

BUYER-SUPPLIER COLLABORATION AND SUPPLY CHAIN RESILIENCE: A CASE STUDY IN THE PETROCHEMICAL INDUSTRY

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ARTICLE INFO

Article details

Submitted by authors 21 Feb 2017
Accepted for publication 16 Sep 2017
Available online 13 Dec 2017

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DOI

<http://dx.doi.org/10.7166/28-4-1736>

ABSTRACT

The purpose of this study was to investigate the underlying mechanisms through which buyer-supplier collaboration enables resilience. A single case study method was adopted, examining a critical case within the petrochemical industry. Data was collected through semi-structured interviews. The rationale for undertaking buyer-supplier collaboration in the focal firm is grounded in Kraljic's procurement matrix, accounting for underlying risks of supply disruptions that are inherent in the resilience discourse. The findings suggested that collaboration between buyers and suppliers does not directly lead to supply chain resilience, but rather enables the antecedents to supply chain resilience. The study developed an understanding of the specific mechanisms through which the antecedents of resilience are enabled in the petrochemical industry.

OPSOMMING

Die doel van hierdie studie was om die onderliggende meganismes waardeur koper-leweransier samewerking veerkragtigheid in staat stel, te ondersoek. 'n Enkele gevallestudie metode was gebruik om 'n kritiese geval in die petrochemiese bedryf te ondersoek. Data-insameling het plaasgevind deur middel van semi-gestruktureerde onderhoude. Die rasionaal om die koper-leweransier samewerking in die geval te onderneem is gegrond in Kraljic se verkrygingsmatriks. Laasgenoemde neem onderliggende risiko's van die lewerings-ontwrigting, wat inherent is aan die veerkragtigheid diskoers, in ag. Die bevindinge dui daarop dat samewerking tussen kopers en leweransiers nie direk lei tot voorsieningsketting veerkragtigheid nie, maar dat dit eerder die voorlopers tot voorsieningsketting veerkragtigheid in werking stel. Die studie ontwikkel begrip vir die spesifieke meganismes waardeur die voorlopers tot veerkragtigheid in die petrochemiese bedryf in staat gestel word.

1 INTRODUCTION AND PROBLEM STATEMENT

In the context of modern markets, no company can compete successfully in isolation; instead, it must operate as part of supply chain networks [1]. While firms are becoming increasingly interconnected, the very nature of such interdependencies has led to more complex and globalised supply chains [2]. Such complexities are compounded by the need to improve internal efficiencies, grounded in philosophies such as lean manufacturing, just-in-time inventory, and supplier rationalisation [3]. The implementation of such philosophies, coupled with increasingly complex and global supply chain configurations, has led to firms becoming ever more susceptible to adverse conditions festering elsewhere in the value chain. As such, upstream supply disruptions often have a severe impact on a firm's cost base, revenue, and shareholder value [3, 4]. Traditional risk management approaches, such as risk identification and quantification, seldom prove effective when a firm is confronted with an unexpected disruption [5]. Alternatively, firms can attempt to manifest supply chain resilience (SCR) in their supply networks, increasing a supply chain's ability to react to

and absorb supply disruptions and return to the operational status quo [4, 6]. Consequently, it is under the auspice of increased supply chain vulnerability and firm interconnectivity that Scholten and Schindler [6] note: “SCR is a network-wide concept, [and should] be adopted by all members of a supply chain to align forces in the case of a [supply chain disruption]”. This study therefore explores such alignment in the form of buyer-supplier collaboration, and the supply chain mechanisms through which such collaboration enables a supply chain to be more resilient.

Supply chain collaboration (SCC) is often regarded by scholars as an integral part of managing the enterprise risks related to supply-related disruptions [8-10]. Relating the concept of collaboration to building supply chain resilience, Sheffi [11] argues that resilience enables supply chain disruptions to be mitigated by providing supply chain members with an early warning of impending disruptions, allowing for coordinated mitigation thereof. Thus scholars broadly agree that collaboration between supply chain members is a formative element in achieving supply chain resilience [12, 13]. Keeping this in mind, Christopher and Peck [14] define supply chain resilience (SCR) as “the ability of a (supply chain) system to return to its original state or move to a new, more desirable state after being disturbed”. A further dimension that could be added to this definition in that SCR not only refers to a system’s ability to return to the operational *status quo*, but also involves the speed at which this achieved [4, 6].

Supply chain disruptions may occur upstream or downstream from a focal firm, although it has been noted that first-tier suppliers (upstream) tend to be of greater concern to overall business continuity [4, 15, 16]. Furthermore, the impact of supply chain disruptions tends to be most profound when occurring upstream from the focal firm [3, 5, 6]. Keeping this in mind, collaboration between supply chain members could take place from either vertical (suppliers or customers), horizontal (competitors and other organisations), or internal (business functions) perspectives [16]. Furthermore, vertical collaboration with suppliers is a costly supply chain exercise through investments in information integration, process and resource integration, and reporting of performance measures to ensure accountability. This results in the need to weigh the potential benefits against their cost [17]. For these reasons, buyer-supplier collaboration is an important construct when investigating the broader concept of SCR [18, 19].

Although Scholten and Schilder [6] investigated the role of collaborative buyer-supplier relationships as a construct of SCR, there has been scant further research into these types of collaborative relationships from an SCR perspective [8, 10]. Whereas Scholten and Schilder [6] examined specific buyer-supplier relationships based on financial spend and the criticality of the supplied product, this study examines only the buyer’s perspective. Therefore, the rationale for undertaking SCC with suppliers in the pursuit of SCR is explored.

The purpose of this case study was to explore the underlying mechanisms through which buyer-supplier collaboration enables SCR. This relationship was explored through a single case in the petrochemical industry. The focal firm represents a majority market share (>40%) of mid-stream fuel supply capabilities in the South African market [21, 22]. The firm therefore represents a valuable case for investigating SCR, given the economic importance of withstanding upstream disruptions and maintaining the subsequent supply of the final product to South African consumers and industry [23]. The aim of the study was therefore to provide new insights into resilience theory through exploring SCC and SCR in the context of divergent supply chain characteristics of petrochemicals, while also defining the specific interrelated mechanisms linking the two concepts.

Considering the above, the following research questions guided the study:

- What is the nature of the collaboration between the South African petrochemical firm and its suppliers?
- Why is SCR in a buyer-supplier context regarded as critical to supply chain continuity in the petrochemical industry?
- What is the nature of the relationship between SCC and SCR in the context of buyer-supplier relationships in the case of the South African petrochemical firm?
- What are the underlying and most prevalent supplier-related vulnerabilities for the South African petrochemical firm?
- How does the South African petrochemical firm implement SCC with various suppliers, given the varying levels of vulnerability present in the supplier relationships?

The study has contributed to the literature by exploring the rationale behind undertaking buyer-supplier collaboration for resilience in the context of petrochemical supply chains under the constructs of Kraljic's procurement matrix. Under this quadratic framework, suppliers are classified according to the complexity of the supplier landscape and associated supply risks, as well as the relative profit impact of the item procured. The findings suggest that varying degrees of collaboration are undertaken between the focal firm and its suppliers, based on their classification into three of the four matrix quadrants. The matrix allowed the study to account for the underlying disruption risks related to the need for SCR. Furthermore, the study has contributed to the SCR literature by finding that SCC only indirectly leads to SCR. Instead, collaboration between the focal firm and its suppliers only enables antecedent elements that in turn enable SCR.

2 LITERATURE REVIEW

2.1 Supply chain resilience

The issue of resilience in the supply chain context is of increased relevance due to higher a complexity in supply chains that results from lean supply chain practices and global sourcing [5, 14, 24]. Gölgeci and Ponomarov [25] note this complexity, observing that the numerous parties constituting a supply chain system are typified by varying processes with differing vulnerabilities and risks, coupled with high systems integration and intricate interaction between supply chain members and processes. Accordingly, supply chains become highly susceptible to various risks that could stem from one or more activities or actors. Implicitly, disruptions to a single node within a supply chain could lead to operational and capacity complications throughout the entire supply chain [26]. When viewing supply chain disruptions in the context of resilience, Mandal [27] defines a supply chain disruption as "an unintended, untoward situation which leads to supply chain risk ... resulting in negative consequences for the focal firm".

2.1.1 Enablers of supply chain resilience

Jüttner and Maklan [12] propose three antecedent supply chain capabilities to achieve SCR that are based on the coordination and integration of resources spanning three functional areas: flexibility, velocity, and visibility.

2.1.1.1 Supply chain flexibility

In the context of supply chain resilience, 'flexibility' refers to a supply chain's existing structure and the ease with which it could be reconfigured [30]. This enables the supply chain to deal with high levels of uncertainty by allowing it to adapt effectively to disruptions caused by changing needs and environmental uncertainty [31-34]. Moreover, flexibility describes a system's ability to adapt to change with minimal time, effort, and performance implications [35, 36]. Scholten and Schilder [6] note strong supply chain relationships, flexible production capabilities, adjustable delivery contacts, and multi-skilled workforces as enablers of supply chain flexibility, in that they allow for some extent of supply chain re-configurability and short-term adjustments. Therefore, flexibility generally comes at a higher cost to the supply chain [37, 38].

2.1.1.2 Supply chain velocity

'Supply chain velocity' refers to the speed of a supply chain network's response to a disruptive event [39, 40]. Christopher and Peck [14] argue that streamlined processes, reducing inbound lead times, and reducing non-value-added time form the basis of increased supply chain velocity after a disruption event. Therefore, in the context of SCR, 'velocity' refers to the speed at which a supply chain responds to changing needs after being disrupted. When compared with flexibility, velocity prioritises the timeliness of a supply chain's response to a disruption over the ability to withstand changing and adverse conditions [12]. Adler *et al.* [41] note a trade-off between flexibility and velocity, where a balance between these two constructs needs to be struck to manage potential supply chain disruptions [33].

2.1.1.3 Supply chain visibility

Barratt and Oke [42] define 'supply chain visibility' as "the extent to which actors within a supply chain have access to or share information which they consider as key or useful to their operations and which they consider will be of mutual benefit". This ability to view the entire end-to-end pipeline is critical to managing supply chains that span multiple firms effectively and efficiently [43]. To gain visibility, Christopher and Peck [14] note the need for data standardisation between supply chain members, while Jüttner and Maklan [12] highlight the need for information in a timely manner, preferably in real time. However, having access to timely and accurate information in a modern supply chain is challenging, given the spatially dispersed and operationally disconnected

nature that often typifies such networks [44]. Supply chain visibility is thus regarded as a requirement for timely and robust responses to supply chain disruptions, making it an antecedent factor in achieving SCR [27, 45]. Thus, having visibility in a timely and accurate manner throughout the entire supply chain enables firms to receive early warnings of potential disruptions, further enabling effective response and recovery [12].

2.2 Supply chain collaboration

Supply chain collaboration (SCC) aims to leverage the capabilities and knowledge of key suppliers under market uncertainty [46]. Despite this, most collaborative situations tend to fail or fall short of expectations, as the rationale behind the collaborative efforts is often misguided. Therefore, understanding the nature of SCC is key to underpinning the context of this study [47].

2.2.1 Collaboration as a supply chain management concept

To manage supply and demand uncertainty, SCC aims to improve operational flexibility by facilitating cooperation between the various supply chain members [8]. In practice, collaboration is regarded as a process where two or more companies formally undertake to share responsibility for sharing information, planning, and managing process execution to enable the formation of synergies between all supply chain members, thereby achieving greater mutual benefit than the firms would achieve individually [6, 48-51]. Therefore, SCC entails the commitment of multiple supply chain members to aligning interface processes according to their mutual strategic objectives, thereby leveraging their respective core competencies to adapt to change [48].

Broader supply chain benefits of collaboration are described by Min *et al.* [52] as improved supply chain effectiveness through the improvement of responsiveness to changing supply chain needs; more efficient supply chains enabled by reduced inventory levels and increased cost savings; and improved supply chain capabilities such as inventory visibility, new knowledge creation, and improved demand planning. Therefore, the rationale behind SCC lies in the fact that an entity cannot optimise its own supply chain operations until the constraints of suppliers and demands of customers are fully understood [51, 53].

However, De Leeuw and Fransoo [54] mention that collaboration between suppliers is not a binary concept, but could be viewed as having varying degrees of intensity. They mention the characteristics of highly integrated collaborative relationships as being long-term relationships between two independent entities participating in the same supply chain; close cooperation and coordination of activities between supply chain members on aspects such as information sharing, joint planning, joint demand management, and inventory management; common goals and objectives between supply chain members; and the creation of supply chain-wide visibility.

2.2.2 The structure of supply chain collaboration

The broader concept of collaboration is rooted in the fact that no single firm is able to compete successfully in the context of modern markets [52, 54]. Similarly, Christopher [53] proposes the idea of network competition, where competition no longer takes place between individual firms in isolation, but between entire supply chains. The concept of SCR is imbedded in the network-wide perspective of supply chains. Therefore, the formative elements of SCR (velocity, visibility, and flexibility) need to be adopted by all supply chain members in order to align network-wide efforts in mitigating a disruption [6].

A variety of forms of collaboration are relevant in the context of network competition. These forms of collaboration can be divided into two categories: vertical and horizontal. Vertical collaboration includes collaboration between customers, internal functions, and suppliers, whereas horizontal collaboration refers to collaboration between non-competitors, internal functions, and competitors [16, 55]. The structure of vertical SCC with suppliers could be considered as made up of three fundamental elements that promote supply chain capabilities: information sharing, decision synchronisation, and incentive alignment [17, 48]. These elements are discussed in more detail below.

2.2.2.1 Information sharing

Collaboration between supply chain members requires a shift from traditional commercial norms towards the sharing of inventory, demand, planning, and financial information [52], necessitated by the network-orientated nature of modern supply chain competition [56, 57]. In the context of SCC, Premus and Sanders [58] describe information sharing as “the extent to which one party in the chain communicates critical and proprietary information to another party”. Therefore, transparency of

information is recognised as a key requirement and an enabler of strong collaboration in a supply chain [59, 60].

The increased complexity of buyer-supplier relationships leads to increased complexity in the information exchanged between the relevant parties [61]. This complexity is generally overcome through implementing information and communication technologies such as electronic data interchanges and the Internet, facilitating the ease and accuracy of the information flow between the collaborating entities [62-65]. With this in mind, Madlberger [66] identifies four dimensions to information, given the multidimensional nature of information sharing: i) the content (the type of information), ii) the frequency of the information shared, iii) the detail of the information, and iv) the 'up-to-datedness' of the information. Collectively, these four dimensions are regarded as the determinants of the quality of information exchanged in SCC [65].

2.2.2.2 Decision synchronisation

Decision synchronisation is regarded as a two-dimensional element, referring to joint decision-making in planning and operational contexts [67, 68]. Synchronising decisions between collaborating supply chain members aims to orchestrate decisions to optimise supply chain benefits through functions such as inventory management, demand forecasting, and product assortment [55, 69]. In the supply chain planning context, collaborative planning aims to balance supply and demand within a supply chain network through demand-driven processes [70]. Soosay *et al.* [71] found that this balance is enabled through more efficient sales forecasts, effective materials management for production, efficient inventory management, and better performance management. Related to information sharing, collaborative planning further requires a bilateral information flow between supply chain members in the joint decision-making process [72]. Consequently, Simatupang and Sridharan [68] recapitulate the concept of collaboration as the integration of aspects such as product assortments, promotion and forecasting in long-term planning, and the measurement thereof. Conversely, joint decision-making in the operational context entails the integration of supply chain operations between buyers and suppliers. The operational context thus includes the replenishment and fulfilment processes relevant to these dyadic relationships [73].

2.2.2.3 Incentive alignment

Scholten and Schilder [6] define incentive alignment as "the process of co-developing systems to evaluate and publicise each other's performance, sharing costs, risks, and benefits among supply chain partners". By aligning incentives, collaborating buyers and suppliers are encouraged to act in a manner consistent with the overall objectives of the formalised collaboration agreement [49]. It could thus be argued that the collaborative agreement between buyers and suppliers should be based upon principles of mutual benefit under the constructs of game theory's classic prisoner's dilemma, as described in Tullock [74]. Under the conditions of a prisoner's dilemma, none of the collaborating members has the incentive to undermine the agreement. Instead, these supply chain partners are incentivised to act in a manner consistent with the mutual strategic objectives, and to contribute positively to the relationship in a scheme that links benefit with the effort invested [46]. Furthermore, a key element of incentive alignment is the sharing of risk between collaborative partners. Sharing the risks and the related costs of supply chain disruptions tends to be a major motivating factor in undertaking collaboration between buyers and suppliers [47].

2.2.3 Challenges to implementing supply chain collaboration

Despite the apparent organisational advantages obtainable through collaborative efforts, very few collaboration initiatives turn out to be even moderately successful if not fully developed to their full potential [75]. The following challenges to supply chain collaboration are identified in the literature: 1. Difficulty in aligning internal processes with those of suppliers [76, 77]; 2. The lack of appropriate data communication; weaknesses in information exchange and connectivity under traditional IT infrastructure, affecting seamless integration [63, 78, 79]; 3. Cultural effects that tend to view the sharing of any form of data as adverse for an organisation's strategic position due to a lack of trust between organisations [76, 79]; 4. The traditional organisational design where functions are separated in 'silos', prohibiting the needs of collaborative efforts between firms [16, 80]; 5. Unwillingness to share risks and rewards between members of a supply chain [79]; 6. The orientation of financial management often restricted to the short-term view of business operations, making long-term agreements such as collaboration more difficult [76].

The challenges to effective collaboration appear not to be insurmountable, but are rather the result of a lack of commitment by organisations due to high associated costs and organisational factors [16]. The costs broadly relate to technological investment to facilitate the exchange of information [77, 81]. Furthermore, the lack of trust between organisations, the unwillingness to share risks are

results, and process alignment relates to traditional inter-firm rivalry [82]. Lastly, internal organisational orientation in the form of functional silos and a focus on financial management are internal barriers that hinder the necessary operational alignment of collaborative buyer-supplier relationships [77].

As noted earlier, these factors prohibit collaborative initiatives from developing to their full potential. In the context of this study, formalising the nature of the interconnectivity between SCR and SCC presents supply chains with additional benefits from collaborative working. This may lead to a more favourable view of the its results, and thus lead to a higher inclination to undertake the perceived costs to obtain the resilience benefit from collaborative buyer-supplier relationships. Furthermore, the extent and intensity of collaboration may vary greatly based on business objectives, which in turn decide the success of supply chain collaboration [65].

2.3 Supplier categorisation

Kraljic [83] introduced a procurement portfolio matrix for the effective management of suppliers and their respective capabilities. This matrix covers the complexity of the supply market as well as the importance of the product sourced [84]. Kraljic’s approach classifies purchased products based on supply risk and profit impact - i.e., ‘low’ and ‘high’ [85, 86]. This produces a 2x2 matrix that categorises products or suppliers into four categories: strategic, leverage, bottleneck, and noncritical, as illustrated in Figure 1. In the context of this study, ‘supply risk’ refers to the availability of alternative suppliers, while ‘profit impact’ relates to losses by the firm if the product cannot be procured [20, 83, 87].

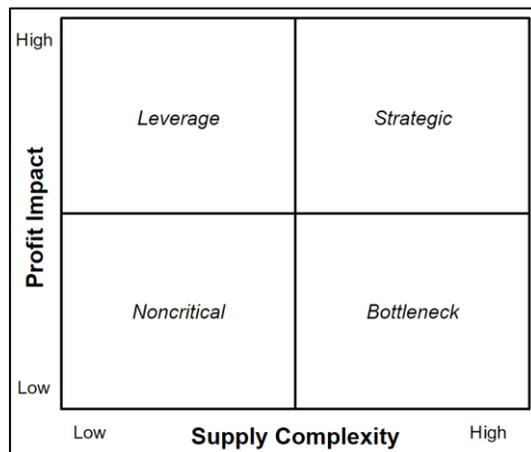


Figure 1: The Kraljic matrix [83]

Related to SCR discussed earlier, Caniëls and Gelderman [88] associate supply complexity with the dimension of supply risk, whereby increased complexity leads to a higher vulnerability of supply disruptions. Similarly, the increased importance of an item sourced from a given supplier leads to more significant losses if its procurement is no longer guaranteed [87, 89]. This falls within the vulnerability framework of Sheffi and Rice [90], which guides practitioners in directing supply chain efforts and relationship management for building SCR. In terms of SCC, Gelderman and Van Weele [85] note the need for collaboration with suppliers with high supply complexity. Furthermore, items categorised by the Kraljic matrix as bottleneck, leverage, or strategic require increasing degrees of buyer-supplier collaboration [86, 91].

3 METHODOLOGY

3.1 Research design

This study employed a single holistic case-study design. This case-study design refers to studies where a single unit of analysis - i.e. buyer-supplier relationships - is embedded in a given context - i.e. a petrochemical firm. Case-study research in the broader sense is also well-suited to exploring complex and unique phenomena - i.e. resilience - in depth [92]. Furthermore, buyer-supplier relationships are embedded in the supply chain network, and are thus subject to network effects, thereby distorting the boundaries between the phenomenon and the context [6]. These distorted

boundaries make the phenomenon ideally suited to a case-study design, exploring whether a new set of explanations could be relevant in a different context [93-95].

3.2 Sampling

This study was conducted in a South African-headquartered petrochemical firm with interests in Southern Africa, North America, and Europe.

Purposive critical case sampling, as proposed by Creswell [96], was used in the study to identify the focal firm for the case study. Yin [93] notes the appropriateness of critical case sampling for a single holistic case study, when an exceptional case offers an opportunity to derive great insights into a given phenomenon [97]. The focal firm was selected on the basis of its majority market share (>40%) of mid-stream fuel supply capabilities in the South African economy [21, 22]. The firm represents a critical case for investigating SCR, with the clear economic importance of withstanding upstream disruptions and maintaining the supply of the final product to consumers [23].

The firm operates a 'buy-make-sell' model with upstream coal, oil, and natural gas exploration capabilities, midstream refining, and chemical production capabilities in South Africa, Europe, and North America, and downstream distribution and retail capabilities throughout South Africa. The firm is classified as a mid-tier Integrated oil and gas company with a global footprint. Thus the unit of analysis was the inbound supply chains of the local South African operations, focusing on collaboration undertaken with first-tier suppliers.

As proposed by Polit and Beck [97], a mixture of purposive and reputational sampling was used to identify potential participants in the study. Initial contact was made with the vice president of the inbound supply chain to facilitate access, obtain advice on how best to sample within the organisation, and obtain referrals to other relevant study participants. This was done to include supply chain professionals from a variety of supply chain roles, and because of the researcher's unfamiliarity with the specific operational structure of the inbound supply chain function of the firm.

3.3 Data collection

The data collection for this study was done through semi-structured interviews. Semi-structured interviews help the researcher to gain perceived causal explanations of SCR in relation to SCC, a key objective of qualitative research employed in this study [98]. Furthermore, semi-structured interviews allow for deeper understanding of the phenomenon through intensive exploration of the apparent causalities [99]. Accordingly, 11 participants were interviewed in person on a one-on-one basis at their respective offices. The focal firm operates numerous business units that participate in various stages of the petrochemical value chain. All of the participants who were sampled fulfil senior sourcing and procurement executive roles, with the majority being designated as vice presidents of their business units' inbound supply chain function. Interview questions and an accompanying discussion guide were primarily formulated in accordance with the needs of the relevant research questions, which were in turn informed by underlying theoretical SCR and SCC concepts developed through the literature review. The average duration of the interviews was around 31 minutes. All of the interviews were recorded in audio format after obtaining permission from the participants. The researchers transcribed each interview recording within one day of conducting it. An iterative process of comparing the verbatim transcripts with the recordings was followed to ensure their accuracy.

3.4 Data analysis

A thematic data analysis procedure was used to analyse the data in this study, allowing the researcher to interpret shared meanings through coding and the subsequent identification of themes [100, 101]. The study employed the analysis process proposed by Nieuwenhuis [102]. Initial thematic codes were generated after the researcher had become familiar with the data. A 'code' refers to a label that provides a means of identifying a feature in the data that is potentially relevant to the research question [100]. Subsequently, themes related to the research questions were deduced from the generated codes, and juxtaposed in relation to the construct of resilience. This allowed for the structuring and mapping of the findings.

3.5 Trustworthiness

To ensure trustworthiness in qualitative research, four sub-criteria need to be met: transferability, confirmability, credibility, and reliability [97, 106]. Transferability was ensured by providing a detailed and thick description of the participants, the methodology, and the research setting, which is critical to context-specific case-study design [107]. Due to the contextual relevance of this case study, an external supply chain professional with significant exposure to the focal firm was consulted to ensure that the interpretation of the contextual data elements was correct, strengthening confirmability [97]. Confirmability was further enhanced by relating data back to the existing literature, thereby ensuring confidence in the research findings [101]. Credibility was ensured through broadly replicating the existing theoretical and research framework employed by Scholten and Schilder [6], the researcher producing a reflective commentary to enhance ‘progressive objectivity’, and relating the research findings to the findings of previous studies [106]. While credibility goes some way towards ensuring dependability, thorough descriptions of the research design, the data-gathering procedures, and the reflective appraisal of the findings were undertaken to enhance the reliability of the findings [106].

3.6 Ethical considerations

The relevant research ethics committee of a South African university approved the study prior to fieldwork being conducted. To conform to the ethical principles of informed consent, participants were requested to read through and sign the informed consent form before beginning the interview. The consent form explained the purpose of the study, the fact that participation was voluntary, and that they would be within their rights to withdraw at any time. Furthermore, assurances of the complete anonymity and confidentiality of the participants’ answers and identity were given. Pseudonyms were subsequently used to identify all participants.

4 FINDINGS

4.1 Rationale for undertaking collaboration with suppliers

Under Kraljic’s matrix discussed earlier, the inability to supply could result from high supply complexity, while the impact could be significant losses for the focal firm [89-90]. But significant losses could be avoided if upstream supply could be secured despite supply-market complexity and the associated risk of disruption. The ability to ensure sustainable downstream supply and to avoid significant losses is therefore rooted in managing upstream supply complexity. This is evident from the following data extract:

“And I think it is number one in our risk assessment document is our inability to supply, ... part of our goals is this whole notion of sustainable supply. And again, that is our biggest risk because we really don’t have the control over our suppliers” (P006, Male, VP: Supply Chain).

The limited control over the actions of suppliers noted above, coupled with supply-market complexity, requires a collaborative orientation towards buyer-supplier relationships [54, 86]. Ultimately, a firm’s decision to collaborate with its suppliers is usually based on a consideration of the benefits (avoidance of losses) and costs associated with such a collaborative relationship [17].

Within the framework of Kraljic’s matrix, the focal firm divides its suppliers into three categories: bottleneck, leverage, and strategic. With this in mind, the findings suggest that most extensive collaboration takes place between the focal firm and its strategic suppliers, as indicated in Figure 2. This is primarily because of the high profit impact of the item being procured, and limited or no availability of alternative suppliers, as the following quote from the data suggests:

“OEM’s, original equipment manufacturers ... we have a big installed base of OEM Supplier B ... in Plant A ... reality is, we can’t change that today, so that’s a strategic relationship” (P007, Male, VP: Supply Chain).

Nudurupati *et al.* [86] note the need to increase the degrees of buyer-supplier collaboration between the respective categories. Related to SCR, each of these categories represents varying levels of supply vulnerability through the likelihood and potential impact (i.e., cost) of being disrupted [87, 88]. Conversely, collaboration with leverage suppliers under the Kraljic matrix is undertaken to a

moderate extent, as illustrated by the framework presented. This implies a product or high profit impact with low supply-market complexity, as multiple potential suppliers are available. Lastly, minimal collaboration takes place between the focal firm and bottleneck suppliers, as the items sourced are not deemed critical to profit impact, with a very limited number of suppliers readily available. This creates a need for low-level collaboration [88].

4.2 Collaboration mechanisms and the enablers of resilience

Four themes of collaborative activities between the focal firm and its suppliers emerged from the analysis. This section discusses these themes in relation to the existing literature, and juxtaposed with the antecedents of SCR - i.e., visibility, velocity, and flexibility. This serves to provide insights into the exact nature of the interaction between SCC and SCR in the context of the petrochemical firm.

4.2.1 Collaborative information-sharing and communication

Sharing information between buyers and suppliers enables visibility within the supply chain [42, 60]. In the context of SCR, visibility enables the early identification of supply disruptions [103]. Furthermore, gaining visibility is dependent on the quality of the information that is shared, facilitated by the alignment of systems [52, 65, 66]. These elements are evident from the data:

“The more accurate demand forecasting and accuracy, which will inform the supplier ... [and would] would stabilise the supply” (P002, Female, VP: Supply Chain).

“The right systems need to be in place to enable the sharing of information. So master data would have to be good, because without the right master data you can't share information properly in the supply chain” (P005, Male, VP: Supply Chain).

Streamlining supply chain processes drives supply chain velocity [14]. In line with the findings of Scholten and Schilder [3], the data provided evidence linking collaborative communication to increased supply chain velocity by streamlining processes and improving overall supply chain performance:

“You tell us where I prevent you from doing your work, because there is something that I want from you and I need to remove all obstacles to get back to the contract so that you can deliver on your contract. And this is where we moved away from: ‘here is your contract, just do’ ... to ‘let’s talk about it together’” (P009, Male, Supply Chain Manager).

In the case of the focal firm, collaborative communication allows a supply chain to increase flexibility by providing additional time to source from alternative suppliers. This typically occurs through advance warning of impending supply disruptions, as illustrated by the following extract:

“When they have got upsets ... they will come to us and say: look, we’ve got operational challenges in here, our challenges will last for about three weeks or four weeks, can you try and source from your alternative? Give us enough time so that you can do that and switch over, and put the logistics around it together” (P001, Male, VP: Supply Chain).

Information-sharing between the focal firm and its suppliers therefore leads to supply chain velocity, visibility, and flexibility. This relationship is shown in the framework in Figure 2. However, the extent of information-sharing in the South African petrochemical industry is subject to regulatory frameworks related to competitive behaviour. This is illustrated in Figure 2 by the negative relation between legislation and information-sharing. While these restrictions might not apply to all buyer-supplier relationships, the highly complex and interconnected nature of the petrochemical and related auxiliary sectors lead to some facets of collaborative communication being restricted:

“Information-sharing has to be done in a selective manner, and you cannot contravene any regulations in different countries with different regulations” (P004, Male, VP: Supply Chain).

“There is a lot of restrictions on what you are allowed to share with your suppliers. So there is ... restrictions from the company’s perspective of what we are allowed to share and what not” (P002, Female, VP: Supply Chain).

4.2.2 *Collective effort and leveraging partner capabilities and insights*

The data highlights collaborative resource-sharing between the focal firm and suppliers, leveraging their partner's resources through reconfiguration according to the collective needs of the various members:

"Eskom is balancing our rotors for our rotating equipment, but they are also balancing their own. And OEM Supplier B, one of our service providers ... also balance their own rotors. Sometimes we balance on behalf of OEM Supplier B, in other instances we balance on behalf of Eskom. It depends on what their workload is" (P009, Male, Supply Chain Manager).

"So actually you get the capacity increase or you get more flexibility because of that common operation et cetera, and that makes it a little more resilient" (P007, Male, VP: Supply Chain).

Such coordination flexibility between different parties enables supply chains to be reconfigured to new requirements necessitated by a disruptive event, and still maintain the desired supply chain outcome [104].

In the context of SCR, decision synchronisation is "essential for effective system-level disruption responses" [12]. The data would suggest that synchronising business decisions through joint planning and operational efforts allows supply chain partners to obtain visibility of issues throughout the value chain, while enabling timely and appropriate responses to impending supply disruptions. However, this is underpinned by effective communication and the flow of relevant information between supply chain partners, as illustrated through the indirect relation between information-sharing and collective effort in Figure 2. Together these facilitate visibility and velocity:

"We tend to have a partnering type of relationship, or a collaborative relationship where we share with each other business objectives. We understand each other's business objectives, and we come up with plans, jointly" (P005, Male, VP: Supply Chain).

"We have seen a situation where I know there might be ... a disruption in a month's time and therefore, through my collaboration with my suppliers ... my suppliers could build stock earlier to meet my demand, and then that has got a minimal impact when I have got that disruption" (P002, Female, VP: Supply Chain).

Supplier collaboration in the form of shared problem-solving allows supply chains to become flexible in their response to a pending disruptive event through the enablement of resource reallocation. This is illustrated by the following extract:

"And because we have a relationship with them, we went back to them and said 'guys, it's critical', and they actually made the date earlier by two weeks, which now fits us. But the reality is, we help(ed) them on our facilities six months ago, where they were in the same issue and then we helped them out" (P007, Male, VP: Supply Chain).

This corresponds with Min *et al.* [52], who note that joint problem-solving is a natural extension of sharing information between supply chain partners, while seeking joint solutions drives supply chain velocity through reducing lead times in response to changing supply chain requirements precipitated by a disruptive event [12].

The data presents a natural extension to joint solution seeking in the form of a bilateral flow of knowledge that is enabled by the collaborative relationship, as noted in Min *et al.* [52]. The bilateral flow of knowledge as a form of information-sharing is therefore a product of collective effort. Beyond specialist insights into their own products and services, suppliers are often exposed to process inefficiencies that the focal firm may not be aware of:

"You guys don't know what is happening on your plant, do you know that X, Y and Z is happening? So if you take X and Y, I can supply to you no problem ... In fact, I can even do better than what I do now'. Because we don't know from a supply chain ... point of view, what is the company doing wrong that prevents the supplier from delivering ... [what] he has been contracted for" (P009, Male, Supply Chain Manager).

When suppliers share such insights downstream, they enhance supply chain velocity by allowing the focal firm to leverage insights to streamline supply chain processes, enabling more timeous supply chain responses in the case of a disruptive event [14].

4.2.3 Joint knowledge creation

Joint knowledge creation is a natural extension of collective efforts within a buyer-supplier relationship. The results from the data analysis differ from the findings of Scholten and Schilder [6], in that no evidence was found to link the length of a buyer-supplier relationship to visibility through process insights and knowledge of typical order volumes. However, it should be noted that this notion is not disproved by the data. Alignment was found in terms of retrospective learning. Ponomarov and Holcomb [105] note that retrospective learning enables supply chain resilience through providing insights into system vulnerabilities (visibility) and facilitating preparedness (velocity), as shown in Figure 2 and illustrated by the following extracts:

“I mean, once you get back to stability, go back and find out exactly what was the root causes et cetera, in trying to resolve them.” (P008, Male, VP: Supply Chain).

“And there are investigation tools that we use ... we gather the people involved around a room ... we can see if this [was] the real root cause of ... the incident” (P001, Male, VP: Supply Chain).

“We try to learn from each other’s incidents and just make sure that we build kind of leading and proactive indicators to prevent catastrophic accidents or incidents” (P006, Male: VP: Supply Chain).

4.2.4 Mutual dependency and relational benefit

The following extract indicates that mutual dependency between the focal firm and a supplier leads to a more collaborative relationship:

“But you pick certain suppliers, which is [generally] strategic, and you then work with them to actually create the value on both sides; that is the other important thing. It doesn’t help you create value on one side, and the other side doesn’t benefit from it” (P007, Male, VP: Supply Chain).

Although not a collaborative activity as such, mutual dependency between the focal firm and its suppliers indirectly enables visibility by making partners more inclined to share information, thus creating visibility in the supply chain. The following illustrative quote provides evidence of such interconnectivity:

“And in terms of sharing the information which would direct the strategic intent of both companies. Because obviously you want to see both companies growing and therefore whatever information that you are going to share should be beneficial for both companies” (P002, Female, VP: Supply Chain).

Keeping the above in mind, Barratt and Oke [42] argue that mutual dependency in supply chain relationships leads to supply chain partners being more willing to share information on a collaborative basis, thereby enhancing visibility. Thus the data correlates with the findings of Scholten and Schilder [6], as mutually dependent buyers and suppliers share information more freely, and by extension enhance supply chain visibility.

4.3 A framework for collaborative activities in building supply chain resilience

The findings identified through themes relate to the focal firm’s rationale for collaborating with suppliers. These themes were subsequently integrated into the framework of Kraljic’s matrix, and helped to contextualise buyer-supplier collaboration in the setting of supply-related vulnerabilities in the resilience context. Furthermore, four themes of collaborative activities between the focal firm and its suppliers emerged: joint knowledge creation, collective effort, information-sharing, and the limiting effect of legislation on the extent on such information flow. These themes are then related to the antecedents to SCR identified in the literature - i.e., visibility, velocity, and flexibility. These relations were explored and elucidated in the findings above, and provide a framework for understanding the interaction between SCR and SCC in the context of the South African petrochemical firm. Collectively, the findings discussed above are presented in a contextual framework (Figure 2).

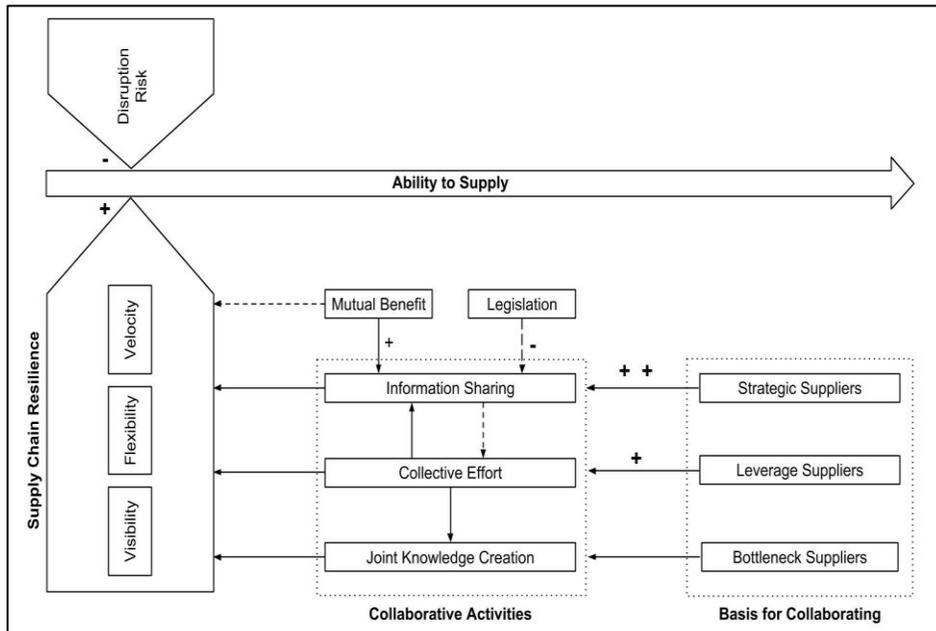


Figure 2: Framework for collaborative activities in building supply chain resilience

5 CONCLUSION

5.1 Summary of findings, and theoretical implications

Whereas most researchers and practitioners agree that SCR is a formative element of SCC, the exact nature of the interaction between the two concepts has, until recently, hardly been defined. With that in mind, the primary purpose of this study was to explore the underlying mechanisms through which buyer-supplier collaboration enables supply chain resilience, through the examination of a critical case in the petrochemical industry. A further purpose of the study was to explore the rationale behind undertaking collaboration between buyers and suppliers in the focal company, using Kraljic's matrix. This allowed the study to account for the underlying supplier-related risks that are inherent in the SCR discourse.

This study finds that collaborative activities between the focal firm and its suppliers do not directly influence SCR, but rather drive visibility, velocity, and flexibility, which in turn enable SCR. More specifically, the findings suggest that joint knowledge creation enables both supply chain visibility and velocity. Joint knowledge creation enables supply chain visibility through process insights, while velocity is facilitated by preparedness and experience of past disruption mitigations. Similarly, collective effort and information-sharing between the focal firm and its suppliers drives all three SCR antecedents. First, collective effort and information-sharing enable visibility through ensuring that quality supply chain data is available to network members. Second, collaborative communication allows buyer-supplier relationships mutually to identify opportunities for supply chain linkage optimisation and process streamlining, thereby enhancing velocity in response to supply chain disruptions. Finally, sharing information between buyers and suppliers enables flexibility through the early identification of impending disruptions, thus allowing sufficient time to restructure various supply chain elements to respond effectively to a disruption. However, the extent of information-sharing is limited by legislation that dictates the types of information that can be shared without breaching competition law. The findings also suggest that mutually dependent supply chain members are more inclined to undertake collaborative communication, thereby indirectly influencing visibility and subsequently SCR.

This study provides empirical support for the literature on the antecedents to SCR. For example, the findings support the notion that gaining supply chain visibility enables SCR by allowing a firm to anticipate impending disruptions better. The findings also present evidence that velocity allows supply chains to implement a faster response to a disruption. Finally, supply chain flexibility enables SCR through adaptability and restructuring of supply chain operations, according to the changing

supply chain needs necessitated by the disruption. However, whereas the literature taking a resource-based approach suggests a trade-off between supply chain velocity and flexibility, the study's findings fail to confirm this notion.

This study also investigated the rationale for undertaking buyer-supplier collaboration in the case of the focal firm under the framework of Kraljic's procurement matrix. This accounted for supplier-related risks underlying the SCR discourse, categorising suppliers as bottleneck, leverage, and strategic. This provides a new perspective on collaborating for SCR, as Scholten and Schilder [19] viewed the basis for collaboration with suppliers purely as a product of financial spend. The findings in this suggest that the firm's rationale for undertaking collaborative activities with suppliers is based on the criticality of the procured product (profit impact), and on the nature of the supplier market (supply complexity). Collectively, the literature notes that these parameters are central to resilience, as these determine the extent and cost of the disruption if supply is not secured.

5.2 Managerial implications

The study provides managerial insights into the importance of collaborative communication and information-sharing in gaining supply chain visibility, helping early identification of impending disruptions. This subsequently enables flexibility through allowing sufficient time to coordinate other supply chain resources to achieve the desired outcome. Furthermore, communication facilitates the streamlining of supply chain processes, thereby enhancing the velocity of subsequent supply chain responses to a disruptive event. Another managerial contribution directly relates to supplier management through collective supply chain efforts and the leveraging of a partner's capabilities. Managers could enhance supply chain flexibility through the reciprocal leveraging of partners' resources to respond to a disruptive event under capacity limitations. Internal process insights are gained through a two-way knowledge flow, thereby enhancing visibility. In the case study presented, the importance of collective learning from past disruptions in gaining visibility and velocity offers managers insights into how joint retrospective learning from disruptive events allows a supply chain dyad quickly to identify an impending disruption. Velocity is also gained through the fact that improved insights are gained and mitigation procedures are put in place. Whereas the above-mentioned managerial implications are generally known within industry, the findings of this study would suggest that supply chain practitioners should be aware that collaborating with suppliers should not be directly aimed at increasing resilience. Instead, buyer-supplier collaboration should enable concerted efforts towards enhancing overall supply chain flexibility, visibility, and velocity individually, and the success of such collaboration should be measured in terms of these elements.

The study also provides practitioners with an outline for using Kraljic's matrix to determine which buyer-supplier relationships would be suitable for undertaking SCC to enable SCR. The classification of suppliers into the strategic, leverage, and bottleneck categories could be used by managers to determine the extent of collaboration necessitated by the supplier's risk profile, thereby collaborating for SCR.

5.3 Limitations and directions for future research

Since the case-study is based on a critical case within the petrochemical industry, this could raise concerns about the applicability of the findings to other firms operating in the industry. However, although the research offers managerial insights into petrochemical supply chains operating a 'buy-make-sell' model, the findings could add value to similar studies in similar industries with comparable supply chains. Therefore, future research could expand the sample to include multiple petrochemical companies, or the generalisability of the findings could be tested by replicating the study in a different industry with similar supply chain characteristics. A further limitation of the study was that the study took the single-company perspective on dyadic buyer-supplier relationships, limiting the study in its supply chain network perspective. Subsequent research in the sector could include the dyadic view by gathering data from both buyers and suppliers. Furthermore, this study gathered data from multiple departments and product lines with variations in types of products and services sourced. Future research into the interaction between SCC and SCR could employ a segregated view, where the procurement of services and products is regarded separately. Exploration around resource redundancy and efficiency in the context of SCC and SCR could provide insights into how much efficiency could be built into a resilient supply chain. This would provide managers with valuable insights, as supply chain as a business function is as much related to achieving the desired outcome as it is to managing the overall system-related cost thereof.

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