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Contextual effects on the LSS implementation in networked service environments

A critical realism case study for the Port of Houston

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Abstract

Purpose – The purpose of this paper is to investigate the contingency effects that contextual factors of a networked service environment have on the phased Lean Six Sigma (LSS) implementation frameworks.

Design/methodology/approach – This paper employs the critical realism (CR) case study research methodology to examine the contingent and causal relationships between contextual configurations of business networks, the DMAIC or PDCA phases in an LSS implementation agenda, and business management functions. The authors conducted a single case study on the basis of challenges they met in kicking off lean transportation in the Port of Houston.

Findings – The key finding from the study is a mid-range theory regarding the contingency effects of contextual factors of service business networks on the phased LSS implementation frameworks. The authors found that when there are complexity and dynamics of contextual factors at the field layer, management should focus more on tasks in early LSS phases to emphasize influencing. When there is no centralized authority in the network and the value-system is loosely coupled, management needs to execute more tasks as described in the define, measure and analyze phases with the purpose of both influencing and orchestrating. When individual actors have goals not aligned well with the goal of the business network and have unmatched operations capabilities, these factors should be considered as early as possible in these LSS phases. When a business network has complicated business processes with high unpredictability and uncertainty and individual actors' value-creation systems are not well embedded in the entire value-creation system, PDCA will be the preferred core structure of an LSS implementation agenda.

Research limitations/implications – This study contributes to the LSS research stream by introducing a causal/contingency model that prescribes the contingency effects of three contextual configurations on LSS implementation. It also contributes to the emerging discipline, business network management, regarding how to use LSS frameworks in strategic planning. It also contributes to the CR school of problem-driven case study by using a strategic initiative framework as a platform and each phase in the framework as a unit. This conceptualization of the entity of interest helps explore the interactions among three theoretical constructs: contextual configurations, phased LSS implementation agenda and management functions.

Practical implications – Managerial implications of this study are twofold. One is the procedure of analyzing the impacts of contextual factors on the causal relationships between LSS implementation phases and network management functions. The entire procedure represents the agenda-setting process of LSS implementation, the most daunting and challenging managerial task in LSS projects. Another one is the guideline on how to determine whether DMAIC or PDCA is appropriate for the LSS agenda when used in a networked environment.

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Originality/value – This paper would serve as an excellent resource for both academicians and LSS practitioners in initiating, orchestrating and managing an LSS project in a networked service environment. This study represents the first effort to explore the impact of contextual factors of business networks on lean transformation.

Keywords Contingency, Critical realism, Sense-making, Lean and Six Sigma, Business network management, Orchestrating

Paper type Research paper

Introduction

Lean Six Sigma (LSS) has gained popularity and acceptance as an integrated framework incorporating both lean and Six Sigma (Antony *et al.*, 2017). LSS has been successfully applied in individual organizations in both manufacturing and service contexts such as the auto industry, education, electronics, construction, software development, call centers, healthcare and logistics services (Albliwi *et al.*, 2014). The implementation and benefits of these LSS projects have been well documented by industry, including the description of how generic LSS principles, tools and frameworks are adapted or modified to fit a particular context (Hadid and Afshin Mansouri, 2014). Meanwhile, scholars have made efforts to understand the theoretical underpinnings of the power, effectiveness and boundary (if any) of the LSS method in order to guide LSS project implementation and prescribe expected business outcomes (Pepper and Spedding, 2010; Assarlind *et al.*, 2013; Albliwi *et al.*, 2014; Antony *et al.*, 2017).

However, all those industrial anecdotes and academic endeavors regarding LSS are largely confined at the level of individual organization with autonomous authority. There is no existing study to investigate how an LSS project is initiated and implemented in a network environment in which value is co-created by multiple stakeholders with autonomous authority. Such a business network has become an emerging yet crucial organization form worthy of academic attention (Håkansson and Snehota, 1989; Anderson *et al.*, 1994; Möller and Halinen, 1999, 2017). Research on network management has evolved into an emerging discipline that extends the boundary of organizations and management studies to the network level (Möller and Halinen, 2017). Literature shows that in managing business networks, managerial emphases have been shifting from planning, organizing and controlling to influencing, orchestrating and managing (Möller and Halinen, 2017). These management functions are highly dependent on context factors spanning from the field and network layers to the focal ecosystem and actor layers. Extant management theories and methodologies should be revalidated or re-tested before being applied in the context of networked business.

Given the power and effectiveness of LSS and the prosperity and proliferation of networked economy and network management research, a question remains unanswered: "Can we apply LSS in a networked business context to improve its efficiency and effectiveness?" If the answer is yes, the follow-up questions would be "How could the phased, or core-structured LSS implementation frameworks such as DMAIC or PDCA be contingent on the contextual factors of the business network?" "What are the contingent effects of contextual factors from different layers of a business network on the entire DMAIC or PDCA LSS implementation framework and each individual phase of DMAIC or PDCA?" "Will the unbalanced LSS knowledge and experience among key actors in a business network affect the process of influencing, orchestrating, and managing the adaption and implementation of LSS over the entire network?" "Regarding the effectiveness of LSS implementation, what kind of existing LSS toolkits will be effective and will the effectiveness of these toolkits be also contingent on contextual factors?" Answers to these questions will contribute to both the LSS and business network management theories and practices.

This study is one of the first academic endeavors to explore the contextual impacts on the implementation of LSS methodology in a networked service environment. Whether LSS implementation will be affected by contextual factors has been the focus of the debate between the contingency and universal perspectives on LSS implementation at the level of the individual organization (Sousa and Voss, 2001). The former argues that it is critical to consider contextual factors when determining an LSS implementation approach or procedure (Shah *et al.*, 2008; Psychogios *et al.*, 2012; Swink and Jacobs, 2012), especially for companies in an industry where LSS is new (Plsek, 2014). The latter argues that a well-structured LSS implementation framework such as DMAIC or PDCA can be applied in any business environment (Salah *et al.,* 2010). This perspective is buttressed by industrial anecdotes that both DMAIC and PDCA are well-structured tools with rich knowledge accumulated over the past three decades from successful applications in many industries (Bortolotti and Romano, 2012; Sreeram and Thondiyath, 2015). We argue that at the network level, an LSS implementation will be contingent on the contextual factors embedded at different layers of a network, albeit that it may arguably be true that the LSS implementation process is universal at the autonomous organizational level.

Our argument is based on the latest theoretical advancements in business network research. First, in the context of a business network, both the strategizing and executing processes are different from those in the context of individual firms. This is because management needs to emphasize more on visioning and sense-making the business objective of the entire network, and constructing and maintaining a management agenda that involves collective actions from all institutional actors across the network (Mason *et al.*, 2017). Second, all sub-dimensions at each layer of the environment, network or focal ecosystem and actor are context-dependent (Möller and Halinen, 2017). The complexity and dynamics of these sub-dimensional contextual factors may affect the power and effectiveness of existing LSS implementation frameworks, such as DMAIC and PDCA. In the context of LSS implementation at individual autonomous organizations, either DMAIC or PDCA can be used both as a visioning tool and an implementing agenda. One concern is that DMAIC and PDCA may be the same epistemologically, but they are different ontologically. In other words, their roles and effectiveness on influencing, orchestrating, and managing may be different. Third, the process of kicking off an LSS project in a networked environment will be different from initiating an LSS implementation in an individually autonomous organization (Möller, 2010). Either the top–down or the bottom–up approach of LSS initiation will not work in a networked environment because no institutional actor has the power to dominate the entire network and the value-creation process is segmented and "owned" by different actors and among them, trust is an issue.

We propose three ambitious goals in this study to support our above arguments. First, we investigate the contingency effects of individual sub-dimensions at each layer of NetFrame on LSS implementation. NetFrame is the general theory of network management proposed by Möller and Halinen (2017) on the basis of their two-decade research on business network management and latest advancements in the research streams under the overarching umbrella of network management. We will review Netframe in the "Related work" session. Second, we will explore the interactions between the sub-dimensions of NetFrame and each of the DMAIC or PDCA phases. From the business network management perspective, we regard DMAIC and PDCA as the platform of LSS implementation, in which management will perform major functions of managing business networks, including influencing, orchestrating and managing (Möller and Halinen, 2017). Third, we will compare the effectiveness of DMAIC- and PDCA-cored LSS implementation platforms with regard to the management activities in NetFrame – visioning, sense-making and agenda-setting. To date, no study has explored if the DMAIC- and PDCA-cored LSS frameworks are fundamentally the same at the individual firm level or extending to the network level.

This paper will proceed from an overview of related works on the contingency stream of LSS implementation and contextual factors encompassed in NetFrame. We will then discuss our research methodology and design from the perspective of critical realism case study

(CRCS) research (Easton, 2010; Wynn and Williams, 2012). After that, our analysis procedure will be described, and research findings will be presented, including our research goals. Finally, we generalize our research findings from the perspectives of contingency and configuration of LSS implementation and make some suggestions for future research.

Related work

Because the purpose of this study is to bridge two independent research streams – LSS and business network research, we will provide an overview of each of them. Both streams have evolved with many publications and perspectives over the past two decades. Here, we will focus our review on the literature relevant to the implementation framework of LSS and the recently proposed NetFrame. In this study, a networked service environment as the research context is used. We also provide an overview of Roth and Menor's (2003) theoretical framework on a service delivery system (SDS) to provide a different configuration of the contextual factors in networked service environments.

Lean Six Sigma

Lean is a management philosophy that emphasizes the elimination of waste while letting the customer pull value through a system (Womack and Jones, 1996). Six Sigma is a process improvement method with a structured roadmap and a set of variance reduction toolkits (De Koning and De Mast, 2006). LSS is the integration of lean and Six Sigma methods (Sheridan, 2000; Shah *et al.*, 2008), which combines the lean tools of waste recognition and removal with the Six Sigma tools of variance reduction and control. LSS has evolved from a theory of scientific management and continuous improvement to become a stand-alone methodology to improve business performance (Laureani and Antony, 2012); see Antony *et al.* (2017) for a brief overview of LSS.

Before the introduction of VSM (Rother and Shook, 2003) and later A3[1], people viewed lean as a philosophy and mostly applied lean principles with the DMAIC methodology to solve specific problems (Pepper and Spedding, 2010). This explains why early studies (i.e. before 2000) viewed LSS as a mix of lean and Six Sigma, and later studies (i.e. between 2000 and 2010, before A3 gained popularity) viewed lean and Six Sigma as fully integrated. Because LSS deployment and implementation models vary widely, the literature suggests developing a body of knowledge or using an LSS implementation framework (Mader, 2008; Jayaraman *et al.*, 2012) that fits the context of implementation. These frameworks focus on continuous improvement cycles which enable firms to methodically choose the appropriate lean and six sigma tools to ensure that the root-cause of the problem is addressed prior to suggesting improvements.

The adoption of lean and six sigma has evolved from individual entities to a networked environment. For instance, lean practices applied in Toyota's supply chain enable the Toyota Production System to be effective, and without it, they would not be able to achieve low inventory levels, high quality, and other benefits (Iyer *et al.,* 2009). In the healthcare industry (which is typically a networked service environment), research on the adoption of LSS covers issues spanning from the environment (e.g. countries or regions) and healthcare to the implementation of tools and methods (Costa and Godinho Filho, 2016). The lack of research on contingency is still a key issue in lean thinking and the adoption of lean tools and frameworks (Hines *et al.,* 2004), especially in the networked environment (Bhamu and Singh Sangwan, 2014). In the following subsections, we will review two LSS frameworks and contingency research on business network, strategic management and service operations management.

The DMAIC-cored LSS framework

Usually, an LSS implementation framework consists of phased core structures to guide planning, executing and controlling an LSS project. One of the two popular LSS frameworks is cored with DMAIC. Scholars in the DMAIC-cored LSS research stream suggest the use of DMAIC – the roadmap of Six Sigma – as the core structure of the LSS implementation framework (Salah *et al.*, 2010). Lean tools will be used in each of the DMAIC phases. They choose DMAIC as the core structure because it has been widely accepted as a robust structure and they believe it will be fitting for the integrated LSS model (Salah *et al.*, 2010, p. 265). The proponents of the DMAIC-cored LSS framework advocate that DMAIC can accommodate proper lean tools at certain steps to tackle specific problems (Hoerl and Gardner, 2010). Moreover, the use of DMAIC is well-known and understood by many process improvement practitioners who will facilitate the LSS implementation process.

Salah *et al.* (2010) claimed that the integration of lean and Six Sigma was enhanced by applying lean principles in all five DMAIC phases. In their discussion of the development and future application of their DMAIC-cored LSS framework, Salah *et al.* (2010) raised two important issues. First, contextual factors play important roles in the choice of lean principles and lean and Six Sigma tools for each of the five DMAIC phases. They recognized the sophisticated relationships between the three lean principles (map, flow and pull) and the three DMAIC phases (measure, analyze and improve). These sophisticated relationships make an LSS project deployment contingent on contextual factors, such as organizational culture. This viewpoint is supported by other studies which emphasize understanding the potential impacts of critical contextual factors (Julian and Ofori-Dankwa, 2017), especially at the beginning of an LSS initiative (Snee, 2010).

The PDCA-cored LSS framework

Different from the proponents of DMAIC-cored LSS implementation frameworks, some scholars propose to use lean tools as the core structure of LSS implementation frameworks (George, 2003; Sreeram and Thondiyath, 2015; Chakravorty and Hales, 2017). Industrial practices show that some companies instead prefer to use non-structured lean tools such as VSM as the core structure. However, the flexibility embedded in VSM prevents it from being used as the core structure because it is often not possible to know the next step before mapping and analyzing the value stream. On the contrary, others prefer to use structured lean tools as the core structure, such as A3 and PDCA. A3 is named after the format of a project report used by Toyota, describing a seven-step implementation procedure that involves tracing a problem from definition through resolution (Shook, 2008). PDCA originated from total quality management and has proven robust regardless of the industry and the size of the project. While A3 can be viewed as a derivative or an extension of PDCA, each of A3 and PDCA has its unique advantages. PDCA has the beauty of simplicity and the power of adaptability, while A3 is effective in facilitating experiential learning (Chakravorty and Hales, 2017), and thinking and leadership development (Shook, 2008).

Sreeram and Thondiyath (2015) developed a PDCA-cored LSS framework based on their analysis of three process improvement methodologies: lean, Six Sigma and systems engineering. They concluded that PDCA is the ideal structure for LSS implementation, because of its "flexibility and simplicity […] (such that) any concept/tool from lean, Six Sigma, and Systems Engineering could readily be integrated into this framework (p. 298)". In the plan stage of their framework, the key tasks include VoC, process mapping/design/decomposition, wasters/redundancy checks, baseline design/performance and root-cause analysis. In the do stage, the primary task is to develop an action plan through trade-off analysis, solution discussion and negotiation and process documentation. The check phase performs testing and validation, implementation and further optimization, ensuring that the LSS implementation can be executed as planned. In the act stage, validated LSS outcomes will be sustained as operational routines and LSS tools such as 5 S and process and process documentation, and the principle of perfection will be carried out.

Business network research

In order for the implementation of lean and six sigma to be successful in a business network, a strong collaboration with suppliers and customers is essential. The collaboration is evidenced by strong supply chain relationships or a strong business network among stakeholders (Iyer *et al.*, 2009; Bhamu and Singh Sangwan, 2014). Generally speaking, there are two types of business networks. One is a set of independent companies that work closely together to manage the flow of goods and services along the value-added chain, which is established and mature, such as Toyota's supply network (Anderson *et al.*, 1994). Another one is a "purposefully designed [...] strategic net formed by a few actors pursuing specified mutual goal(s) and having jointly agreed and contractually defined roles and responsibility" (Möller and Halinen, 2017, p. 6), such as the biotechnology industry's innovation network (Dhanaraj and Parkhe, 2006; Forkmann *et al.*, 2018).

While research on each type of business network may have diverted goals and interests, three commonly agreed themes have converged from both schools of research. First, "network management should be examined from a configurational perspective – combining structure, governance, and context with network effectiveness (Möller and Halinen, 2017, p. 6)." Second, a business network has layered "organization" structure which includes the filed layer that a business network is embedded in, the business network or the focal (eco) system layer, the organizations/operations process layer and the actor layer (Ritter *et al.*, 2004; Möller and Halinen, 2017). Third, diversified goals and interests of actors in a business network, combined with unbalanced authorities and mentality among actors, demand new managerial activities for visioning and orchestrating on a commonly accepted management platform. We use the term "platform" to refer to an infrastructure where multi-firms using different management systems can work collaboratively together.

NetFrame: general theory of business network management

Möller and Halinen (2017) developed an outstanding framework – NetFrame – to describe a general theory of network management, which applies if a researcher is oriented to an established network or an emerging one. The overarching theoretical proposition of the NetFrame prescribes that the managerial decisions and actions are influenced and conditioned by three contextual layers – field, network and actor. The field layer represents an (external) environmental context that reflects the degree of maturity or emergence and the level of institutionalization of a business network. The network layer reflects the goals, value-system(s), and organizations and governance structure at the holistic network level and the network can be either an established or an emerging one. An actor can be either a person or an individual firm. Factors relevant to the actor layer may include, but are not limited to, an actor's network position and roles, the resources and capabilities an actor has, and an actor's network experience and individual goals.

Contextual factors at the three layers of NetFrame may independently and or interactively affect the management functions of the business network – influencing, orchestrating and managing, via six sets of management activities (Möller and Halinen, 2017). The six sets of management activities include visioning and sense-making, mobilizing and creating constellations, goal construction and organizing, effectiveness seeking efficiency seeking and network maintenance. This overarching proposition can lead to a corollary that can more concisely prescribe the theoretical underpinning of NetFrame – "the conditioning factors – involving the environment context, network/ecosystem context and actor context – *jointly* condition the nature of feasible and probable management activity configuration – also involving network constellation creation, organization and government creation" (Möller and Halinen, 2017, p. 20. italic was added by authors). In other words, these activity sets should have varied emphases and contents across different types of networks.

Lean and six sigma literature reveals the success of LSS implementation will be affected by individual contextual factors within the three layers of NetFrame and their interactions. For instance, at the network layer, key considerations include the interactive effects between project complexity and project uncertainty (Nair *et al.,* 2011), process complexity and process uncertainty (Wang and Vogt, 2018) and the actors' network positions and the strength of their social network ties (e.g. in the context of manufacturing supply chain management) (Westphal *et al.,* 1997). Factors across the layers of NetFrame can also collectively affect the success of LSS implementation. Industrial evidence shows that environment factors such as industry (i.e. service or manufacturing) and national mentality, network factors such as network governance structure and the extant facilities and technology, and actor factors such as an actor's network position and relative power and corporate culture and working habits, can all affect the success of LSS implementation (e.g. Shah *et al.*, 2008; Psychogios *et al.,* 2012; Swink and Jacobs, 2012). However, to the best of our knowledge, there is no study articulating how these cross-layer factors interactively affect LSS. In brief, authors of this stream of the LSS literature agree that the ways these individual and interactive contextual factors affect the implementation and success of LSS is contingent on the research context and objectives.

Contextual factors in a service environment: perspectives from strategy and operations management

Because our research context is a networked service environment and our research objective is to explore how contextual factors affect LSS implementation, we provide a brief overview of the contingency perspectives of two alternative frameworks relevant to the networked service environment. The first alternative is the "environment-strategy-process" strategic management framework (Miles *et al.*, 1978). It has been well acknowledged that contingency effects exist in the interface between corporate strategy and operations processes (e.g. DiMaggio and Powell, 1983; Voss *et al.*, 2016; Duncan, 1972; Drazin and Van de Ven, 1985). The triad of this strategic management framework is analogous to the three-layer dimensional structure of NetFrame. Strategic issues at the entire network level are emphasized on the network layer dimension of NetFrame, while the value-creation processes of business network constitute the actor layer of NetFrame.

The second alternative is the "structure-infrastructure-integration" service operations management framework (Roth and Menor, 2003). Roth and Menor (2003) claimed that the interaction between a holistic service system (i.e. service business network in this study) and individual actors could be analyzed through the structure, infrastructure, and integration dimensions of the theoretical configuration of the SDS. The structure dimension includes facilities and layout, technology and equipment, aggregated capacity planning, and service product-process interfaces. The infrastructure dimension includes factors such as people, policies, practices, processes and performance systems. The integration dimension includes operations organization and coordination, service supply chains, integration technologies and learning and adaptive mechanisms. These three dimensions capture the key contextual factors recognized by the contingency research stream in strategy and service operations management. The LSS literature shows that the dimensions of structure, infrastructure and integration are critical to the success of LSS implementation (Netland, 2016). Firms implementing lean and six sigma in a service environment should consider these factors to support decision-making (Malmbrandt and Åhlström, 2013).

In summary, our literature review on LSS and LSS implementation frameworks reveals that while DMAIC and PDCA have the same originality (i.e. quality management) and share a similar set of tasks or toolkits, they may take different paths toward the same goal(s), which may be due to their ontological differences. Thus, contextual factors may have different effects on each phase of DMAIC and PDCA and the interfaces between the phases.

In other words, an LSS implementation agenda with the DMAIC core structure and one with the PDCA core structure may lead to different outcomes. Our literature review on NetFrame and SDS reveals their similarities and differences. Both frameworks consider the complexity and dynamics of the external environment, the holistic goals of the entire network/system and individual function/sub-system/actor's goals, the roles and position of individual actors or processes in a system (i.e. core vs non-core), and the resources, capabilities and governance models at both the system/network layer and the individual actor (function/sub-process/individual person) layer. The major difference between the two frameworks is that NetFrame emphasizes influencing then orchestrating, while SDS focuses more on managing then orchestrating. This is due to the lack of central authority and a high level of process complexity in a networked service environment (Wang and Vogt, 2018). Bridging both frameworks lays down the foundation of evaluating the effectiveness of an LSS implementation in a networked service business environment when contextual factors are considered.

Research background: kicking off LSS implementation in the Port of Houston

Before discussing our research methodology, we briefly introduce our research background. In the Summer of 2016, one of the researchers was contacted by Greater Houston Port Bureau to suggest a solution to solve the unproductive chemical tanker movement (UPCTM) problem in the Port of Houston. The Port of Houston consists of 139 terminals with more than 400 ship and barge docks. The chemical complexes developed around the Houston Ship Channel (HSC) represent the second largest petrochemical refinery center in the world. Each year, there are more than 25,000 ship and 220,000 barge movements along the HSC. The movement of chemical tankers constitutes around 40 percent of all vessel movement handled by the Port. It is reported that 40 percent of chemical tankers' movements in the port are unproductive, which means the purposes of those movements are not for loading or unloading but waiting. It is estimated that each year, the UPCTM problem collectively costs stakeholders hundreds of millions of dollars. The Port of Houston represents a networked service environment without a central authority. GHPB has the mandate to promote the maritime industry and the greater Port of Houston complex. It is a non-profit organization and currently provides four core services of vessel information, port information, networking, and advocacy. It is a non-profit forum for the port and is not an administrative or executive authority in any way. Directors of the GHPB are drawn from the members and interested parties, and these are generally senior executives of companies represented in the port. Many of these companies are international companies.

Two co-authors went through multi rounds of data collection and analysis and presented research findings periodically to GHPB, selected member companies and some board members to get feedback on the research team's findings and suggestions. Key milestones were reached during this research project that lasted over one and a half years. The first milestone was the conclusion in the fall of 2016 that quantitative methods such as optimization and dynamic scheduling could not fundamentally solve the UPCTM problem because of the low visibility of real-time data and unrealistic assumptions of processing time at each service stage for quantitative methods. The second milestone was achieved in the spring of 2017 when the authors reached a conclusion that the best feasible solution to solve the UNCTM problem was to develop a platform and working agenda that could visualize the wastes along the port call process of chemical tankers (i.e. the entire service process) so that stakeholders in the Port of Houston could work together to improve the efficiency of the service process. Based on the research team's suggestion, GHPB set up a Port Efficiency Project and designated a VP of GHPB to coordinate the research team with key stakeholders involved in the port call process. The third milestone was the research team's suggestion in the summer of 2017 to undergo a lean transformation within the Port of Houston. GHPB and member companies only partially adopted this suggestion because some of them could not see the benefit they would achieve during or after the lean transformation.

They agreed with our vision on lean transformation but wanted to see a step-by-step implementation agenda. The agenda needed to have clear instructions and descriptions regarding key stakeholders' power, responsibility, liability and benefits at each phase of the implementation process. The research team first tried the DMAIC-cored LSS implementation framework. Following the general guidelines of DMAIC implementation, the research team presented the working agenda with regard to each phase of DMAIC to GHPB and selected or volunteered member companies. The major challenge encountered by the research team was the self-sustainability of the define, measure and analysis phases. By self-sustainability, we mean the outputs from a previous phase should be able to sustain the next phase to complete its tasks. For example, the initial problem we defined, based on our quantitative data analysis, was challenged after we moved to the second phase. When we simulated the tasks in the measure and analysis phases, new problems emerged. The new problems included issues such as what we measured in the second phase was not sufficient to support our analysis, and the problem we measured was not actually the true problem.

In November 2017, we presented our findings and suggestions by following the PDCA-cored LSS framework to the GHPB and member companies who agreed with our recommended implementation agenda and recommended us give a presentation to the board of directors. In February 2018, the chairman of the board of directors accepted our proposed agenda, established a pilot LSS project with the seven member companies as we suggested, and brought in an LSS Master Blackbelt to lead the pilot project. Our effort convinced the Port of Houston to kick off their lean transformation journey.

Methodology: CRCS

Before describing our research protocol, we define the terms used in this study by following Gerring's (2004) case study terminology (p. 342). Gerring (2004) posits that "for methodological purposes a case study is better defined as an in-depth study of a […] relatively bounded phenomenon where the scholar's aim is to elucidate features of a large class of similar phenomena, […], and the case study method is correctly understood as a particular way of defining cases (p.341)." We use the terms "case study" and "case study research" interchangeably as a research methodology, which connotes the protocol or architecture of the entire research procedure, including case study design, analysis and generalization. A case study sample consists of a number of studied cases, and each studied case is comprised of several "units." A unit may consist of several sub-units, which depends on the purpose and depth of analysis. Each (sub-)unit is observed at discrete points in time, comprising cases. Thus, observation is the "nucleus" of a case study. A case is also comprised of several relevant dimensions (variables), each of which is on an "observation" or "observations." These terms will be used to describe our case study database, which is to be discussed in the following sub-session.

Case study design

Due to the reflective nature of this study, we view the "CRCS" method as most appropriate. A case study research may take one of four philosophies – positivism, relativism, pragmatism and realism – to "inform us of the nature of the phenomenon examined (ontology) and methods for understanding it (epistemology)" (Van de Ven, 2007, p. 36). Realism represents a philosophical movement characterized by the existence of a mind-independent reality and the ability of a theory to capture partial aspects of reality. Critical realism (CR) is one form of realism, which "assumes a transcendental realist ontology, an eclectic realist/interpretivist epistemology, and a generally emancipatory axiology (Easton, 2010, p. 119)."

CSCS, a case study method based on the CR philosophy, is different from other prevailing case study methods in a number of ways. First, CR is in contrast to positivism that underpins the well-established case study approaches advocated by two dominant authorities on case studies, Eisenhardt (1989) and Yin (2003). Eisenhardt and Yin prefer multiple case studies which rely on replication logic representing a linear and positivistic approach (Dubois and Gadde, 2002). A positivistic approach is more appropriate for a deductive multiple case study in which the researchers "retain only the relationships that are replicated across most or all of the cases" (Eisenhardt and Graebner, 2007, p. 30), but not for a single inductive or abductive case study aiming at deep-structure probing or theorizing (Weick, 2007).

Second, the CRCS is more appropriate in handling complex research phenomenon in which the researcher needs to constantly go back and forth from one type's research activities to another, between empirical observation and theory, and between framework, data source and analysis (Dubois and Gadde, 2014, p. 1279). The going back and forth (i.e. matching) process requires that the CRCS researcher possess rich knowledge and experience when shifting from one theoretical paradigm to another to find a better-fit explanation of the research phenomenon. Thus, it is impossible for the researcher to conduct "theoretical sampling" (Eisenhardt, 1989) and claim that theoretical development should be "part of the design phase" (Yin, 2012). It is worth noting that the deep-probing matching process for theorizing mentioned above is different from the concept of "pattern matching" in the mainstream of case study research (Miles and Hubberman, 1994). Pattern matching is a deductive-logic-based technique commonly used in multiple case study to develop "testable hypotheses" (Eisenhardt, 1989). On the contrary, the deep-probing matching process during CRCS analysis emphasizes more on the identification of a tight and emerging framework (Dubois and Gadde, 2014) consisting of necessary and contingent relations and providing theoretical insights that other research does not (Easton, 2010).

Third, CRCS uses a phenomenon-oriented research design that is more appropriate to reality-grounded theorizing. A CSCS views a research phenomenon consisting of objects/entities which have causal powers and liabilities. The events or outcomes are "made" by the objects/entities, which are investigated by critical realists. Entities may possess necessary relationships or contingent relationships. A necessary relation means entities depend on each other, while a contingent relationship between entities is conditioned upon some circumstances or contexts. Contextual factors such as the structure of entities may exert contingent effects on "emerged" causal relationships that are part of the research findings. These phenomenon-grounded issues in italic are framed or confined in a CRCS design and are easily used in practice to guide case study research. An initial working framework involving these issues will be frequently modified along with an ongoing back and forth process of observing and theorizing.

In summary, CRCS has an advantage over other case study methods by providing a philosophical justification for case study research, employing a matching process that warrants deep-probing, and employing a phenomenon-grounded working framework that is easy to apply. These advantages also hold when CRCS is compared with other field-based case study approaches such as action research and design sciences.

CRCS analysis

Our research protocol follows Easton's (2010) suggestion of a CRCS research procedure. CRCS employs the most fundamental aim of CR – explanation – from research design to finding generalization. Explanation means to answer the question "what caused those events to happen?" CRCS method follows the general structure of CR to present and explain causal relationships, which is depicted as "object – causal power/liability – conditions – events." This method is "particularly well suited to relatively bounded, but complex, phenomena such as organizations, inter-organizational relationships, or nets of connected organizations (Easton, 2010, p. 123)." Easton's (2010) CRCS research procedure includes the following tasks:

(1) To determine the phenomenon to be studied. It should be noted that the boundary of a phenomenon may change during research. If this happens, the phenomenon will also change.

(2) To understand the nature of the research question. "The research question must be of the form 'What caused the events associated with the phenomenon to occur' (Easton, 2010, p. 123)." Easton (2010) claims that it is only possible to understand a social phenomenon by recording and analyzing the associated events that take place as a result of the actors acting, whether they are human or non-human. The events can be recorded live or exist in records of the past, including the memories of those human actors (Easton, 2010).

(3) To identify the entities and objects that characterize the phenomenon being studied. A proven theoretical or practical model will help identify entities and objection and conceptualize the phenomenon. The initial conceptualization may change as the research progress. If that happens, the basic entities and their powers and liabilities need to be powerful enough to have some continuity of existence regarding extant theory.

(4) To collect data, the primary source of case study data is qualitatively collected from semi-structured interviews or field observations. CRCS method also permits the use of other forms of data collection such as experimentation and derivation from primary data, unless the experimental or derived data can "provide insights not obvious in the more traditional modes of research, […] (and) the choice of data collection will be governed by what is thought to be required to establish a plausible causal mechanism (Easton, 2010, p. 124)."

(5) To interpret data, critical realists accept that any explanations are necessarily fundamentally interpretivist. They will face the challenge of the double hermeneutic – not just study what "objects/entities" do but also study how people (i.e. entities) understand their world and how this understanding shapes their practice.

(6) To seek epistemological closure of an explanation, explanations invoke causal language and the identification of mechanisms and offer the data as evidence. As critical realists only recognize retroduction as the key epistemological process, understanding how it might work is important. Retroduction is a meta-process that delivers the outcome that is the identification of mechanisms that explain what caused particular events to occur. "The cutting edge of this method is to continue to ask the question why? (Easton, 2010, p. 124)." Causal misattribution is the major concern during interpretation and explanation. It is desirable that researchers put forward and research a number of different causal explanations.

(7) To judge whether the explanation is "good" or not, researchers can follow the concept of "judgmental rationality" by comparatively evaluating existing or possible arguments against the researchers' explanation. Then, the researchers can reach their conclusions, though provisional, regarding what the reality is mostly and objectively like.

The presentation of CRCS findings

The "primary objective research of CR-based research is to provide clear, concise, and empirically supported statements about causation, specially how and why a phenomenon happened (Wynn and Williams, 2012, p. 789)", with the ultimate research goal of theory development and generalizability (Easton, 2010). We present our research findings with three considerations. First, we present our research phenomenon in the way suggested by Easton (2010), which includes the seven tasks described above. Second, to extend our discussion on plausible contextual effects on the possible mechanisms, we present our CRCS data in the form that includes: PDCA and DMAIC phases, major tasks in each phase, the LSS toolkits we used, the challenges in performing these tasks, contextual factors from both NetFrame and SDS perspective and management functions. Third, we present possible causal mechanisms with regard to entities, mechanism, management functions and events. The mechanism includes both causal and contingent relationships.

CRCS findings

Research phenomenon

Given the research questions and research context, we regard this study as a reflective single case study from the CR perspective. Table I summarizes the phenomenon of interest. Five entities are involved in this phenomenon, including the board of directors of GHPB, GHPB's project teams, key stakeholders, the research team and the two LSS platforms. The board of directors has the power and liability for accepting, rejecting or ignoring the suggestions made by the research team and the project team at GHPB. The project team at GHPB can recommend the research team's findings and suggestions to the board of directors, organize meetings for the research team and stakeholders and coordinate among the three entities including the board of directors, stakeholders and the research team. Key stakeholders include the chemical tanker companies, the Pilot House and towing companies, liquid terminals and terminal operators, land storage facility operators/owners and others (Figure 1). Stakeholders can either promote and participate in the project or a specific task,

Entities	Board of directors of GHPB	Project team at GHPB	Key stakeholders	Independent researchers	DMAIC or PDCA-cored LSS platform
Power Liability Structure	Accept Reject Ignore	Recommend Organize meeting Coordinate	Promote Participate Trust	Passionate Be rigor Multi-disciplinary	Improvement methodology Sense-making Phased agenda
Mechanism	Visioning, sense-making, sense-giving, agenda-setting				
Events	Accept or reject change initiatives/change agenda				

Table I.
Briefing of research phenomenon

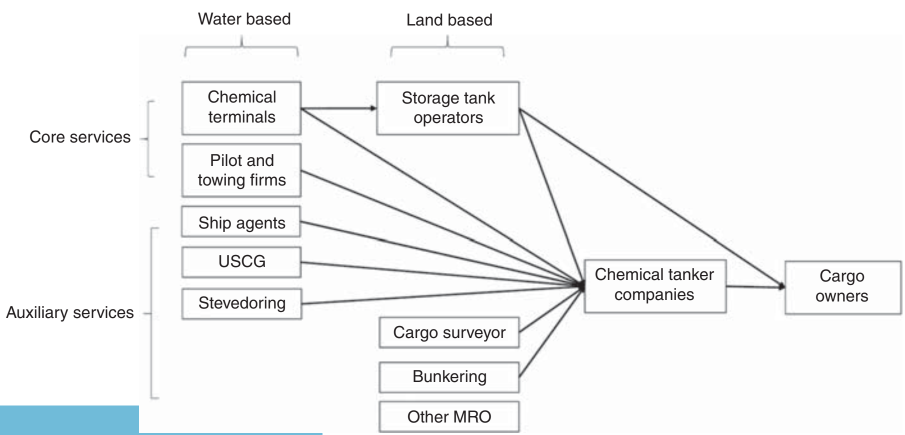

Figure 1.
Organizational structure of the service network

reject or remain silent. The key issue among the stakeholders is the structure of developing and maintaining trust. The research team consists of independent researchers who have a passion for working on this project. Their knowledge structure is multiple disciplinary, with years of working and research experience in maritime settings, and their research is rigorous. Both DMAIC- and PDCA-cored LSS frameworks, non-firm entities that we view as platforms, have the methodological power to remove wastes and control processes. Both frameworks are supposed to have the capabilities of sense-making and agenda-setting.

We view the mechanism as the outcomes of the interaction between management functions and contextual factors. All entities have a shared goal: to improve the efficiency of the port. Thus, if the LSS implementation agenda suggested by the research team makes sense to all other entities, the board of directors will accept the suggested agenda and move on to the next phase of LSS implementation. Otherwise, it was recommended that the agenda is changed or rejected. For example, when the research team presented their findings and suggestions to the president of GHPB and a few participating member companies, more than half of them rejected the findings, and the data we collected and used were not sufficient to depict the entire "picture" of the port call process. After a round of field trips and interviews, the research team found the UPCTM problem was just a symptom of uncoordinated planning and scheduling. To gain better planning and scheduling, it is required to have a centralized planning system that synchronizes all movements and terminal operations. Suggestions for information sharing were rejected again by some of the stakeholders because their headquarters would not allow them to share real-time operating data.

CRCS data

Table II presents the CRCS data. We do not include the SDS contextual factors in this table because all three configurations of SDS contextual factors – structure, infrastructure and integration, have impacts on the challenges we faced during our application of LSS tools for a specific task, our preparation for the working agenda or our presentation to the audience (GHPB, stakeholders and or board of directors). LSS tools were primarily selected from the literature on DMAIC toolkits (Salah *et al.*, 2010) and the ones shown in Table II were the ones we eventually used for each designated task in each phase. We developed a stage-process framework to understand the interaction between service stages and operational processes and each stakeholder's power and liability in each operational process (Figure 2). The 5 Whys analysis is straightforward, and the fishbone diagram is highly illustrative. For instance, with both tools, we found that there were no universally accepted measures for the movement and handling of liquid chemical cargos. Each company has its measurement systems to support its corporate objectives and maximize its profitability. The lack of a common measurement system means all the companies focused on different measurements, which makes it difficult to communicate between companies and obtain cooperation. It is challenging to identify which performance measure should be monitored and improved that will be acceptable to all parties.

Challenges in executing key tasks

The fifth column in Table II summarizes the challenges we identified during the Port of Houston's strategic LSS initiative. The sixth column indicates the possible NetFrame contextual factors that may cause these challenges in each task. The service network in the Port of Houston has a complicated value-creation system with many stakeholders' sub-value-creation systems. Most of their operational processes are embedded or connected with others' operational processes. Each stakeholder has its business objectives and governance structure without a central authority that can efficiently and effectively coordinate all stakeholders' activities. The challenges we faced in executing the first four phases span all three layers of NetFrame, which partially explain why we found the problem identified in

Table II. Challenges we faced in applying DMAIC- and PDCA-cored LSS implementation frameworks

PDCA phase	DMAIC phase	Major tasks	LSS tools	Challenges during application	NetFrame contextual factors	Network management functions
Plan-part I	Define	Identify and map relevant processes	VSM	High complexity; segmented; high embeddedness; unique organizational structure; loose planning and scheduling	Field: complexity and embeddedness; Network: organization	Influencing
		Identify stakeholders	SIPOC; Stage-process mapping	Power and liability vary across service stages; game-playing; selfish; "everybody is competing with others"	Field: embeddedness; Network: Goal and governance; Role: position, capability, goals	Influencing
		Determine and prioritize customer needs and requirements	QFD	VOCs of their ultimate customers (i.e. cargo owners) are neglected; each stakeholder has own customers	Network: goal, value-system, organization, governance; actor: network position, resource and capability, goals	Influencing
		Make a business case for the project	Lean thinking; value-waste visualization	Flow visualization and variability calculation; Data availability; LSS experience	Network: goal, value-system, organization; actor: capability, goals	Influencing
Plan-part II	Measure	Select one or more issues critical to quality (CTQ)	Lean principles; TIMWOODS; ABC analysis	Unpredictable service stage and service sequence; classical queuing theory cannot be used directly to aggregage process information	Network: value-system, organization, governance	Influencing, Orchestrating
		Operationalize CTQ	Processing mapping; VSM	Draw a high-level process mapping with "story-telling" metrics	Network: goals, value-system; actor: goals	Influencing, Orchestrating
		Vaidate measurement systems of the CTQs	MSA, Gage R&R	Sense-making; create a shared vision	Network: value-system; actor: network position, resources and capabilities	Influencing, Orchestrating
		Access the current process capability	Stage-process mapping; process-sigma level analysis	Link firm-level operational causes to the effect at the network level; consensus on the income-demurrage cost structure	Network: value-system; actor: network position, resources and capabilities	Influencing, Orchestrating
		Define objectives	FEMA, DFSS	Private data on scheduled and actual time for each movement; unexpected detention and demurrage fees	Field: complexity, dynamics; Network: value-system innovativeness, governance; actor: capabilities, goals	Influencing, Orchestrating

(continued)

PDCA phase	DMAIC phase	Major tasks	LSS tools	Challenges during application	NetFrame contextual factors	Network management functions
Plan-part III	Analyze	Identify potential influence factors	5-why, 5S, QFD, gemba walk	Trust, LSS knowledge and experience, accountability	Field: complexity, dynamics; Network: value-system(s), organization, governance; actor: network positions and roles capabilities, goals	Orchestrating, Managing
		Select the vital few influence factors	Lean principles; TIMWOODS; ABC analysis; affinity diagram	The boundary of decision-making, the rules to determine the boundary, and the criteria to choose the influence factors	Field: complexity, dynamics; Network: value-system(s), organization, governance; actor: network positions and roles, capabilities, goals	Orchestrating, Managing
Do	Improve	Quantify relationships between Xs and CTQs	Correlation/regression/ANOVA	Leadership alignment across firms; culture change; mindset change; project sponsorship	Network: value-system(s), organization, governance; actor: network positions and roles, capabilities, goals	Orchestrating, Managing
		Design: to modify the settings that influence CTQs	DOE; TCPTS alignment	Trust, power and liability, precess-reengineering	Network: value-system(s), organization, governance; actor: roles, capabilities, goals	Orchestrating, Managing
		Conduct a pilot test of improvement actions	TCPTS alignment	Making sense the pilot project, visioning, agenda-setting, coaching or leading	Network: value-system(s), organization, governance; actor: network positions and roles, capabilities, goals	Orchestrating, managing
Check	Control	Determine the new process capability	QFD, Hoshin-kanri, Gant-chart	Goal alighment; centralized authority to control and coordination	Network: goals, organization, governance; actor: network positions and roles, capabilities, goals	Managing
Act		Implement the control plan	Hoshin-kanri, Gant-chart, leadership development	Shared implementation platform	Network: organization, governance; actor: network positions and roles, capabilities, goals	Managing

Table II.

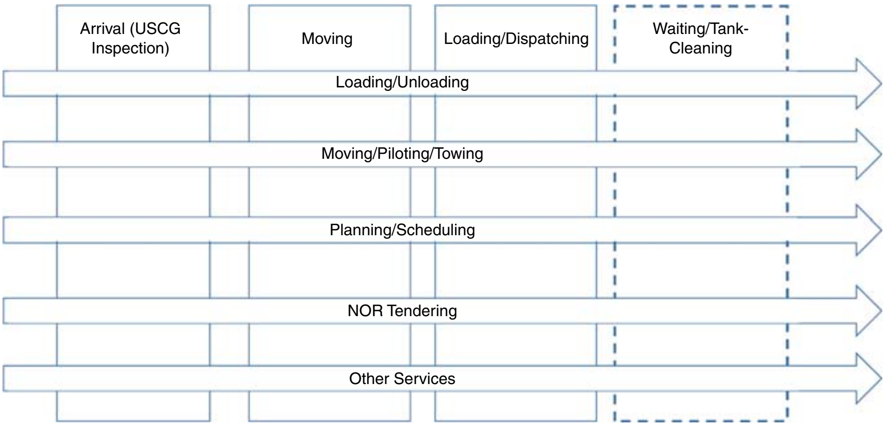

Figure 2. A stage-process framework for integrated chemical tanker port call service

the define phase had to be changed once we executed the measure, analysis and improve phases. We had to go back to previous phases to recollect data throughout the process. Once we completed the 12th task, we discovered that only the contextual factors at the network and actor layers might cause the challenges.

The 12th task – quantify relationships between Xs and CTQs – is the first task in the improve phase. In this task, we quantified the time impact of some critical contextual factors, such as the key stakeholders that are highly related to schedule uncertainty or unpredictable service times and service stages, and associated the time impacts with cost. After seeing this analysis, GHPB and some member companies accepted our suggestions and recommended we present our solutions to the board of directors.

For SDS contextual factors, we found that each SDS configuration has some factors that may cause challenges. For example, the challenges we faced in conducting the first task were due to the physical environment and facilities – factors from the structure dimension, existing policies, practices and performance measurement system – factors from the infrastructure dimension and coordination – a factor from the integration dimension. Overall, we identified three major challenges from the SDS perspective: collecting sufficient data that are accurate and reliable; describing the service system holistically yet simply enough to see how value flows and where wastes reside; and demonstrating why it is critical to motivate and synchronize the execution of the project among key stakeholders. Because we found invariant impacts from these three configurations on each task, we did not include the SDS contextual factors in Table II (Easton, 2010).

Interactive effects between implementation phases and management functions

For network management functions, we found that tasks in the define phase predominantly affect the influencing function. Each entity was influencing or being influenced. The define phase itself influenced GHPB, the board of directors and key stakeholders through this phase's visioning and sense-making capabilities. The five tasks in the measure phase affect both the Influencing and orchestrating functions. After we completed these five tasks, GHPB, the board of directors and key stakeholders encouraged us to move to the next phase. To get all stakeholders' acceptance, the proposed LSS implementation platform needs to show how stakeholders' operations are synchronized.

Tasks in the analysis phase consider contextual factors that span from the field layer to the network and actor layers. The LSS tools provided in Table II are only a few tools we used during research. When we move to the analysis phase, fewer contextual factors from the field level but more contextual factors from the actor layer are required. In the improvement phase, the three tasks are affected by contextual factors in the network and actor layers. These tasks will affect orchestrating and managing, while managing is gaining more attention. Tasks in the control phase spans from determining process capabilities and rolling out an implementation agenda over the network (Forkmann *et al.*, 2018). Because the research team does not get involved in the pilot project, the challenges listed in Table II are based on the authors' "best reasoning" (Easton, 2010) from the authors. Tasks in the control phases are expected to be affected by contextual factors from both NetFrame and actor layers. The focus on these tasks is the managing function.

By the time we completed this research project, the focal of our recommendation was to develop a (network) environment in which a centralized coordination mechanism can perform collaborative planning and scheduling among key players. To this end, our recommended LSS implementation agenda emphasizes developing the "teamwork spirit" over the network and a culture of trust and risk/benefit sharing. Trust is one of the driving factors of the lack of real-time data visibility. While there exists a common data platform for most stakeholders to upload their estimated available time, arrival time and or departure time to share with others, they do not upload data promptly, nor are there any incentives for them to do so. Companies do their scheduling individually in the way of the "best professional guess." Scheduling managers constantly "watch" the updates of online information and make "professional guesses" when adjusting their existing schedules.

Self-sustainability of DMAIC and PDCA

Our case analysis also indicates that the PDCA structure has higher phase self-sustainability than the DMAIC structure. We found that it requires multiple rounds of interaction between the actionable times designated before entering the do or improve phase. There are two possible reasons for the iterative process. First, when the key performance measure at the network level (e.g. the UPCTMs) is decomposed to the operational level (how each stakeholder performs their jobs and measures their performance), conflicts are found between the service objective at the port level and the firm level. Second, there are many conflicts between service stage and service processes. It requires highly collaborative planning efforts to identify the area of improvement that most stakeholders will agree with. In this sense, the plan phase in PDCA encompasses the actions to ensure they reach that consensus is more self-sustained than the define phase in DMAIC does. The output of the plan phase of PDCA provides sufficient information and a solid plan to roll out the LSS project.

Discussion and generalization

Our research context is a networked service environment characterized as a loosely coupled value-creation system that individual key stakeholders have autonomous authorities with unaligned yet competing objectives. Our findings regarding the relationships between contextual factors, management functions and DMAIC phases can be summarized in Figure 3. The relative position and "size" of each phase is determined by the span of the contextual factors that affect the phase, as well as the management function(s) each phase affects. The dotted contour that encloses five DMAIC "ovals" can be viewed as an LSS implementation agenda. Figure 3 depicts "how each DMAIC phase affects business network management functions under the contingent effect of NetFrame contextual factors." The integral "path" of the five phases of DMAIC represents the LSS implementation agenda.

Figure 3 reveals that when developing an LSS implementation agenda for a networked service environment, one needs to consider contextual factors from all three layers of a business network in early phases, and gradually narrow down the "span" of contextual factors to the layers of network and actor, and finally to the actor layer. In other words, at the beginning of an

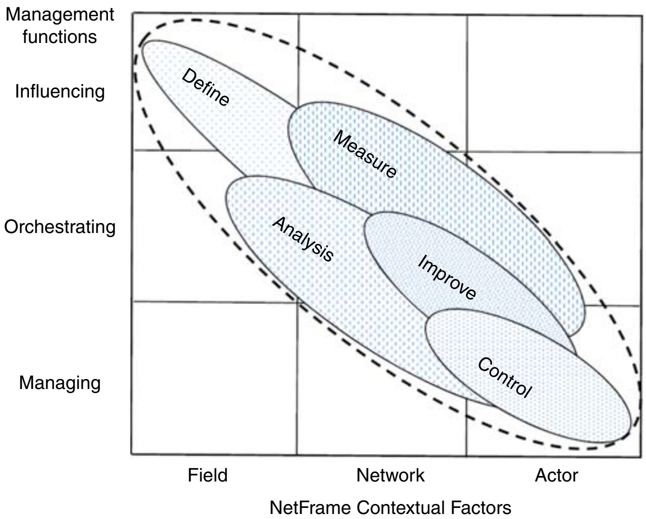

Figure 3. The contingency effects of networked service environment on DMAIC-cored LSS framework

LSS agenda, management activities confined in an LSS implementation agenda are contingent on contextual factors from all three layers, and at the end of the agenda on the lower layer only. The contingency effects from the high network layer are "swaying away" along with the progress of an LSS implementation, indicating that network management activities are narrowing their focus more on the lower layers where value is created.

With regard to our first research objective – the investigation of contingency effect of each layer of NetFrame on the LSS implementation, our discussion mimics a pattern between the change of the span of effective contextual factors and the progress of an LSS implementation. We generalize this pattern to the following mid-range proposition:

> *P1.* In an LSS implementation in a networked service environment, the span of contextual configurations changes from all high, medium and low layers of business network to medium and low layers and finally to the low layer, along the progress of LSS implementation progresses from early, middle, and later phases of LSS implementations, respectively.

Our second research objective is also achieved with two intertwined observations. First, we observed that as LSS implementation progresses, the focus of management functions starts with influencing, and gradually shifts to orchestrating and eventually ends up with managing. By gradually, we mean the process of shifting looks like a continuous process rather than discrete. This observation implies that in a networked service environment, the management activities in an LSS implementation agenda should first emphasize visioning and sense-making to influence actors. In our case, influencing means visioning and sense-making through which actors are gradually accepting our suggestions and solutions on improving the port efficiency through lean transformation and grating us to move forward. It is a process to align individual value systems with that of the entire network to serve ultimate customers and create more value for them. Orchestrating means the synchronization and coordination of individual actors' management and operations activities at the network level, through the LSS implementation platform we are proposing. Orchestrating is critical because it transforms vision into actions. Most of the challenges we met are related to orchestrating, due to many unforeseen contextual factors that emerged when we performed tasks oriented to orchestrating. Finally, management functions focus on managing and controlling the execution of LSS implementation plan. This observation reveals the trajectory of the change in the focus of management functions. This observation leads us to propose another mix-range proposition:

> *P2*. Along with the progress of LSS implementation in a networked service environment, the focus of management functions gradually shifs from influencing to orchestrating and finally to managing.

The above observation of the gradually shifting management focus is paired with another observation relating to our second objective. From Figure 3, we observed a pattern of paired interactions between LSS implementation phases and layered contextual configurations. The term "paired" means the three contextual configurations from the high to low layers of business networks are paired with the early, middle and final LSS implementation phases, respectively. Combining both observations, we can holistically describe the relationships among the causal and contingent relationships among the contextual configurations, LSS implementation phases, and management function. Specifically, the impact from the early (i.e. the define) phase of DMAIC-cored LSS implementation on the management function influencing is contingent on the contextual configuration at the field layer. The impacts of tasks confined in the middle phases (i.e. measure, analyze and improve) on management functions are conditioned by the contextual configurations, mainly from that in the network layer. The effects from the final LSS implementation phases (i.e. control) would be conditioned mainly from the contextual configuration at the actor layer. Consequently, we can propose the following mid-range causal mechanism that prescribes the causal and contingent relationships among the LSS implementation phases, management functions and contextual configurations:

> *P3*. In a networked service environment, the impacts of LSS implementation phases are contingent on the contextual configurations from the business network perspective.

From the CRCS research perspective, the direct events caused by management functions, confined in the LSS implementation agenda that we propose, are the acceptance, ignorance and rejection of the suggestions or solutions we provided to GHPB, the board of directors, and stakeholders. Following Easton's (2010) suggestions on theory generalization, we present *P3* in Figure 4. In Figure 4, the entity is a phased LSS implementation platform with the core structures being DMAIC, PDCA or A3 (not discussed in this study). The mechanism is the contingent relationship between contextual configurations on the causal relationship between an LSS platform and management functions. Events can be the acceptance, ignorance or rejection of a proposed LSS platform. The framework depicted by Figure 4 is a general contingency theory of phased LSS implementation agenda in networked service

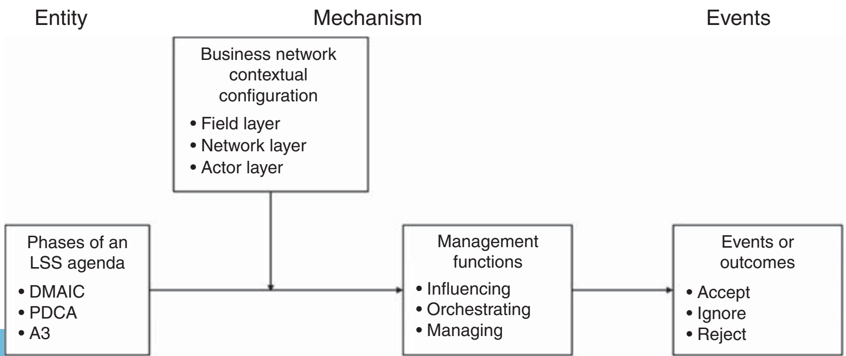

Figure 4.
A general contingency theory of phased LSS implementation agenda in service business networks

environments. From this observation, we claim that our second objective has been achieved. The observed interaction pattern can be generalized as the following mid-range proposition:

P4. Along with the progress of LSS implementation in a networked service environment, contextual factors at the higher network layer interact with more early LSS phases to affect influencing and orchestrating; while contextual factors at the lower layer interact with later LSS phases to influence orchestrating and managing.

Self-sustainability of DMAIC phased LSS implementation agenda

It is worth noting that our case indicates that the first three phases of DMAIC are not self-sustainable. For instance, the outputs of define cannot support measure and analyze such that the outputs of measure and analyze can either be rejected or ignored or lead to solutions or suggestions that cannot remove the root causes and solve a problem. In a complex and dynamic networked service environment, it is almost impossible in the define phase that all needed contextual factors are well considered and all management activities are clearly defined in the first try. If not, the following measure and or analyze phases will not have all the necessary information to generate the right solutions. Thus, it is unavoidable to go back and forth among these three phases, which may lead to an ineffective, or fail-prone implementation agenda. In practice, the conjunction between two consecutive phases serves as a "gatekeeper" which determines "go or no-go." For example, by the end of the measure or analyze phase, we found that the some important (contextual) factors had been neglected in the define phase, which is highly possible to result in a failed LSS implementation. In our case, we encountered at least three times when we made presentations, findings or suggestions that were not accepted and we had to go back to the earlier phase(s).

In this study, PDCA is preferred from the self-sustainability perspective. This conclusion indicates our accomplishment of the third research objective. The plan phase in PDCA includes all tasks defined by DMA. Thus, it will not encounter the "back and forth" situation. In our case, once we switched to PDCA as the core structure, we quickly completed the plan phase (i.e. the analyze phase) and passed the do phase in one run. One possible explanation is that we had done all necessary data collection and analysis so that the success of our plan phase was not generalizable. However, we argue against that explanation. The PDCA framework has long been recognized as having a "prolonged" planning process, as corroborated by many Japanese anecdotes that support "slow planning but fast executing" philosophy.

Figure 5 represents our proposed framework on the contingency effects of the networked service environment on the PDCA-cored LSS framework. We purposely align the four phases along the diagonal of the matrix and the boundary of an early phase cover the boundary of the later phase. In the plan phase, contextual factors at all three layers are supposed to be considered and all management functions will be affected by plan. In the do phase, management activities will not be affected by contextual factors at the field layer, and influencing would not be a management concern. The check phase will affect both orchestrating and managing functions, and their impacts on both functions will be contingent on the contextual factors at both the network and actor layers. Finally, the act phase focuses on the managing function, and its effect on managing will be contingent on the contextual factors at the actor layer. It should be noted that the relative positions and sizes of the four phases are not induced by our study but a way to depict lean philosophies.

For the third research objective, we claim that the PDCA-cored LSS implementation framework is flexible to accommodate unexpected issues. We first applied the DMAIC-cored LSS framework on the Port of Houston's UPCTM problem. When we moved to the analyze phase, we found that the input information to the analyze phase was insufficient. Therefore, we had to go back to the define phase to look at the service process interfaces. After we identified potential areas for improvement, we found that many activities at the tertiary

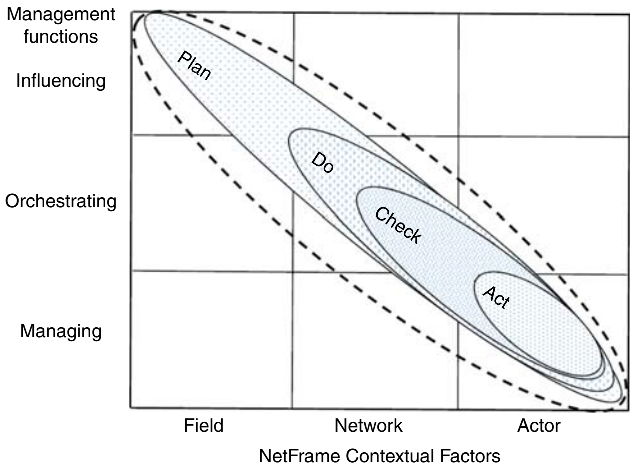

Figure 5. The contingency effects of networked service environment on DMAIC-cored LSS framework

operational level caused unexpected operational process variations. These variations, in turn, caused the changes in the planned service flow or service sequence at the system level. We conducted three rounds of "define-measure-analyze," which led us to conclude that the phases in the DMAIC-cored LSS framework are not self-sustainable.

Contributions and implications

Theoretical implications

This study contributes to the research stream in LSS in three ways. First, we developed a mid-range theory regarding the contingency effects of contextual factors at the field, network and actor layers of service business networks on the causal relationships between LSS implication phases and management functions for business networks. The DMAIC-cored and the PDCA-cored LSS implementation frameworks have been applied at autonomous organizations. This study is the first study aimed at exploring the contingency issues when applying a phased LSS implementation in a networked service environment. The proposed contingency framework (Figure 4) enriches the research stream of LSS by broadening the debate on which phased structure (i.e. DMAIC or PDCA) should be used as the core structure of LSS implementation frameworks. Our study shows that for a networked service environment, a PDCA-cored structure has its advantages over a DMAIC-cored structure.

Second, this study contributes to the emerging discipline of business network management regarding how to use LSS frameworks for strategic planning. Researchers in business network management advocates that issues encountered in business networks can be efficiently addressed by applying a general theory of network management (i.e. NetFrame). Out study shows the power and effectiveness of NetFrame in a research context relevant to sense-making (Gioia and Chittipeddi, 1991) or organizational change (Battilana and Casciaro, 2012). A change program needs to make sense of the change initiative to all stakeholders. This study contributes to the school of strategic planning of change initiative (Wolf and Floyd, 2017) by introducing the use of an LSS framework as the planning tool and the use of this tool with the considerations of the contingent effects of contextual factors in business networks.

Third, we contribute to the CR school of theory-driven case study by exploring the causal relationships among constructs involved in a phenomenon of interest. It has been long acknowledged by scholars, especially theorists, that most research on quality management, six sigma and lean lacks theoretical rigor. This can be evidenced by the number of LSS research published on the top journals of strategic management and organizations studies. One reason might be the prevailing research methodologies – positivism and interpretivism – not supporting the theorizing of answers to questions such as "What causes an LSS initiative success or failure in a business context?" Our contribution to the CRCS research stream is the conceptualizing an LSS framework as a platform so that the general CRCS research protocol and framework can be adopted and applied. Conceptualizing a change initiative program as a platform and treating the platform as an entity may bring scholars more research opportunities, especially when a single case constrains the research context.

Managerial implications

In addition to the theoretical contributions, this study offers two contributions to practitioners. One is the procedure of analyzing the impacts of contextual factors on the causal effects from LSS implementation phases on network management functions. This procedure is the agenda-setting process of LSS implementation. Identification and prioritization of critical management tasks in each phase of a proposed LSS agenda have been the most daunting and challenging jobs for both change-initiators and change executors. Inappropriately developed LSS implementation agenda may either lead to a rejection of a lean transformation initiative or make a LSS program a failure.

Another contribution to practitioners is our suggestion on the choice of DMAIC or PDCA as the core structure of an LSS project, at least in a networked business environment. While our mid-range theory is confined in the networked service environment, our discussion regarding why PDCA is the appropriate structure of our research context offers some generalizable guidance to make this decision. For instance, DMAIC might be a good choice for the core structure if there is a centralized authority or a powerful actor who can easily influence other actors' decisions. Another example is that the complexity and uncertainty at the layer of individual actors will not dramatically increase the complexity and uncertainty at the field or network layers. In both examples, it is possible to collect all the necessary information to define the problem, and it is not necessary to come back to the define phase once the project proceeds to the next phases.

Limitations and conclusion

Limitations

While the limitations of a single case study research method did not affect the contributions of this study, two limitations of this study are worth mentioning. First, we chose the CRCS research as our research method because we agree with its basic assumption (Easton, 2010). Like all other CR-based research methodologies, this research method cannot prove the conclusions we have drawn are the "right answer." What we believe is that this method is the best one given our research phenomenon. Others may prefer to use other field-based research methods such as action research or design sciences. The applications of our research findings may be limited due to the lack of commonly accepted criteria to judge the choice of the method and the procedure of how we analyzed the data and reached conclusions.

The other limitation is our adoption of the list of tasks from the literature, which includes 17 tasks. Our original list of tasks that we used includes 32 tasks, which provided us a detailed understanding of which tools would be effective in performing these tasks and what would be the contingent effects of textual factors on the causal effect between these tasks and management functions. The long list of tasks increased the length of the paper significantly, so it was reduced. However, such the reduced version of tasks decreases the comprehensiveness of challenges we met during this study.

We suggest two future research directions. First, we suggest blending NetFrame and SDS to develop a general framework for service business networks. We used SDS's contextual configurations in our study, but there is invariance regarding their impacts on LSS phases, so we excluded them from further discussion. It would be valuable if both

NetFrame and SDS are bridged to develop an overarching theoretical framework for service business network management.

Another future research topic is to explore the impacts and interactions between the three dimensions of the SDS and the core structure and the linkages between the core and the available tools. In our case, we find that the integration dimension of SDS has a greater impact than the other two dimensions on the robustness of the core and the feasibility of the linkages. The three dimensions may also have interactive effects on the applicability of an LSS framework. Such a study will help to identify which dimension(s) represents the most influential critical success factors for an LSS initiative.

Conclusion

In conclusion, we propose a framework of the contingency effects of contextual configurations on the causal effects of LSS implementation phases on the network management functions. Our framework suggests that the impacts of LSS implementation phases on network management functions are contingent on: the complexity and dynamics of contextual factors at the field layer of business networks, the levels of goal complexity and autonomy and the tightness of governance structure at the network layer and the roles, capabilities and goals of the layer of individual actors.

When contextual factors in the field contextual configuration are more complicated and dynamic, management attention should be placed on multiple LSS phases (i.e. both the early and middle phases). When contextual factors at the field layer have low complexity and dynamics, more management attention of an LSS implementation agenda should be paid to the lower layer of business networks – the actor layer. When contextual factors at the network layer are complicated, dynamic and have high uncertainty, such as the goals of the network, the embeddedness and connectedness among its sub-value-creation systems, and the governance structure of the network, these contextual factors will affect the span of their impacts on the causal effects from LSS phases to network management functions.

The higher the complexity and uncertainty are these factors, the wider (i.e. more phases) and the deeper (i.e. the higher the expectation on each task) the impacts these contextual factors have. At the actor layer, the more critical the roles and position an actor has, the earlier the LSS phase(s), the better to consider this actor's goals and capabilities. With regard to the choice of the core structure of an LSS implementation, PDCA is the ideal core structure if contextual factors make it highly possible to iteratively go back and forth between the tasks confined in early phases.

Note

1. A3 is an approach used by Toyota to solve problems and help people to learn (Shook, 2008).

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