The paper *“The role of supplier information availability for construction supply chain performance”* by Bäckstrand and Fredriksson focuses on the analysis of the construction supplier’s coordination needs and the degree of their current information availability. It has been suggested that the problems with information availability differ between suppliers who continuously supplied materials to the site and suppliers who did so only intermittently. Thus, 4 suppliers, 2 with continuous supply and 2 with intermittent supply, that deliver materials and/or tools for production have been selected and analyzed. The authors summarized information-sharing activities between the construction site and the suppliers in terms of the 6 factors affecting information availability. The empirical study has shown that information availability is a real problem for construction supply chain suppliers. The main contractors, the ones responsible for the coordination of supply chain, do not see the effects of low information availability on the supply chain, although the supply chain performance effects have been found at both ends of the supply chain. The delivery pattern has been shown to affect both the information available to and the information needed by the suppliers. Suppliers with intermittent supply have less access to the information on-site due to their lack of presence there, and therefore suffer more from the lack of information sharing. Suppliers with continuous supply can use their presence on site to increase their service offerings to main contractors, which allows them to improve their information availability and eventually their supply chain performance. Therefore, a supplier could be not just a receiver of the information, but also a gatherer.

The temporary coordination among different organizations in project-driven supply chains (PDSC), e.g. construction supply chains, introduces new risks that might hurt project performance, and cannot be efficiently handled by the traditional project risk management techniques. To analyze risks and increase the resilience of PDSC, new approaches that would allow to handle uncertain and unpredictable scenarios are required. The paper *“Supplier Resilience Assessment in Project-Driven Supply Chains”* by Shishodia, Verma, Jain analyzes the sources of risks on the supplier side of PDSC and studies the factors that contribute to the resilience of suppliers in PDSC. The identified factors could be helpful in developing managerial guidelines for assessing suppliers, decision-making and devising strategies to control them effectively. The authors measure

supplier resilience using grey relational analysis, which implies assessment of supplier ratings and assigning of weights to supplier attributes, and calculate a resilience score for every supplier. Based on the resilience score, suppliers are prioritized according to their level of resilience capabilities. The score could give early warning signals to a project manager and have a more proactive supply relationship management. The proposed technique has been tested for two case studies and managerial insights have been provided into how to reduce the risks of the suppliers according to their scores. Using the performance scorecards of the suppliers should help organizations in choosing the right strategies for selecting, segmenting and developing their suppliers. Although gaining the right amount of information and evaluating the risks are essential for a better decision making, it might not be enough to improve the performance.

The paper *“Innovative decision support model for construction supply chain performance management”* by Yildiz and Ahi emphasizes the need of a proper decisions support tool to increase supply chain management performance. The authors propose a tool based on the Supply Chain Operations Reference (SCOR) model. The model offers a common set of supply chain performance metrics, which are compared, weighted and prioritized using a combination of methods: Analytic Network Process (ANP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and The Decision-Making Trial and Evaluation Laboratory (DEMATEL). Since a single method might lead to a wrong decision and inefficient allocation of the resources resulting in a higher cost, the authors suggest to use a combination of the above-mentioned techniques to overcome these disadvantages and provide a better decision support system for the managers. The implementation process has been demonstrated using a case study of a construction company. The tool has helped to select the most effective supply chain performance metrics, rank them according to their score and use the ranking to help managers to take more precise decisions on improvements. Their results show that use of the tool has the potential to improve decision quality regarding cash cycle time, return on working capital and perfect order fulfillment. Since ETO projects often require some customization, they are characterized by a greater complexity, that has a negative impact on the balance between supply and demand, and, in turn, on the performance. Due to the complexity, ETO companies could respond to the supply-demand imbalance only within tactical planning horizon with the intensive communication between different demand- and supply-facing departments, called cross-functional integration.

The paper *“Managing complexity through integrative tactical planning in engineer-to-order environments: Insights from four case studies”* by Shurrab, Jonsson, Johansson studies the customer fulfillment order process (COFP) as one of the tactical-level planning processes that requires a high-level of cross-functional integration. In particular, the authors look at different mechanisms used in ETO projects to realize cross-functional integration and how these mechanisms mitigate the negative impact of complexity on the demand-supply balance. The authors conducted interviews with 19 managers across 4 companies over 27 occasions to study their COFP decisions. They provide a set of propositions on detail and uncertainty as components of complexity in demand-supply relationships and how their can be reduced using different coordination mechanisms. Based on the propositions, they presented a framework for managing complexity in ETO projects. Complexity of ETO construction projects and inability to proper coordinate off-site fabrication and on-site installation of the components by various suppliers results in a high amount

of non-value adding activities on-site, which negatively impact the performance. Therefore, construction projects are often known for long lead times and budget overruns.

The paper *“Overall Construction Productivity: a new Lean Metric to identify construction losses and analyze their causes in Engineer-to-Order Construction Supply Chains”* by Braglia, Dallasega, Marrazzini analyzes and classifies losses of Engineer-To-Order construction projects, and suggest a new metric, Overall Construction Productivity (OCP), to evaluate the impact of identified losses. OCP is a product of three components: External Influence Mitigation, which covers losses due to inefficiencies that are external to the first-tier supply chain, Internal Supplier Effectiveness, which determines losses due to inefficiencies that are internal to the first-tier construction supplier but external to the installation on-site, and On-Site Effectiveness, which reveals the causes of losses internal to the installation on-site. Since problems in a construction project are often interrelated, there is a chain effect of losses. The proposed OCP metric helps to decouple different types of losses to avoid a chain effect and define the appropriate improvement actions in time. The authors present the results of successfully applying the proposed framework for a ETO façade supplier company and a hospital construction project, and discuss the strength and limitations of the approach.

The complexity of megaprojects is even higher, which often results in a failure to achieve planned cost, schedule and revenue targets. One of the reasons is an inability to innovate and adapt to new unexpected circumstances. The paper *“Innovation In Megaprojects and the Role of Project Complexity”* by Cantarelli focuses on the interaction between project complexity, innovation and performance in megaprojects using a multi-case study approach. Project complexity has been characterized based on structural dimensions, uncertainty, dynamics, pace and socio-political issues. The paper does case studies of TGV Med in France and HSL South in the Netherlands. Data sources include papers as well as government reports. The authors identify for each case the aspects of innovation, the complexity dimensions that were drivers of innovation, and the impact of innovation on the project performance. They develop a set of propositions on the relationships between project complexity, innovation, and performance, and policy implications. For example, interactions between project complexity and innovation may create additional risk and uncertainty in delivery for megaprojects. The authors state that innovations increase uncertainty which can impact project outcomes. They recommend an ex-ante evaluation adopting both a tactical and strategic performance perspective, and considering alternatives to innovations to deal with complexity.

Due to length and complexity of Engineer to Order (ETO) projects, engineering changes (EC) are often required. If the changes are implemented successfully, it can bring additional profit to a company and provide a competitive advantage. Although a lot of practices and tools have been developed to effectively and efficiency implement ECs in ETO projects, companies still report cost and time overruns due to ECs. The paper *“Analysing the factors affecting engineering change implementation performance in the engineer-to-order production environment: case studies from a Norwegian shipbuilding group”* by Iakymenko, Brett, Alfnes, Strandhagen identifies potential contingency factors that impact the implementation of engineering changes in ETO projects and analyzes their effect on the EC implementation performance: cost, time and profit margin. The

authors study six ECs in a Norwegian shipbuilding company and investigate eleven contingency factors that play a role incl. EC type, time of EC occurrence, maturity of the product design and technology, experience, knowledge and skills of design and engineering staff, etc. Based on the analysis of the results, several propositions have been developed how these factors impact the implementation performance. Recommendations on the tools and practices that can be used by ETO companies to eliminate negative impacts of ECs are provided. The study suggests that allocating as many ECs as possible to the beginning of the project allows to reduce high supply chain related costs.

Although the Engineer to Order (ETO) industry deals with complex, customized products, in the current competing environment it faces the same challenges as other industries, including pressure to reduce time-to-market, decrease costs, improve performance, and shorten a product life cycle. Mass customization is one of the strategies that helps to address these challenges. To succeed in mass customization, a company needs to have three capabilities: solution space development, robust process design, and choice navigation. The last one allows customers to choose or configure the product that matches their needs, and it is implemented using product configurators, applications that translate customers' needs into product requirements. The most commonly reported benefit of product configurators is a lead time reduction. The paper *"Implementing configurators to enable mass customization in the Engineer-to-Order industry: a multiple case study research"* by Cannas, Masi, Pero, Brunø studies the challenges that ETO companies face when implementing product configurators to enable mass customization and how companies manage these challenges. The authors perform study seven ETO companies, using face to face interviews, document analysis and company visits to gather data. All companies reported that the implementation of the product configurator makes easier to manager mass customization in ETO companies, however there are certain challenges to consider. It has been observed that companies at different stages of the implementation phase face different challenges. The actions taken by companies are summarized. As a result, a practical tool for the implementation of the project configurator is presented.

In addition to the "common" project challenges faced by ETO companies, there is an increasing pressure from the manufacturing side of their supply chains to focus on the sustainability of their operations. Nowadays, various digital technologies are available that could help companies to attain more sustainable operations if applied correctly. The paper *"Sustainability challenges and how Industry 4.0 technologies can address them: A case study of a shipbuilding supply chain"* by Strandhagen, Buer, Semini, Alfnes, Strandhagen identifies sustainability challenges and explores how Industry 4.0 technologies can enhance sustainability of ETO supply chains, in particular, addressing the issues of shipbuilding industry. Through an empirical investigation of the shipbuilding industry and reviewing relevant literature, the authors derive a list of sustainability challenges that the shipbuilding industry faces at different phases of a ship's life cycle. They provide an overview of relevant digital technologies and address links between sustainability, digitalization and manufacturing for the life cycle of ships. The authors present 9 different scenarios how digitalization can improve sustainability in the shipbuilding industry. The paper provides a guideline for researchers on future research topics about sustainability and digitalization in ETO companies, and for practitioners regarding the potential application areas for digital technologies.

Another “modern” concept that has received a lot of interest among researchers and practitioners is the cloud manufacturing. Cloud Manufacturing (CM) or “Manufacturing version of the Cloud Computing” is a service-oriented model that shares manufacturing capabilities and resources on a cloud platform with multiple users. The paper *“The role of Engineering-to-Order machinery manufacturers in future Cloud Manufacturing supply chains: a business case and a strategic perspective”* by Tedaldi and Miragliotta demonstrates a real-life application of the CM paradigm in ETO industry. The paper is based on interviews with the Chief Technical officer of an ETO machinery manufacturer that provides on-demand manufacturing services in the metal industry through a CM platform. The authors highlight the role of the manufacturer in the implementation and development of the CM paradigm as a relevant contributor, and emphasize that the use of the CM platform could be a strategic benefit for the growth of the manufacturer.

We hope you enjoy this research journey through rich contexts in construction management and supply chains, get challenged by the opportunities to improve performance of projects and megaprojects, and learn about best practice ideas. More importantly, we look forward to continued research that can improve project outcomes and deliver outside benefits to companies and society.

Future research directions

The papers in this volume showcase how supply chain management is challenging in a construction environment, given long lead times, changing specifications and project complexity. While the cases provide a rich base of domain knowledge, there remains a range of opportunities to build more decision support solutions that can coordinate across stakeholder preferences, and enable optimization. More specifically, we propose a number of areas for future research, which are summarized below.

First, there is an opportunity to develop the body of knowledge to include more quantitative studies. As is shown from this special issue, there is great value in the context offered by qualitative studies. However, as the ETO field moves forward to a position of maturity, there are many opportunities to gather insights from larger quantitative datasets. In particular opportunities to apply tools from game theory, multi-objective optimization, statistical data exploration to shed even more insights. But that requires a comprehensive dataset that gathers projects across industries and characterizes their attributes.

Second, technological advances generate many opportunities (but also challenges!). Papers in this special issue have demonstrated some of the potential gains from better information management, use of digital technologies, product configurators and cloud-based services. Technology can play an important role in the co-ordination of information requirements across the stakeholders and we will likely see this trend continue and accelerate across ETO type industries. Research that supports the way in which these technologies can be adopted and exploited for improvement would be very welcome.

Third, there is also an opportunity to consider the appropriate management structure and governance to deliver desired outcomes. We see from papers *“An investigation into design and performance of supply chains for public procurement projects”* by Genovese, Morris, Acquaye, Koh, and *“Procurement organisation in project-based setting: a multiple case study of engineering-to-order companies”* by Moretto, Patrucco, Walker, Ronchi, in particular, the need to integrate clear upfront planning and procurement with the project delivery processes, and choose the right configurations, focus and relational types. These contingency based prescriptions are valuable, and we would welcome more evidence to show which configurations work, and which do not, according to different situations. In terms of the governance of the project process, there is a danger that project decision making is too centralized and thus vulnerable to error, or it is too decentralized and lacks coordination. Research into the right balance of centralized vs decentralized control may shed insights.

Finally, there is much potential to harness the innovation potential of SMEs. The paper *“Innovation In Megaprojects and the Role of Project Complexity”* by Cantarelli notes the intricate relationship between complexity and innovation in megaprojects, and this observation can be extended to the area of SMEs. The latter play a vital role in niche industries, specialist capability and local economies, and hence, it is vital that public clients and large engineering organizations find ways of engaging with SMEs. We would welcome further research that would support, or increase our understanding, of these processes.

Concluding Remarks

The construction industry and complex engineering work is a key sector of every country and the application of Operations and SCM techniques holds much promise to improve performance of construction firms and their projects in many ways. In this editorial, we have conceptualized construction and complex engineering projects as ETO supply chains, where products are designed, engineered and finished after an order has been received. This facilitates discussion across sectors, as well as adaptations to mainstream SCM theory and practice. We have also presented an outline framework to categorize the papers in this special issue. This, hopefully, serves as a helpful guide to the reader, but also contextualizes the wider challenges of implementing operations and SCM concepts. We hope our readers help the field by taking up the challenge of understanding these more complex interactions shown in the framework and their impact on project success.

Common themes arise from the papers included in this special issue, including those related to procurement, logistics, supplier and supply chain management, engineering changes, innovation and complexity management, as well as adopting new technologies and performance measures. We see these issues explored in a range of industrial contexts, including shipbuilding, construction, machinery, as well as ‘megaproject’ situations, primarily through case-based approaches. Looking across these papers, our suggested areas for future research are to give further insights and guidance for technological advances in ETO supply chains, further development of appropriate management and governance structures to deliver desired outcomes, and research investigating the innovation potential of SMEs. Overall, while qualitative approaches have given much

insight, as the field evolves, an increase in quantitative studies may provide useful clarity. A final comment concerns contingency, which has formed the theoretical basis for a number of papers in this special issue. There is still a relevant challenge for researchers to understand and explain which approaches work in different situations, and to show the relevant evidence and prescriptions.

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