Supply Chain Control Towers: Integrative Human, Operational, and Technological Capabilities

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Abstract

Despite the availability of big data and the development of advanced SC analytics, companies have low knowledge on how to integrate these advanced technologies into supply chain systems to gain more control, reduce cost, and manage risk.This study investigates a single case study of a company that developed a supply chain control tower targeting to gain control and responsiveness over its supply chain operations. The supply chain control tower provides two solutions (i) the management of risk proactively and (ii) the plan and execution of supply chain to control costs. The SCCT plan demonstrates how companies can use SC analytics to transform big data into intelligent assets. Findings show that the supply chain control tower have to use advanced technological capabilities and discusses how they affect control, standardisation, and flexibility.

Keywords
Supply chain control towers; supply chain; intelligent supply chains; case study; advanced analytics.

1. Introduction
One of the common strategies to deal with supply chain complexities is to outsource transportation, warehousing and distribution to third-party providers (3PLs). Companies have followed a similar strategy to gain supply chain (SC) visibility and end-to-end (E2E) SC control by outsourcing logistics supply chain control towers (SCCT) to 3PLs (Vlachos 2021). Capgemini defines the SCCT as "*a central hub with the required technology, organization and processes to capture and use supply chain data to provide enhanced visibility for short and long term decision making that is aligned with strategic objectives*" (Bhosle et al. 2011). Other consulting firms provide analogous definitions highlighting the instant data exchange and the concurrent collaboration of all supply chain stakeholders (Trzuskawska-Grzesińska 2017). Spite the importance of supply chain control and a large amount of literature on this topic (Barratt and Oke 2007; Brandon-Jones et al. 2014; Swift et al. 2019; Vlachos et al. 2021), there are not enough studies that investigating SCCT (Bhosle et al. 2011; Biederman 2013; Bleda et al. 2014; Hofman 2014).

This study examines a manufacturing company that recently insourced and upgraded its SCCT. The study makes the following two contributions: The performance of SCCT is based on three capabilities and the interactions among them: human, technology and operational. The SCCT demonstrates how companies can transform big data into integrated information and intelligent assets utilising advanced SC analytics. The SCCT capabilities have specific managerial implications for companies that are looking to improve visibility, planning, execution, and risk management.

2. Literature review
2.1 Supply chain control tower
The SCCT concept stems from aviation, where a controller monitors plane activity in the sky and ground corridors. It took a few decades after the first discuss activity control tower, which was commissioned at Croydon air terminal in 1920, for companies to create coordination control towers to oversee transportation courses, and around the turn of the twenty-first century, companies began to create SCCT, primarily in response to increased complexity associated with supply chain globalisation (Shou-Wen et al. 2013). The first conception of SCCTs, was the logistics control towers, which looked at physical distribution and coordination. One such logistics control towers was implemented by Scania in 2003. It proved successful: a third party managed the car logistics flows and managed to predict almost 100% accurately all shipments; subsequently there were 10% cost savings too (Cooke 2014). However, as more products, markets and suppliers added to supply chain operations due to

globalisation, SCCTs have started to provide visibility not only for transportation but also for demand, supply and environmental risks, such as shifting consumer patterns, supplier quality issues and natural disasters, respectively (Manuj and Mentzer 2008).

The SCCT offers four solutions: (i) Visibility, (ii) SC analytics, (iii) Risk management and (iv) Supply chain plan and Supply chain execution. The SCCT integrates these solutions within the same organisational unit (Figure 1). As most companies lacked the technological capability and expertise to develop an SCCT internally, leading 3PL companies initially developed these SCCT solutions (Trzuskawska-Grzesińska 2017).

2.2 Visibility

Among several definitions of supply chain visibility, Williams et al. (2013) describe it as capability to accessing high-quality, accurate, timely, complete and usable supply chain information. SC visibility may alleviate adverse 'Bullwhip' effects, allowing a fast, real-time response to SC problems (Caridi et al. 2014; Skoumpopoulou et al. 2014; Somapa et al. 2018; Srinivasan and Swink 2018; Wei and Wang 2017). For example, Swift et al. (2019), examining conflict minerals supply chains, found that the visibility capability allows firms to improve their operational and market performance across their supply chain.

Williams et al. (2013) classify SC information into market type such as requirements, availability, price, and upstream/downstream type, such as Point-of-Sale (POS) data (actual sales), demand forecasts, inventory levels promotion plan, lead times and exact delivery dates/times. Barratt and Oke (2007) find that SC visibility varies considerably based on both technological (i.e., Electronic Data Interchange-EDI, vendor managed inventory-VMI, efficient consumer response-ECR, collaborative planning forecasting and replenishment-CPFR) and non-technological (face-to-face meeting, customer service managers, emails) factors. However, as Barratt and Oke (2007) note, substantial investment in technological enablers are required to achieve real-time sharing of critical upstream and downstream information, even in the case where partners are willing to do so (Wei and Wang 2017). Sheffi (2015) advocates early detection as the only solution for SC disruptions and suggests SCCT as a supply chain structure that allows the supply chain visibility.

2.3 SC analytics

While SC visibility deals more with how to access information across the supply chain, SC analytics deals with the analysis of vast amounts of data acquired from different sources, such as ERP, Internet of Things (IoT), EDI, extranets, and handheld devices across the supply chain. SC analytics are now possible due to techniques such as artificial intelligence and machine learning, which were impossible a few decades ago (Duan et al. 2019; Mangina and Vlachos 2005; Spanaki et al. 2020; Wang et al. 2020).

An SCCT equipped with advanced analytical capabilities can improve real-time analysis of SC events, run predictive and prescriptive scenarios, improve operational efficiency and, ultimately, reduce costs (Brintrup et al. 2019; Fosso Wamba and Akter 2019). If a firm chooses to internalise this capability into an SCCT, it would have to invest in appropriate technologies, i.e., artificial intelligent and skilled workforce as well as transform its processes to enable internal, cross-functional collaboration, and integration of data sources and systems (Spanaki et al. 2020; Wang et al. 2016). Mcafee and Brynjolfsson (2012) describe this big-data-driven transformation as a 'managerial revolution' and scholars argue that SC analytics is now the next frontier of supply chain transformation (Fosso Wamba and Akter 2019). However, despite the hype, in a world economy where small and medium enterprises prevail, a recent PwC (2018) survey has found that only one out of three companies digitise their supply chains while anticipating a five-year transformation or longer depending on resource constraints in building in-house technological capabilities (Mangina et al. 2020; Schrauf and Berttram 2018).

2.4 SC risk management

One of the key advantages of combining SC visibility and analytics is the ability to detect, early, any events that may cause a disruption to SC execution. For example, Walmart SCCT monitors hurricanes with the purpose to avoid any disruption to their supply chain by proactively reconfiguring the routing of their deliveries and adjusting inventory levels (Annosi et al. 2021; Lee et al. 2016; Manuj and Mentzer 2008; Simchi-Levi et al. 2015). Companies like Walmart have developed SCCTs as an intelligence capability that can manage risk proactively by assessing events at a global level and calculate the possibility for them to escalate (Fawcett and Waller 2014; Mcafee and Brynjolfsson 2012; Sheffi 2015).

Fragmented internal and external supply chains react slowly in coordinating responses to a crisis, although a fast response is the key element of any resilient supply chain (Braunscheidel and Suresh 2009). In an increasingly volatile business environment, where the latest pandemic made clear that it is almost impossible to predict all risks and uncertainties, the SCCT role would become more critical, particularly when decision making needs to take place within minutes or hours instead of days or weeks (Sharma et al. 2020).

2.5 Supply chain (SC) planning and execution

By improving demand forecasts due to advanced SC analytics, streamlining demand with supply due to SC visibility, and detecting and mitigating risks early, the SCCT provides a competitive advantage for SC planning and execution that are impossible to offer when using traditional supply chains.

Typically, a linear supply chain forces companies to plan in a linear, sequential way: First, the forecast demand. Second, the prepare plans for production operations. Then they plan procurement needs. Third, they proceed in procuring the required raw material and suppliers. Fourth, they produce the manufacturing products (or offer the services if they are in the service business). Fifth, after production, they devise distribution plans (Galasso et al. 2008; Oliva and Watson 2011). The whole process can last many months resulting in disconnecting actual demand with products delivered; the end result is huge waste of time, products, resources, and a huge environmental impact. Moreover, the risk of failure is high due to Bullwhip effects and other system dynamics (Graham et al. 2004; Kovács and Falagara Sigala 2021; Vlachos and Bourlakis 2006).

However, Industry 4.0 technologies offer now new capabilities to supply chain stakeholders. The implementation of a SCCT allows the compression of time in planning supply chain activities (Figure 1). For example, companies collect data and information in real-time from diverse sources, media, and sensors. They can also able to combine these data (big data), run supply chain analytics, and based on empirical, data-informed findings to take decisions and then execute them (Vlachos 2021).

The SCCT allows companies to closely monitor how well they meet service level agreements (SLAs) while optimising pricing, inventories, routing and scheduling which, overall, reduces cost-to-serve by customer segments(Bhosle et al. 2011; Vlachos 2016).

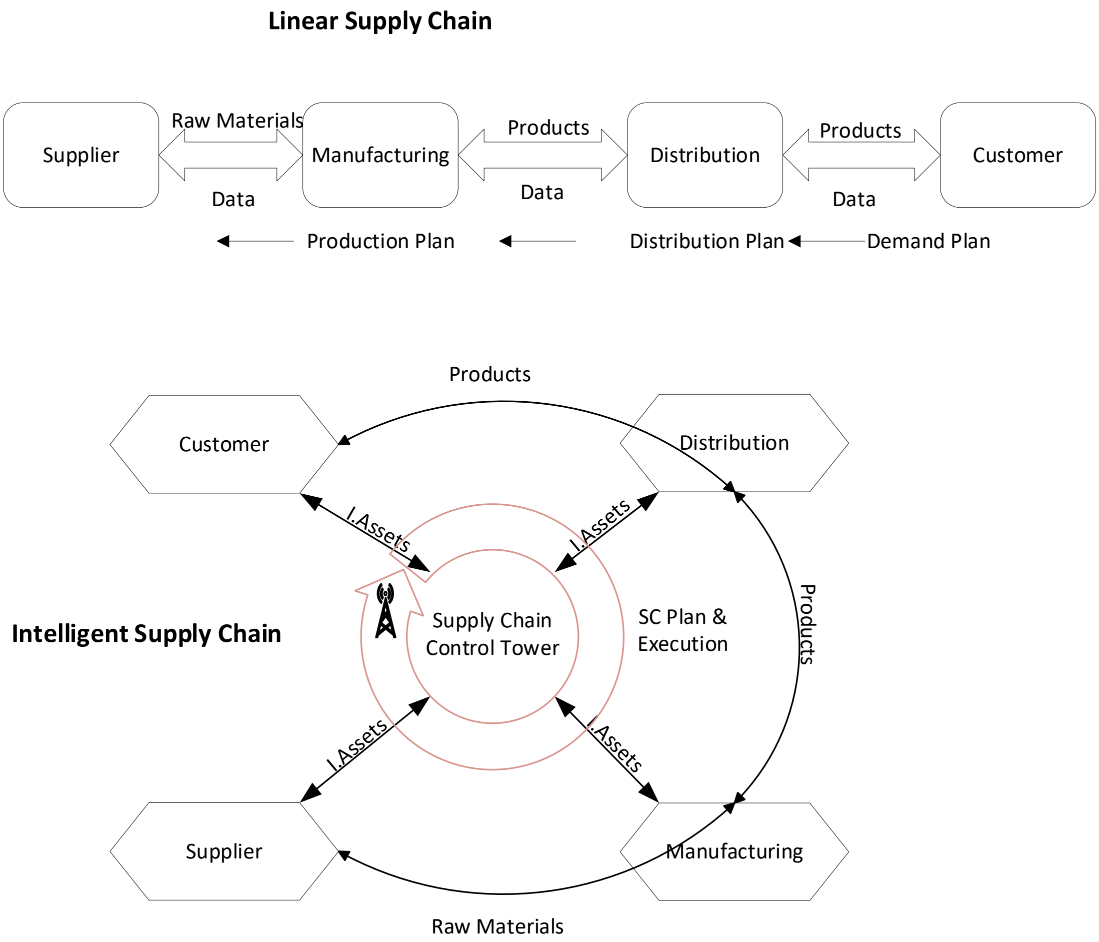

Figure 1. Linear vs Intelligent Supply Chains and SCCT

3. Methods

This study investigated a single case study of a large manufacturing company that had recently internalised the SCCT. The study followed the protocols and methods suggested by the literature (Yin 2018). Data and method triangulation was used to ensure the validity of the findings. Specifically, the company was suitable for this investigation based on its previous experience with the SCCT, the need to internalise this unit, and the challenges it faced. The data collected via interviews. The analysis of data involved an analysis of the events took place during the implementation of the SCCT and specifically the SCCT capabilities (people, operations, technology).

4. Findings

4.1 SCCT: Operational capability

The SCCT operates at three levels:

a: **Data aggregation**. The SCCT aggregates data from internal and external sources into one singular master database, which allows the SC visibility and accelerates SC planning and execution. Data sources include demand, supply, distribution, partners, suppliers and environmental sources, such as weather, traffic and port information. The ERP links with IntelLogFlows to aggregate data on a functional level such as procurement, supply and operations.

b. **Rule-based Alarms**. A key role of the SCCT is to be proactive in any possible disruptions. The company has identified five themes or themes and within each theme there are sub-categories with more detailed performance indicators. These themes are supply manufacturing, demand, distribution and environmental sensing (Figure 2). Each category is monitored in real-time or near-real-time. In order to assess the risk of disruption, each risk is categorised into four levels. Then, an alarm is set based on specific rules. For example, an alarm is set based on the fill rate. If the fill rate drops below a certain level, it becomes ‘red’ or ‘amber’ and this triggers a specific action such as the company needs to order more to replenish the inventory etc. The uniqueness of the SCCT is that it integrates all the alarms and rules under the same application, allowing the company to learn and improve its operations. The Figure 3. Represents the graph of Demand Volume, Forecast and variability.

Figure 2. Operational capability: Sensing and Visualization

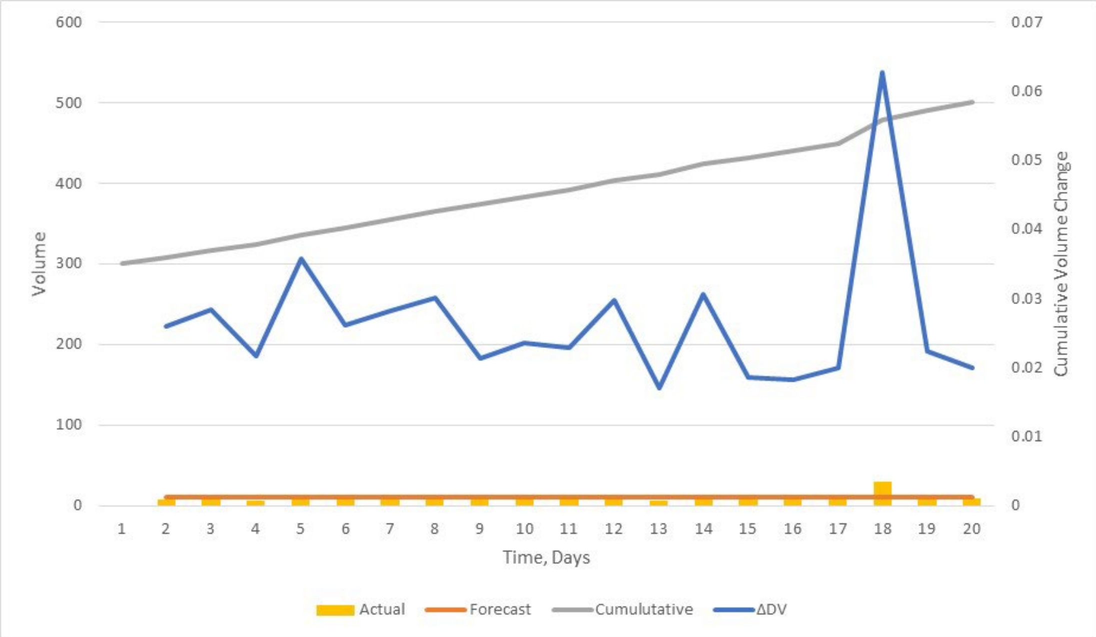

Figure 3. Demand Volume, Forecast, Variability

c. Decision making – SC planning & execution

SC planning and execution takes place at three levels: operational, tactical and strategic. The operational level is typically conducted by the SCCT team on a daily basis while the tactical and strategic levels require multi-departmental collaboration and top management involvement. The SCCT provides the evidence and analytics to mitigate a risk or prevent disruption from escalating, which requires the evidence-based collaboration between (a) the SCCT leaders; (b) regional managers or other points of contact; (c) functional managers; and, (d) supply chain stakeholders. Normal supply chain planning and execution includes decisions about: (1) schedule the supply every week or every two weeks but aligh them with monthly and yearly targets (2) develop contigency and mitigation plans in case of disruption evens for example, natural disasters, nowithstanding the pandemic disruption while not foreseen, contigency plans were in place (3) develop and integrate with suppliers in order to work together and collaborative in case of disruptions; often suppliers need support in managing inventories, develop their own plans etc; (4) when possible, run simulations to make planning more reliable; advanced analytics can be prove useful if the data are available and accurate; (5) execute plans based on the accumulated knowledge still being able to change the course quickly in case of disruptions.

4.2 SCCT: technological capability

SCCT requires advanced technological capabilities. SCCT technological capability consisted of: (i) SCCT systems; (ii) SCCT resources; and, (iii) SCCT capabilities.

Regarding the information systems, SAP was already in transition to replace old systems; this transition took a bit longer than expected to complete but when finished, this ERP allowed the SCCT systems to run more effectively. There are many sub-systems, like warehouse and transportation management systems, that are smoothly linked to each other; one advantage is that the ERP systems and sub-systems of supply chain stakeholders can be also get integrated under the same SCCT.

Regarding resources, the company have developed bid data in the form of raw, mostly quantitative data. However, these data were also analysed into meaningly information and even further created intelligent assets. Raw data are transformed into integrated information, e.g., weekly demand volume and variation per product category or market. Integrated information is processed and transformed to an intelligent asset.

4.3 SCCT: Human capability

One of the early key decisions that Alpha had to make was recruiting the right people. In total, the SCCT team consisted of eight people. The first person (Respondent 1) works as a transportation specialist; the main tasks include seeking disruptions in the transportation planning and dealing with claims about it. The second respondent has a more diverse role which include managing carriers, looking into supply chain projects and integrating various systems. The third respondent had a similar role to respondent 1 but he changed his role into information systems administrator. Respondent 4 was employed as business process expert to help in various roles. The leader of the SCCT team was also interviewed (Respondent 5). Respondent 6 is the head of the SCCT. Three more employees are involved in SCCT as senior and junior analysts.

5 Discussion

Companies have developed linear supply chains for many decades. Linear structures create cost efficiencies via close collaboration/integration with tier one suppliers and customers but offer little or no visibility and control beyond them.

A number of factors, including globalisation, Industry 4.0, big data, financial crisis, and the pandemic crisis force companies to transform linear supply chains into intelligent supply chains (Fatorachian and Kazemi 2020; Zekhnini et al. 2020). However, only but few empirical studies inform how companies can transform their supply chains digitally and recent surveys report failures in projects involving technologies such as artificial intelligence and machine learning(Vlachos 2021).

Supply chain control towers can offer visibility and control over the E2E SC; however, a literature review revealed only anecdotal case studies and a lack of theoretical support concerning how companies can take advantage of technological capabilities.

The present study examined the SCCT insourcing in the manufacture sector. This study showed that SCCT implementation was conducted in distinct phases that allowed the development of human, technological, and operational capabilities in a balanced way. First, an SCCT team was assembled and designed the SCCT processes. Then, during Phase II, technological capabilities were increasingly used to develop intelligent assets: raw data from ERP and partners' systems via EDI links were processed into integrated information and, using SC analytics (simulations, artificial intelligence), transformed into intelligent assets. These assets were the basis for incident management, planning evaluation, and (near) real-time decision making. The results of the study show that in order to overcome various SCCT constraints, companies need to co-evolve human, technological and operational capabilities.

5.1 Limitations and recommendations

The collection of empirical data was bounded by confidentiality thus it is not possible to present specific quantitative improvements. However, empirical studies can adopt methods like surveys and experimental designs that quantify KPI and calculate the exact effects of human, operational and technological capabilities. Future research would apply socio-technical systems theory to examine intelligent supply chains and expand this framework beyond manufacturing sector.

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Biography

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