Building data analytics capability to increase information processing capacity: The case of a professional service firm

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Abstract

Supply chain literature has emphasised the importance of data analytics capability in driving supply chain outcomes. Additionally, along with knowledge and professional judgement, providing data-driven analyses has become a critical component of professional service operations. However, there remains little understanding of how organisations build data analytics capability to reduce supply network uncertainty. A single case study of a professional service firm revealed analytics capability to be a combination of three capabilities, each with its distinct micro-foundations. We argue that the development of analytics capability requires the interaction of individual abilities and knowledge-bases with social and technical inter-organisational processes and structures.

Keywords: Organisational information processing theory; data analytics capability; micro-foundations; professional service operations

Introduction

To deliver complex projects, client organisations need to coordinate complex, multi-tiered supply networks. The complexity of supply networks, task interdependency, and relatively longer timescales of these projects create uncertainty regarding supply network performance, and consequently, project performance. Organisational information processing theory (Galbraith, 1974) suggests that organisations can manage uncertainty by (1) reducing information processing needs, and (2) increasing its information processing capability. Failure to achieve a fit between information processing needs and information processing capability would lead to suboptimal performance. While the nature of complex projects makes it is difficult to reduce information processing needs (Zhou, 2012), recent scholarship has argued

that the development of data analytics could increase an organisation's information processing capability, thereby reducing supply chain uncertainty (Srinivasan and Swink, 2018). There is, however, very little understanding of how an organisation develops its data analytics capability (Kache and Seuring, 2017). Furthermore, scholars have called for the identification of micro-level antecedents of operational capabilities (Roscoe *et al.,* 2019). Drawing on the micro-foundations of capabilities literature (Felin *et al.,* 2012) this paper addresses the question: "*How does the interaction of individual-level attributes, and supply network processes and structures contribute to the development of data analytics capability in a professional service firm?*"

Our study makes three inter-related contributions. First, we found that data analytics capability is composed of three capabilities: data capture, data integration, and data visualisation. Second, these three capabilities have different micro-foundations, thereby highlighting the importance of a holistic approach in developing this critical capability. By doing this, we contribute to information processing theory and the emerging discourse on digitalisation, digital transformation, and more specifically, data analytics in operations and supply chain management literature. Third, by we contribute to the literature on professional service operations to examining how a professional service firm builds its data analytics capability to create a new service offering for its clients.

The paper has been structured as follows. We start with providing the theoretical background, briefly reviewing literature on organizational information processing theory in the supply chain context, professional service operations with a particular focus on knowledge as a capability, and the micro-foundations literature to inform our conceptualisation of the data analytics capability. We then provide a description of our methodology, followed by a description of our findings. We conclude this paper by stating our contributions to the emerging discourse of data analytics capability in the supply chain literature, professional service operations, and organisational information processing theory.

Theoretical background

Increasing information processing capacity through lateral relations and vertical information systems

To execute tasks involving high degrees of uncertainty, firms need to organise themselves to use information effectively (Galbraith, 1977). The collection, processing, and distribution of information is a critical task for such organisations (Tushman and Nadler, 1978). Organisations coordinate routine tasks through rules and programs, however, as tasks become more complex and the pre-defined rules are insufficient, organisations resort to hierarchy to deal with exceptions (March and Simon, 1958). If the uncertainty of tasks and the number of exceptions continue to increase, the hierarchy would become over-loaded, and the organisations would coordinate by specifying outputs, goals or targets. As hierarchy becomes overloaded and the outcomes become more difficult to specify, the organisation has two options: either reduce the need to process more information, or increase its information processing capacity (Galbraith, 1974).

Organisations reduce their information processing needs through (1) the creation of slack resources, and (2) the creation of self-containing tasks. The creation of slack resources, such as increasing inventory and capacity in the supply chain has been considered to be an effective approaches to managing supply base complexity and supply chain risk (Chopra and Sodhi, 2004). The approach to create self-contained tasks, or modularisation, and subsequent outsourcing of the modules has also been considered an effective approach to managing supply

chain (Chopra and Sodhi, 2014). However, too much modularity could hamper supply chain collaboration by emphasising specialisation over collaboration (Tee *et al.*, 2019).

Another approach to managing uncertainty is increasing the organisation's information processing capacity by: (1) creation of lateral relations, and (2) investment in vertical information systems. This strategy involves moving the decision-making to where the information exists. The creation and management of non-hierarchical, lateral, inter-organisational relations has been of significant interest to the strategy and supply chain scholars. Research has, for example, examined the role of formal and informal socialisation mechanisms (Cousins *et al.*, 2006), information sharing (Krause *et al.*, 2007), and technical exchange (Lawson *et al.*, 2008), in reducing opportunism, and increasing supply chain performance (Carey *et al.*, 2011). Recent research has examined coordination in strategic alliances (Gulati *et al.*, 2012), and inter-organisational project networks (Oliveira and Lumineau, 2017), and how knowledge asymmetry, bounded rationality, and relational inertia could make lateral relationships ineffective, and even dysfunctional (Kalra *et al.*, 2020). In contrast, investment in vertical information systems has long been acknowledged as an alternative to investing in expensive information processing and exception management resources (Galbraith, 1974), allowing the organisation to process formalised data, and adjust existing and create new plans (Srinivasan and Swink, 2018). Organisations are increasingly adopting supply chain information systems such as enterprise resource planning, warehouse management, and transportation management systems (Kache and Seuring, 2017). These systems contribute to supply chain integration and increase the organisation's information processing capability (Srinivasan and Swink, 2015).

Professional service operations

The pursuit of specialisation and focusing on their core competencies has led organisations to outsource complex work to external experts, a phenomenon referred to as 'corporate function unbundling' (Sako, 2006). These external experts, also known as professional service firms, deliver routinised IT services, perform R&D, provide strategic, functional, and legal advice, perform audits, and deliver complex projects. These firms are employed by different types of organisations across a variety of sectors to deliver complex products and services, and major projects (Gann and Salter, 2000).

Von Nordenflycht (2010) identifies three definitional characteristics that are central to professional service firms (PSFs): 'knowledge-intensity' (or human capital intensity), 'low capital intensity' and consisting of a 'professionalised workforce'. Another attribute associated with a PSF, is that of a knowledge-broker exploiting the structural hole between the client and the knowledge-based resources (Hargadon and Sutton, 1997). PSFs typically organise themselves around project-based structures, leveraging its knowledge-based resources to deliver a (relatively) customised service to the client.

Operations and supply chain management scholarship has characterised professional service operations as those exhibiting (1) high levels of customer contact, (2) high levels of customisation, and (3) Fluid/flexible processes with high labour and low capital intensity (Lewis and Brown, 2012; Schmenner, 1986). The PSFs pose unique challenges in terms of monitoring and communicate "opaque" service quality, limited scope for standardisation and transferability of practices from one project to another, and micro- and macro-levels governance (Lewis and Brown, 2012). Knowledge intensity remains the single most defining feature of PSFs, and most examination of such operations have considered the role of knowledge embedded in professionals and organisational routines (Spee *et al.*, 2016).

However, the management of knowledge as a resource, i.e., its acquisition, orchestration, and usage to deliver knowledge-based services has been less understood. Indeed, recent studies have identified knowledge management as one of the topmost challenges faced by PSFs (Brandon-Jones *et al.*, 2016). The advances in information technology have contributed to an increase the generation, storage, and availability of data, which has led to an increased attention on how organisations can develop the capability to generate useful insights from the complex, inter-organisational big data (Kache and Seuring, 2017; Srinivasan and Swink, 2018). Analytics capability is a technologically enabled ability to process large *volumes* and *varieties* of data with the *velocity* required to gain relevant insights, thereby enabling organisations to gain competitive advantage (Srinivasan and Swink, 2018). This allows the organisation to process, organise, visualise, and analyse data to enable data-driven decision making and execution. As a manifestation of vertical and lateral information systems, an analytics capability increases the organisation's information processing capability (Galbraith, 1977; Tushman and Nadler, 1978). Recent studies have called for examining the micro-foundations of dynamic digital capabilities being developed by organisations (Roscoe *et al.*, 2019). Adopting a micro-foundations perspective, this study contributes to this stream of literature to examine how a PSF develop its data analytics capability to reduce supply chain uncertainty.

The micro-foundations of data analytics capability

The central argument of the micro-foundations approach is that differences between individual-level factors could influence the implementation, and could explain one organisation's superior performance outcome over another. Macro-focused strategy scholars often use concepts such as capabilities, routines and environment without taking into consideration the individuals and their social interactions, with the individuals being treated as interchangeable parts (Felin *et al.*, 2012). The micro-foundations framework rejects the notion that casual mechanisms in social work exist solely on the macro-level and argues for unpacking of macro-level explanations.

More recently, this approach has been adopted in the strategic and operations management literature to examine the development of organisational routines and capabilities (Felin *et al.*, 2012; Roscoe *et al.*, 2019). This stream of literature draws attention towards the three types of micro-foundations: individuals, processes (and their interactions), and structures. We build on this conceptualisation to examine how the interaction between individuals, processes, and structures contributes to the development of governance capabilities.

Behavioural theory of the firm suggests that individuals engaging in collective activities could have different goals motivated by their organisational roles (Cyert and March, 1963). These organisation roles, combined with their existing knowledge sets, focus their attention on different aspects of the collective activity. To ensure the alignment of goals and reduce disagreements and conflicts, the interaction between these diverse sets of individuals needs to be governed through a variety of formal and informal mechanisms (Cousins *et al.*, 2006). Formal socialisation mechanisms involve designated structures created to communicate expectations and share useful information. Informal socialisation mechanisms, in contrast, are impromptu chats and informal communication occurring outside the workplace or working hours. While formal socialisation mechanisms are found to be helpful in goal alignment, monitoring, and coordination (Oliveira and Lumineau, 2017), informal mechanisms are found to promote the development of trust and increased information sharing (Cousins *et al.*, 2006), although not always leading to good outcomes (Kalra *et al.*, 2020). Finally, organisational and inter-organisational structures specify the conditions that enable and constrain individual and

collective action (Felin *et al.*, 2012). These structures could be organisational hierarchies, standard operating procedures, integrated project teams, and contracts (for example, Oliveira and Lumineau, 2017). The design of these structures is important for integration, control, and coordination (Schepker *et al.*, 2014). The governance literature has acknowledged the role of hierarchies, contracts, and relational mechanisms such as trust and power to govern organisational and inter-organisational relationships (Cao and Lumineau, 2015). However, scholars have called for examination of how micro-foundations, such as individual skills, goals and knowledge, and complex social processes, contributes to the development of structural mechanisms for governing complex projects (Zhou and Poppo, 2010). We address this call by examining how a professional service firm developed its analytics capability to reduce supply network complexity.

Methodology

We undertook a single case study of a global professional service firm (from hereon, PSF) focused on consulting in the construction sector, with its headquarters in London, UK. The organisation provides services across four verticals: development, consultancy, construction, and facilities management across eleven sectors. Our study focused on the consultancy vertical. Within the consultancy vertical, the PSF provides three types of services: (1) project and program management, (2) cost consultancy, and (3) advisory services.

Our main focus of data collection were interviews with the managers inside the organisation. Of the 30 interviews conducted, fifteen interviews were conducted with program and project managers, information managers, and managers responsible for functional data such as sustainability, quality, and planning managers. Seven interviews were conducted with client organisation, and eight interviews were conducted with industry experts and other organisations working with the PSF to aid in the development of its data analytics capability. The interview duration was between 55 to 95 minutes. The interviews were recorded and transcribed, and in two instances where we could not obtain the permission to record the interview, notes on the conversation were made. Finally, because of the restrictions imposed by the COVID pandemic, all interviews were conducted using MS Teams.

We gathered evidence from the PSF's consultancy across three major projects being undertaken in London. We conducted interviews with client organisations and the project and program managers. We triangulated the dataset through rich secondary data on the three projects, and interviews with industry experts, and other organisations that have worked with the PSF. Our interview guide covered questions on the motivation, challenges, and approaches to building a data analytics capability. We specifically focused on the individual level attributes, organisational and inter-organisational processes, and organisational and inter-organisational structures contributing the development of the data analytics capability (Felin *et al.*, 2012). Our interviews with the industry experts helped us understand the developments in the wider ecosystem that are enabling and constraining the development of the PSF's data analytics capability.

Our analysis strategy was guided by the theory development approach developed by Gioia et al. (2012). Data were coded on individual-level attributes, processes, and structures contributing to development of data analytics capability. These first-order concepts were then reduced to second-order themes, which eventually led to the identification of aggregate dimensions. These aggregate dimensions were identified as three inter-related capabilities underpinning the overall data analytics capability.

Findings

The components of data analytics capability

We found that data analytics capability comprises three distinct yet interrelated capabilities: data capture, integration, and visualisation. Data capture involves standardising the data, creating information channels to smoothen the flow of data, and setting up mechanisms to govern the flow and capture of data. Due to the complexity inherent in the context, the projects managed by PSF involved suppliers of diverse capabilities, sizes, and sectors. The suppliers also adopted platforms that were more consistent with their organisational strategy. Moreover, smaller suppliers did not always have sophisticated information systems, and therefore captured the data manually on sheets of papers and uploaded scanned copies of the information. This led to the generation of diverse, unconnected, and complex datasets. The PSF needed to ensure that the data are captured in a standardised manner. The PSF created asynchronous and synchronous channels for facilitating information flows. First, the tiered supply network structure was leveraged as an information-gathering mechanism. PSF included provisions in their Tier-1 contracts mandating the sharing of data. The contracts also made Tier-1 suppliers responsible for capturing data from lower-tier suppliers. The contractual mechanism was complemented by the deployment of project-level data coordinators to facilitate data flow from Tier-1 suppliers. Second, the PSF also deployed sensors on the site to capture real-time data. Finally, PSF created formal mechanisms to govern data sharing. First, the data's intellectual property (IP) rights were negotiated and shared fairly between the PSF and its suppliers. Specifically, the rights to data rested with the suppliers, while the IP rights to the insights generated by data analysis were with the PSF. The provisions further specified that the supplier data would not be shared with any third party (except regulators) without written permission from the supplier. The suppliers were also ranked and scored on their compliance with PSF's data-sharing requirements, and the rank tables were shared with the supplies. These scores were also taken into account while renewing supplier contracts for future projects. These formal mechanisms enabled the development of trust between supply chain partners, which further facilitated data sharing in the supply chain.

Along with data capture, the PSF also had to develop the capability of processing and integrating diverse datasets. There was an understanding that there was an asymmetry of information between the PSF and the suppliers. Therefore, the project team challenged the validity of the shared and captured data during monthly meetings to reduce the discrepancy between the shared and the actual data. Furthermore, data were also monitored during informal meetings. The information management team at PSF transformed the data structure by manually linking the datasets through queries on the project-level. The PSF's information managers on the project level manually linked the datasets through queries to ensure a smooth flow of within-project data. Finally, with a view of building towards common data environments on a firm-level, the information management teams maintained a standardised schema. They manually linked project datasets on a functional level to achieve data transformation and increase the scope of the database. The project-level data, now organised by functions on the firm-level, was owned by functional teams. These functional teams had the expertise of their specific functions, such as sustainability, quality, and health and safety. They would further identify gaps in the data and communicate them to the project-level teams. The information managers on the project-level would then coordinate with suppliers to ensure the validity and completeness of data capture. The functional data also sourced specialist capabilities from external service providers to develop solutions to achieve cross-project data mapping. The functional managers also maintained relationships with their peers working at

other PSFs in the ecosystem to keep abreast of recent advancements in data practices. These interactions created new data needs, which steered further capture of data at the project-level and integration of data at the firm-level.

Data visualisation capability was considered to be the ability to create meaningful representations of data to enable sensemaking. This capability was composed of two mechanisms. The individual and collaborative sensemaking were enabled by creating shared dashboards, some on Microsoft PowerPoint, others on Power BI. Depending on their organisational roles, stakeholders focused their attention on different aspects of data, which led to varying needs in terms of visual representation. These needs also informed the development of visualisations of project-level and program-level data. The visualisation of data from different organisations (within an inter-organisational project) and different functions (on PMO level) enabled communication between stakeholders, facilitated collaborative sensemaking and decision-making, and further improved dashboards. Another mechanism that informed the visualisation capability was algorithmic sensemaking. In this form of sensemaking, manual processes interacted with algorithmic processes such as regulator-issued templates (driven by their decision rules) and software templates that linked the captured data with the software's decision rules, enabling quantitative analysis and building of three-dimensional models.

The three capabilities: data capture, data integration, and data visualisation combined to form the PSF's data analytics capability. The next section discusses the development of the data analytics capability from a micro-foundational perspective.

The micro-foundations of data analytics capability

Adopting a micro-foundational lens, we found that the individual level attributes, and the processes and structures enabling the development of the three capabilities, i.e., data capture, integration, and visualisation capabilities, are different. To develop the capability of capturing data on the project-level, individuals operating at the individual project and the organisational level play important roles. Managers operating on the project-level, based on their past experience, consider suppliers to be opportunistic, and therefore expect discrepancy in the data shared and the actual data. Similarly, the suppliers demonstrate different behaviours based on different beliefs. If suppliers believed the PSF to be opportunistic, they hid the sensitive commercial data and shared manipulated data, albeit slightly. Even in cases where the supplier trusted the PSF, there were concerns regarding the PSF having adequate data protection and risk management processes in place, which inhibited suppliers from sharing sensitive data. Secondly, the functional champions based at the PSF, made frequent visits to project sites and captured data by themselves. This was because of the functional expertise of the managers would determine the kind of data to be captured. Furthermore, the functional managers kept an eye on the innovations in the field, as well the emerging regulatory requirements, which made the managers the most suitable to collect data relevant to them. Although the PSF included provisions in the contract mandating the sharing of data by the suppliers, the PSF still relied on the close relationships of project-level coordinators with its suppliers to coordinate the flow and capture of the data from the suppliers. Over time, PSF negotiated property rights of the captured data with suppliers and made them explicit in the contract, which increased trust between the PSF and its suppliers, thereby facilitating data flow and capture. The final mechanism that contributed to the quality of data sharing was through formal socialisation processes and standardised data capture and sharing through supplier trainings.

The PSF further recognised that the it needs individuals with the ability to integrate diverse sets of knowledge, and develop technological skills to integrate and process data. These

individuals were deployed in both intra- and inter-organisational roles. Within the organisation, the individuals with a combination of functional (for example, sustainability, and quality) and technological (for example, small-scale data analysis, data processing) were deployed. These individuals owned the maintenance and analysis of data on a functional level. They also worked with external service providers to develop organisational capabilities to maintain and analyse big data. These processes contributed to development of data integration capabilities in the form of functional software and applications. The intellectual property for these applications was owned by the PSF. The PSF would license the usage of these innovative applications to their current and future clients. In contrast, the individuals with higher levels of technological expertise (i.e., database management, querying, linking, and manipulation) but were functionally-agnostic were deployed in inter-organisational project teams. These individuals were responsible for maintaining the quality of data by monitoring the quality of data shared by its suppliers. They also transformed the data and manually linked different datasets to generate reports for the functional experts (at the organisational level) and to aid in the planning (and to some extent predicting) the project performance. In sum, the PSF's data integration capability involved the interaction of professionals with different knowledge bases, with both organisational and inter-organisational structures, through complex organisational and inter-organisational processes.

The PSF had to develop data visualisation capability to achieve two distinct objectives. The first objective involved conforming to the reporting requirements of a diverse group of stakeholders, such as the clients and the regulatory bodies. To achieve this objective, the professionals who operated at typically senior levels played an active role. These professionals communicated regularly with policymakers and senior management of the client organisations. They would also participate regularly in industrial conferences and demonstrate the practices they (or the PSF) have adopted in high-performing projects. These professionals were motivated to develop their visualisation capabilities. A closer examination of the their practices revealed the reliance on technologically simpler dashboards and visualisations created on Microsoft PowerPoint. The professionals considered PowerPoint as a tool for individual and collaborative sensemaking, and communication, rather than communication itself, and considered the attention to specific aspects of stakeholder requirement to be a crucial ability. The second objective for developing the data visualisation capability, was making sense of the complex data to create effective descriptions of data and identify underlying relationships. The development of this capability involved individuals with strong functional knowledge and moderate technological expertise to enable them to interact with functional information systems. These information systems produced visualisation through in-built algorithms, which themselves are a combination of bodies of knowledge, narrative templates, and pre-defined decision rules. Therefore, the two objectives for developing the PSF's data visualisation capability required interaction of distinct professional abilities and roles with contrasting sensemaking processes, informed by organisational, regulatory, and project-level rules.

Discussion and Conclusions

This study makes three main contributions to the literature. Recently, operations and supply chain management literature has begun to emphasise the IT-supply chain interface focusing on data analytics capability (Kache and Seuring, 2017). Scholars have argued that an organisation's data analytics capability contributes to positive supply chain outcomes, such as increasing supply chain transparency (Srinivasan and Swink, 2018). Our research contributes to this stream of literature by arguing that data analytics capability comprises three inter-related

capabilities: data capture, data integration, and data visualisation. Moreover, adopting a micro-foundational perspective, we argue that these three capabilities are developed from the interactions of distinct professional abilities, organisational and inter-organisational processes, and organisational and inter-organisational structures. Second, this study makes a contribution to the literature on professional service operations. While scholars have argued that professional services are characterised by their reliance on knowledge as their key resource (Von Nordenflycht, 2010), there is little understanding of how the professional service firm develops this resource and the capability to leverage this resource (Brandon-Jones *et al.*, 2016). By focusing on how the project and program-level data are captured, integrated, and visualised, this study develops a theoretical understanding of a crucial component of professional service operations, and firms. Third, supply chain literature has acknowledged the role of data analytics in increasing an organisation's information processing capacity, thus increasing supply chain transparency. However, these macro-level explanations do not uncover the micro-level attributes and mechanisms that influence these macro-level relationships. By arguing that professionals' behavioural traits and abilities interact with organisational and inter-organisational processes to increase a PSF's information processing capacity, this study contributes to the organisational information processing theory.

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