Supply chain risk management processes for resilience: A study of South African grocery manufacturers

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Background: The supply chain risk management (SCRM) process is aimed at the implementation of strategies that assist in managing both daily and exceptional risks facing the supply chain through continuous risk assessment to reduce vulnerability and ensure continuity.

Purpose: The purpose of the study was to determine whether the SCRM process enables supply chain resilience among grocery manufacturers in South Africa. The fast-moving consumer goods (FMCG)-manufacturing industry faces increased risk because of the nature of their products being perishable with a limited shelf life.

Method: This study was conducted using a descriptive qualitative research design. Data were collected by means of 12 semi-structured interviews with senior supply chain practitioners within the South African grocery manufacturing industry.

Findings: The study found that most firms informally implement SCRM processes of risk identification, assessment, mitigation and monitoring to mitigate disruptions. Furthermore, the findings indicate that the SCRM processes facilitate resilience among grocery manufacturers in South Africa.

Conclusion: The managerial implications show that supply chain managers of grocery manufacturers should formalise the SCRM process and develop risk assessment scales to better prioritise risks in order to run a resilient supply chain. The research contributes to the supply chain management field by adding to the scarce literature relating to SCRM as an enabler of supply chain resilience in a South African context.

Introduction and problem statement

Because of the competitive business environment today, firms have been forced to expand their operations globally for cost effectiveness (Colicchia, Dallari & Melacini 2010:680; Diabat, Kannan & Panikar 2011:2; Pettit, Croxton & Fiksel 2013:46). The global dispersion of operations including suppliers, manufacturing plants, warehouses and customers has increased firm network complexity and risk vulnerability (Sachdeva, Kayis & Dana Kamingsih 2012:834; Soni & Kodali 2013:25). This has led to increased interest in supply chain resilience and supply chain risk management (SCRM) to cope with complex supply chain risks (Leat & Revoredo-Giha 2013:219; Scholten, Sharkey Scott & Fynes 2014:211; Wieland & Marcus Wallenburg 2012:888; Wilding, Colicchia & Strozzii 2012:403). SCRM has received increased attention from researchers and practitioners because of the uncertainty and complexity facing supply chains. SCRM provides effective tools and practices which, aligned with the corporate strategy, mitigates the challenges created by uncertainty and complexity (Wieland & Marcus Wallenburg 2012:888; Wilding et al. 2012:405).

Supply chain risks are events that negatively affect supply chain operations (Leat & Revoredo-Giha 2013:221). Managing global supply chains and meeting growing customer requirements have made firms more conscious of their vulnerability to threats affecting operational and environmental activities (Harrison et al. 2013:264; Urciuoli et al. 2014:46). Several disruptions have affected firm supply chains. Examples include Ericsson which experienced a disruption in 2000 when their only supplier of integrated circuits suffered a shutdown because of a fire by lightning. The result was that Ericsson exit the mobile-phone handset business (Chakravarty 2013:40). Another example of financial losses from such disruptions include 300 billion US dollars lost because of a Japanese earthquake and $40 billion from the explosion of a high-tech deep-water oil well in the Gulf of Mexico (Chakravarty 2013:40–41). In order to manage these risks, many firms are building supply chain resilience capabilities.
According to Ponomarov and Holcomb (2009:131), supply chain resilience is an adaptive capability that prepares, responds and recovers supply chains from unpredicted events, through maintaining stability of operations (Park 2011:109; Wilding et al. 2012:404). An aspect of resilience gaining attention by academics is SCRM (Breuer et al. 2013:333; Leat & Revoredo-Giha 2013:220). The tools provided by SCRM assist on-going risk assessment with the goal of decreasing vulnerability and guaranteeing continuity (Breuer et al. 2013:333; Vilko, Ritala & Edelmann 2014:5) for firms in industries such as automotive, electronics, agriculture and fast-moving consumer goods (FMCG) (Ketkar & Vaidya 2012:60; Leat & Revoredo-Giha 2013:220; Li, Tan & Hida 2011:5428).

Globalisation has increased cost pressures and customer demands pressuring FMCG firms to seek and implement efficient processes and reduce redundancies through just-in-time production or decreasing the supplier base (Diehl & Spieiner 2013:311; Li et al. 2011:5417). These practices have led to risks such as non-receipt of raw materials, mismatch in quantity supplied, inventory write-off, increased cost of fuel leading to higher costs of transportation, and for grocery manufacturers specifically, constraints of holding a limited amount of safety stock because of the perishability of products as well as product contamination (Glendon & Bird 2013:4; Kärkkäinen 2003:50; Leat & Revoredo-Giha 2013:220). These risks, in turn, are pushing firms to seek resilience capabilities through the SCRM process (Leat & Revoredo-Giha 2013:220; Töyli, Wieland & Marcus Wallenburg 2013:312). The supply chain process entails risk identification, risk assessment, risk mitigation and risk monitoring (Sodhi, Son & Tang 2012:5; Xie, Tummala & Schoenherr 2011:477).

Despite increased attention, research on supply chain resilience and SCRM has been undertaken separately, and as such there is limited scientific research in the field of supply chain resilience and SCRM, considering SCRM as an enabler of supply chain resilience (Scholten et al. 2014:211; Sodhi et al. 2012:3; Töyli et al. 2013:301). An in-depth search in the literature available in the South African context further revealed a gap in the existing body of knowledge. A study by Breddell and Walters (2007) proposed a structured and disciplined framework to integrated supply risk management. A more recent study by Agigi, Niemann and Kotzé (2016) introduced supply chain resilience in the South African context, focusing on supply chain design approaches as an enabler of supply chain resilience.

Although the SCRM process is well established in literature, and the reality of increased risks is present for most global firms, the SCRM process and the management thereof are not formally implemented in firms (The Global Supply Chain Institute 2014:2). The purpose of this study was to explore whether the SCRM process enables supply chain resilience among grocery manufacturers in South Africa.

This study is guided by the following exploratory research questions:

- What are the supply chain risks faced by South African grocery manufacturers?
- What risk identification process or processes are used by the manufacturers?
- What risk assessment methods are used by the manufacturers?
- What risk mitigation practices are implemented in case of supply chain risks?
- What risk-monitoring mechanisms are used by the manufacturers?
- How does the SCRM process mitigate the risks faced by the manufacturers and enable supply chain resilience?

Based on the numerous risks facing supply chains, SCRM is growing in importance for researchers and practitioners and in protecting firms from disruptions that cause major losses in productivity and profitability. This study, therefore, makes the following contributions. Firstly, most SCRM research is based in Europe, Asia and America. This study extends SCRM research into the African context, specifically South Africa. Secondly, literature on SCRM in the FMCG industry globally is limited. This study reduces this gap and broadens SCRM to the context of grocery manufacturers. Thirdly, the managerial implications show that supply chain managers of grocery manufacturers should formalise the SCRM process and develop risk assessment scales to better prioritise risks in order to run a resilient supply chain.

The following literature review sections detail supply chain risks, supply chain resilience, SCRM and the SCRM process. The methodology section will follow thereafter. The article concludes with the presentation of the research findings, limitations and recommendations.

**Literature review**

**Supply chain risks**

In seeking cost reduction and competitiveness, firms have resorted to globalisation and outsourcing, which have led to increased connectivity and interdependency (Amoo Durowoju, Kai Chan & Wang 2012:999; Le, et al. 2013:783). As a result, risk exposure has increased because of shorter product life cycles, higher dependency on suppliers and other external players in their supply chain. These affect supply chain performance by disrupting the smooth flow of materials and information in the supply chain in turn causing financial losses (Chakravarty 2013:39; Punniyamoorthy, Thamaraiselvan & Manikandan 2013:80; Rajesh, Ravi & Venkata Rao 2014:246).

According to Liu, Lin and Hayes (2010:224), risks are any exposure posing a threat to the existence of a business (Spiegler, Naim & Wikner 2012:6162). Firm risks can be divided into four main areas, namely financial, operational, strategic and compliance risks. However, supply chain risks comprise disruptions that interfere with the consistent movement of materials, information and finances, which may negatively influence the achievement of a firm’s goals,
as well as the supply chain, with regard to cost, quality and time (Colin et al. 2011:840; Hofmann et al. 2014:162; Spiegler et al. 2012:6162). According to Wilding et al. (2012:413), supply chain risks are categorised as internal and external risks. Internal risks include forecast inaccuracy, worker accidents, distorted information, quality issues and capacity cost, while external risks include price fluctuations, plant fires, labour disputes, customs and regulations and economic downturns (Dash Wu, Olson & Dash Wu 2010:698; Lin & Zhou 2011:177).

Risk drivers are the sources of supply chain risks. They determine the degree of risk and have different avenues from which they arise: from internal operations, the supply chain and the external environment (Olson & Wu 2011:402; Pfohl, Köhler & Thomas 2010:35). The drivers from the external environment include wars and global financial crises. Drivers from internal operations include product quality capabilities and financial solvency, and supply chain drivers include globalisation and increased outsourcing (Dash Wu et al. 2010:695; Thun, Drüke & Hoenig 2011:516).

Real-world business scenarios of risks and their effects include Toyota’s recall of gas pedals (Choy et al. 2011:1004; Rotaru, Wilkin & Cegłowski 2014:1246) and Boeing’s shortage of building parts for the 787 planes because of a disruption with their Advanced Integration Technology (Saghaian & Van Oyen 2012:834). Apple suffered a shortage of DRAM chips because of an earthquake in Taiwan leading to customer loss (Amundson et al. 2013:3944; Chakravarty 2013:39; Liu, Li & Wu 2014:1201). A port strike that lasted 40 days in Hong Kong from April to May 2013 also disrupted the movements of goods affecting lead time of various firms whose operations passed through the port (The Global Supply Chain Institute 2014:23).

The Barloworld supply chain foresight reported that labour unrest and inefficiency of ports and harbours in South Africa are a few of the major risks faced by South African firms. Furthermore, the report stated that South African firms tend to apply reactive strategies when faced with such challenges instead of anticipating and aligning the firms’ strategies to be flexible and responsive to changes occurring in the market. The lack of effective processes within firms was cited as a constraint to implementing proactive strategies to mitigate risks (Barloworld 2014:16).

Because of the above-mentioned risks and their negative effects on firm operations and performance, firms need resilience capabilities to avoid, mitigate and reduce the effects of disruptions (Johnson, Elliott & Drake 2013:333; Urciuoli et al. 2014:57). The need for resilient firms in South Africa, especially, is evident and this research aims to address this issue by studying South African grocery manufacturers; the SCRM processes they have in place; and importantly, to determine whether the supply chain resilience capability is present as a result of these processes.

Supply chain resilience

As mentioned previously, supply chain resilience has been growing as a research focus because of its importance in preparing firms for disruptions that negatively affect their supply chain productivity, profitability and competitiveness (Töyli et al. 2013:311; Urciuoli et al. 2014:47). It is therefore necessary to discuss supply chain resilience within risk management.

Supply chain resilience is an adaptive capability that enables preparation for unexpected events, counters disruptions and returns operations to a stable state through continuity of operations at the expected level of connectedness and control over structure and function (Johnson et al. 2013:325; Ponomarov & Holcomb 2009:131; Töyli et al. 2013:301). Resilience is not only reactive but also a proactive, structured and an incorporated consideration of proficiencies that a supply chain possesses to deal with unforeseen events (Johnson et al. 2013:333; Wilding et al. 2012:404).

Supply chain resilience consists of two main capabilities, namely flexibility and redundancy. Redundancy focuses on limiting risks and its consequences by keeping reserves such as safety stock and sourcing from multiple suppliers (Jüttner & Maklan 2011:247; Zsidisin & Wagner 2010:3). Flexibility ensures speedy responses to risk that may materialise. From a supply management context, firms can invest in strong buyer–supplier relationships that motivate suppliers to take extraordinary measures to mitigate risks (Mensah & Merkuryev 2014:316; Zsidisin & Wagner 2010:3). Thus, to increase resilience, businesses should invest in mechanisms that facilitate both flexibility and redundancy. This is because a strategy that implements only redundancy or only flexibility would increase the risk occurrence costs (Wieland 2013:660). While the two capabilities are both important, their applicability in terms of the risks differs. Redundancy is preferable for everyday risks because of high frequency of occurrence and low impact while flexibility is preferable for exceptional risks usually of low probability and high impact which require rapid response (Kumar, Himes & Kritzer 2014:887; Wieland 2013:662). Other capabilities facilitating resilience include visibility, collaboration and velocity (Jüttner & Maklan 2011:252). By applying these capabilities to the supply chain, risk impact is reduced. The capabilities of resilience are intertwined with those of SCRM because they mitigate risks throughout the supply chain (Leat & Revoredo-Giha 2013:229). Additionally, some research shows that SCRM is the most pronounced resilience driver because it builds coordination within relationships in the supply chain which are essential to building resilience (Breuer et al. 2013:332; Jüttner & Maklan 2011:255; Töyli et al. 2013:312).

Supply chain risk management process

SCRM is the implementation of strategies that assist in managing both daily and exceptional risks facing the supply chain through continuous risk assessment to reduce vulnerability and ensure continuity (Breuer et al. 2013:333;
Wieland & Marcus Wallenburg 2012:888). The relationship of SCRM to resilience has been supported in literature. For example, risk-oriented actions such as supply chain risk effect management and supply chain risk knowledge management have been shown to have a positive impact on resilience capabilities such as flexibility, velocity, visibility and collaboration (Jüttner & Maklan 2011:252; Töyli et al. 2013:310).

Apart from strategies that may be implemented to manage risks in the supply chain, SCRM also comprises the SCRM process. Xie et al. (2011:477) construe the SCRM process to include risk identification, risk assessment, risk mitigation and risk monitoring, as illustrated in Figure 1. These steps equip managers with strategic information to select strategies that mitigate different risks to improve overall performance of the supply chain (Chapman, Bernon & Haggett 2011:1030; Xie et al. 2011:481). The four phases are discussed in the next sections.

**Risk identification**

The first critical step of the SCRM process is risk identification as it identifies vulnerabilities and the relationships between risks both internal and external to the firm (Breuer et al. 2013:335; Colin et al. 2011:839; Sachdeva et al. 2012:835; Wilding et al. 2012:413). Without identifying risks, it is challenging to develop relevant mitigation strategies with the available expertise to reduce the risk impact (Dash Wu et al. 2010:696; Lin & Zhou 2011:181; Punniyamoorthy et al. 2013:80).

Risk sources can be categorised according to external and internal risks. External risks are outside the scope of control of the firm while internal risks are associated with decisions made and actions taken within the firm (Trkman & McCormack 2009:247; Zamora, Adarme & Palacios 2012:396). Lin and Zhou (2011:177) outlined several sources of internal risks, which include research and development risk, production risk, planning risk and information risk. External risk sources include policy risk, supply risk and delivery risk (Lockamy 2011:412). Risk identification is finalised by linking risk sources with activities they affect in the supply chain (Breuer et al. 2013:333–334; Cagliano et al. 2012:823–824).

Because of the complex nature of supply chains, certain tools and techniques to ease the risk identification process are necessary. The methods used include locating risks, assessing the possible damage to the firm as well as its partners and the impact on the supply chain altogether (Lavastre, Gunasekaran & Spalanzani 2012:831). The failure modes and effects analysis (FMEA) encompasses these methods as it is a proactive tool that compels managers to continuously evaluate processes to identify where and how they might fail as well as to evaluate the impact of different failures in order to prevent them and to rectify the processes before an adverse event occurs (Sachdeva et al. 2012:835; Sharma & Bhat 2014:72; Xie et al. 2011:476).

After identifying risks, the likelihood and impact of these risks on the firm are determined in the risk assessment phase.

**Risk assessment**

Risk assessment determines the likelihood, frequency and the impact of disruptions within a range of different possible scenarios relating to disruptions (Amundson et al. 2013:3945; Bandaly et al. 2012:265). Limited resources can be effectively allocated to mitigate critical risks through risk prioritisation effected by risk assessment (Lockamy 2014:769; Punniyamoorthy et al. 2013:94; Soni & Kodali 2013:44).

The impact of risks is determined through the effects on the performance indicators of an organisation such as profitability and productivity. Examples of the impacts of risks include poor delivery performance, low-quality products and delivery of raw materials with wrong specifications (Ghadge et al. 2013:535; Vedel & Ellegaard 2013:512). Risk likelihood is another essential factor that determines the probability of a risk occurring. With risk impact and likelihood, firms can attach weights to each risk to determine the most detrimental ones (Kumar et al. 2014:878; Lockamy 2014:769).

It is important to consider whether a risk has a low or high probability of occurrence as well as low or high impact on the firm. Critical risks such as a vital component supplied by one supplier may need increased safety stock to mitigate the possibility of a risk, whereas an inessential component may not need a high amount of safety stock (Kumar et al. 2014:879). Therefore, each risk requires separate assessments to identify a feasible strategy to avoid failure during mitigation (Sharma & Bhat 2014:67; Wagner & Neshat 2012:2888). Risk assessment tools that can be employed include FMEA (Bandaly et al. 2012:253) and supply chain simulations to aid the visibility on the impact of a risk on financial, production, logistics and trade performance (Berle, Norstad & Asbjørnslett 2013:261; Lavastre et al. 2012:831). Following risk assessment, relevant strategies need to be developed in the risk mitigation phase.

**Risk mitigation**

Research on the SCRM process has mostly been performed on the risk mitigation phase because these strategies determine whether a firm would be able to effectively deal with risks (Marley, Ward & Hill 2014:143; Scholten et al. 2014:219). Risk mitigation reduces risk probability or impact or both. It is important for managers to choose an appropriate mitigation strategy for each risk (Liu et al. 2014:1203; Sodhi et al. 2012:6; Wagner & Neshat 2012:2888).

According to Cukrovic et al. (2013:21), firms have three mitigation responses for risks which may affect their

![Risk management process](https://doi.org/10.1108/13598541111171165)

**FIGURE 1:** The supply chain risk management process.
operations. These responses are accepting, reduction or sharing the risk with other supply chain partners. Accepting includes buffers, contingency planning and secure sourcing; reduction includes increased product differentiation, use of approved suppliers and multiple sourcing; and sharing may include supplier development initiatives (Ghadge et al. 2013:535). Mitigation strategies can also be categorised as proactive or reactive. Proactive strategies reduce the likelihood of a risk that may occur in the supply chain, while reactive strategies mitigate the effect of a risk after it has occurred (Scholten et al. 2014:216; Thun et al. 2011:5514). Proactive strategies include improved tracking and tracing and selecting high-quality suppliers with high dependability. Reactive strategies include dual sourcing, multiple sourcing and safety stocks (Kumar Sharma & Bhat 2014:1025–1027; Thun et al. 2011:5517–5518).

Before choosing a risk mitigation strategy, each risk facing the supply chain must be evaluated against the mitigation strategies available to the firm. In order to choose a relevant mitigation strategy for any risk, a cost–benefit analysis needs to be undertaken with risk appetite as a constraint (Diehl & Spinler 2013:317; Kumar Sharma & Bhat 2014:1032). In completing the SCRM process, firms need to follow through to risk monitoring.

Risk monitoring

According to Jüttner and Maklan (2011:253), it is imperative for firms to closely monitor the possibilities of various risk events. Firms that monitor their supply chain have improved visibility through the several nodes linking them, which positively impacts their resilience (Töyli et al. 2013:303). Risk monitoring determines the progress of mitigation actions, corrects deviations, identifies new preventative measures and predicts possible risks (Saghafian & Van Oyen 2012:835; Xie et al. 2011:480).

Most literature on risk monitoring is focused on the suppliers’ side of the supply chain. Some of the activities that firms participate in with regard to supplier monitoring include visits to supplier sites, regular assessment of suppliers’ processes and supplier performance measurement systems. When participating in these activities, firms use tools and techniques such as supplier questionnaires, benchmarking, on-site capability reviews and financial risk assessment (Curkovic et al. 2013:25; Scannell, Curkovic & Wagner 2013:372). However, firms need to consider which supply chain partners and risks require more priority with regard to risk monitoring. This is determined by identifying the partner and risk with the highest priority (Curkovic et al. 2013:25; Jung, Lim & Oh 2011:624; Xie et al. 2011:478). According to Xie et al. (2011:481), ever-changing risks make it important for firms to continuously monitor and assess risks in order to remain resilient in a turbulent business environment (Charkhab, Eslami & Dehnavi 2014:420; Thun et al. 2011:5514).

In summary, the above-mentioned processes namely risk identification, risk assessment, risk mitigation and risk monitoring are essential in effectively mitigating risks. Table 1 summarises the literature sources used in the discussion of the processes.

Agigi et al. (2016:2) describe SCRM as a set course of action taken by firms to identify, assess, analyse and manage risk in the firms supply chains. The probability of events is an essential determinant of strategies to be implemented within the SCRM process (Kumar et al. 2014:879). Supply

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### Table 1: Summary of literature review

| Supply chain management process | Description of process | References |
|--------------------------------|------------------------|------------|
| Risk identification | It is the process by which potential risk sources that may affect performance are identified. | Berie et al. (2013) |  
| Risk assessment | It determines the likelihood, frequency and the impact of disruptions within a range of different possible scenarios related to these disruptions. | Amo Durowoju et al. (2012) |  
| Risk mitigation | It is the element of the SCRM process that reduces the probability of specific risks occurring or their impact or both. | Marley et al. (2014) |  
| Risk monitoring | It is the means by which firms are able to determine the progress of their mitigation actions, take corrective actions for any deviations and also identify possible new preventative measures. | Charkhab et al. (2014) |  

Note: Please see the full reference list of the article, Simba, S., Niemann, W., Kotzé, T. & Agigi, A., 2017, ‘Supply chain risk management processes for resilience: A study of South African grocery manufacturers’, Journal of Transport and Supply Chain Management 11(0), a325. https://doi.org/10.4102/jtscm.v11i0.325, for more information.
chain resilience is concerned with proactive and adaptive capabilities aimed at assisting firms’ readiness to combat unanticipated risks where probabilities cannot necessarily be determined (Agigi et al. 2016:2). This study aims to determine whether the SCRM process can enable supply chain resilience.

Research method and design

Research design

A descriptive qualitative research design was adopted for the study. This research design provides rich and detailed information from the participants’ perspective and experiences on the focal topic (Neergaard et al. 2009:2). The thematic analysis technique used in this research design was flexible and therefore allowed the researcher to discover new insights through the use of semi-structured interviews (Sandelowski 2000:338).

Sampling

The unit of analysis for this study was FMCG grocery manufacturers in South Africa. Homogeneous sampling was used where resembling individuals and sites were selected based on their capacity to provide rich information that assisted in understanding the focus topic (Creswell 2012:206–208). Supply chain executives, general managers and logistics directors were among the participants interviewed in the study. For purposes of collecting relevant information, the interviewee selection was of utmost importance. Participants had to possess strategic and operational knowledge of the firm’s supply chain and willing to share openly on risk, disruption and the mitigation strategies used. This specific sampling also permitted the understanding of the FMCG grocery manufacturing industry with product categories including frozen, canned and packed foods, confectionary, beverages, hygiene and personal products. Because of the sensitive and permissible nature of these products, the industry is vulnerable to a number of disruptions.

Twelve firms participated, permitting a total of 12 face-to-face semi-structured interviews. The final sample size was decided based on the guidelines by Guest, Bunce and Johnson (2006:61), stating that 6–12 interviews are satisfactory for the development of meaningful themes, valuable interpretations and the occurrence of saturation in the data, whereby no more meaningful information is drawn out of the interviews and information obtained from further interviews proves to be repetitive. Data saturation occurred on the tenth interview conducted in this study.

Data collection

Based on the literature review, a discussion guide was compiled followed by a pilot study with one industry practitioner to verify the suitability of the questions as well as the probable duration of the interviews. From the pilot study, minor changes were made to the discussion guide, allowing for the initiation of data collection. Twelve face-to-face interviews were conducted at the participants’ offices. In approaching the participants, the researchers made telephone calls, which were followed by an email with the discussion guide and informed consent form attached. A convenient time and venue were arranged through email and telephone calls.

Each interview started with a brief introduction of the interviewer, the purpose of the study, clarification of confidentiality and anonymity and a request to digitally record the interview. Each interview lasted about an hour. The researchers transcribed 10 of the 12 interviews. Two remaining interviews were transcribed, proof read and certified by a transcription service because of time constraints. The researchers checked all transcriptions while listening to the digital recording and made changes where mismatches were found with the digital recordings. The participant profiles are shown in Table 2.

Data analysis

A thematic analysis was conducted to analyse the data collected in this study. Thematic analysis identifies, organises and reports patterns within data called themes. It is flexible enough to provide rich and detailed accounts of data (Braun & Clarke 2006:79; Penney et al. 2011:3). Initial exploratory analysis was carried out by listening to the digital recordings and matching against the transcripts in order to familiarise and engage with the data and generate codes (Creswell 2012:243). Sections of the data that included applicable information were labelled to outline the meaning of the section in particular. A broad list of codes, forming patterns, was generated and an analysis was performed to select and combine related codes. Thereafter, the related codes were combined to form bigger themes, which provided deeper meaning. The final themes were determined through their applicability in answering the study’s research questions (Braun & Clarke 2012:6365).

| Participant pseudonym | Job title | Firm pseudonym | Product category pseudonym | Interview duration (min) |
|-----------------------|-----------|----------------|---------------------------|-------------------------|
| P1                    | Planning Manager | C1 | XY1 | 69 |
| P2                    | Supply Chain Executive | C2 | XY2 | 97 |
| P3                    | Customer Service and Logistics Director | C3 | XY3 | 66 |
| P4                    | General Manager | C4 | XY4 | 70 |
| P5a and P5b           | Supply Chain Development Manager | C5 | XY5 | 86 |
| P6                    | Supply Chain Planning and Integrated Business Planning Manager | C6 | XY6 | 59 |
| P7                    | Head of Supply Chain | C7 | XY7 | 57 |
| P8                    | International Supply Chain Manager | C8 | XY8 | 51 |
| P9                    | Plant Manager | C9 | XY9 | 64 |
| P10                   | Supply Chain Manager | C10 | XY10 | 55 |
| P11                   | Integrated Business Planning Lead | C11 | XY11 | 64 |
| P12                   | General Manager Supply Chain | C12 | XY12 | 77 |
Trustworthiness

The research reliability is supported through a detailed description of the research design to enable the replicability of the research by future researchers. A descriptive background to the study was provided, an interview discussion guide was developed, and the process for data analysis was discussed. A rich, thick description of the sites and participants was provided following the deliberate use of verbatim quotes from the participants which added to the authenticity of this study (Polit & Beck 2012:595). Furthermore, to ensure credibility, peer debriefing sessions were held with selected individuals at the researcher’s university. The study was scrutinised by an experienced supply chain academic and a research methodology expert to eliminate any biases and preferences by the researchers. A detailed explanation of the grocery manufacturers who participated in this study was provided by clearly indicating the various product categories represented by each manufacturer. An audit trail, including the interview transcripts, recordings as well as the themes and subthemes, was kept. Furthermore, triangulation through individual interviews whereby some company documents on risk assessment were provided to supplement information gathered. Interviewing 12 participants from the 12 firms provided verification of the SCRM practices across grocery manufacturers because many of the practices were repeated in different firms.

Findings

This study set out to determine the use of the SCRM process for resilience among grocery manufacturers. The result of thematic analysis of the findings according to subthemes, themes, and the participants are shown in Table 3.

The study identified the following themes which directly answered the study’s research questions, namely (1) supply chain risks, (2) risk identification, (3) risk assessment, (4) risk mitigation, and lastly (5) supply chain resilience. Supply chain risks were identified in the first step of the SCRM process and will be covered under risk assessment. Each main theme and sub-theme is discussed and supported by verbatim quotations from the participants.

Risk identification

Risk identification is the first essential step of the SCRM process whereby potential risks are identified and relationships established between internal and external risks (Breuer et al. 2013:335; Sachdeva et al. 2012:83). Under risk identification, two subthemes are discussed, namely risk drivers and risk identification tools. Fourteen risk drivers were identified during the study. These were divided into internal and external risk drivers. Internal risks are risks associated with decisions and actions taken from within a firm, while external risks are those that are out of the scope of control of the firm (Trkman & McCormack 2009:247; Zamora et al. 2012:396). Typically, firms employ different methods to identify risks and these are discussed next.

Most of the firms investigated lacked formal risk identification tools. The tools were both reactive and proactive. Reactive methods discover risks only after they have occurred, while proactive methods discover risks before they occur (Scholten et al. 2014:216; Thun et al. 2011:5514). The reactive method to risks is illustrated by the following quotes:

Yeah so I think identifying the risks uhm ... (Pauses) yeah reactively is always easy because it kind of hits you in the face. (P1, Male, Planning Manager)

And then you get your ad-hoc ones that just happen and then you go into a bit of a crisis management. (P3, Male, Customer Service and Logistics Director)

Proactive methods consist of FMEA, feedback, audits, brainstorming and observations. Feedback, for example, is illustrated in this quote:

So we get you know continuous feedback. We try and develop sort of contingency plans ahead of time and we expect our suppliers to do the same. (P6, Male, Integrated Business Planning Manager)

| Themes               | Subthemes       | P1 | P2 | P3 | P4 | P5 | P6 | P7 | P8 | P9 | P10 | P11 | P12 |
|----------------------|-----------------|----|----|----|----|----|----|----|----|----|-----|-----|-----|
| Supply chain risks   | Transportation risk |   |    |    |    | X  |    |    |    |    |     |     |     |
|                      | Supplier risk   | X  | X  | X  | X  | X  | X  | X  | X  | X  |   X |   X |     |
|                      | Labour risk     | X  | X  | X  | X  | X  | X  | X  | X  | X  |   X |   X |     |
|                      | Forecasting risk| X  | X  | -  | X  | X  | -  |    |    |    |     |     |     |
|                      | Facility risk   | -  | X  | X  | X  | X  | X  | -  | -  | -  |     |     |     |
|                      | Product risk    | -  | X  | X  | X  | X  | X  | X  | -  | -  |     |     |     |
| Risk identification  | Risk drivers    | X  | X  | X  | X  | X  | X  | X  | X  | X  |   X |   X |     |
|                      | Risk identification methods | X  | X  | X  | X  | X  | X  | X  | X  | X  |   X |   X |     |
| Risk assessment      | Assessment tools| X  | X  | X  | X  | X  | X  | X  | X  | X  |   X |   X |     |
|                      | Assessment scales| X  | X  | X  | X  | X  | X  | X  | X  | X  |     |     |     |
| Risk mitigation      | Flexible strategies| X  | X  | X  | X  | X  | X  | X  | X  | X  |   X |   X |     |
|                      | Redundant strategies| X  | X  | X  | X  | X  | X  | X  | X  | X  |   X |   X |     |
|                      | Mitigation criteria| X  | X  | X  | X  | X  | X  | X  | X  | X  |   X |   X |     |
| Risk monitoring      | -               | X  | X  | X  | X  | X  | X  | X  | X  | X  |     |     |     |
| Supply chain resilience | -             | X  | X  | X  | X  | X  | X  | X  | X  | X  |     |     |     |

Table 3: Summary of themes and subthemes identified per participant.
In the South African context specifically, it was found that labour risks are reoccurring, and as such these risks are identified from experience. This method of risk identification was not identified in previous literature. A reason for this could be that experience as well as reoccurrence of the labour unrest risk is specific to the South African context. The quote below illustrates this point:

probably through experience have learnt what are the things that we need to watch out for so we would uhm have plans in place by our own labour unrest … So we know once a year your wage negotiations that’s a volatile period. (P5, Male, Customer Service and Logistics Director)

These methods assist grocery manufacturers in South Africa to identify potential risks for mitigation.

**Risk assessment**

Risk assessment assists firms to prioritise risks based on likelihood, frequency and the impact (Amundson et al. 2013:3945; Bandaly et al. 2012:265). In order to understand risk assessment, two subthemes were investigated, namely the risk assessment scales and risk assessment tools implemented by firms.

**Risk assessment scales**

Assessment scales assist firms to prioritise risks within their supply chain. In this study, grocery manufacturers identified two scales, namely risk likelihood and risk impact illustrated in the following quotes:

We look at the impact, the likelihood, and then the inherent risk. (P5, Male, Supply Chain Development Manager)

But if we look at our whole business as a total, we use those scales right through, right. So whether it’s financial, operational, we always look at it that way to say it is at a high risk, low probability what is the financial impact of that et cetera et cetera. We use a robot system. So those little robots in all our reports say red, yellow, green to say where we think the risks would be and you know probability of them um of occurring. (P2, Male, Supply Chain Executive)

These scales are in line with literature on risk prioritisation whereby risk impact and risk likelihood are the standard risk prioritisation scales (Kumar et al. 2014:878; Lockamy 2014:769).

Two firms did not have assessment scales. This is illustrated by:

I don’t think we’ve done, in C10, I don’t think we’ve done an official rating scale as yet, but I think it’s pretty informal in terms of the way it has been done in the past. (P10, Male, Supply Chain Manager)

The monetary fraud, those risks are generally monitored but generally in supply chain, we don’t have a proper scale that we can implement. (P11, Male, Integrated Business Lead)

**Risk assessment tools**

The tools in the participant firms were categorised according to internal and external assessments. Internal assessments focus on the firm’s operations, while external assessments focus on the external supply chain partners such as suppliers and customers. Internal assessments included Pareto analyses and Key Performance Indicators. Internal assessments are illustrated by this quote:

We have a joint scorecard so we jointly measure ourselves and the level of inventory the filling rate, on-time delivery and so on. (P7, Male, Head of Supply Chain)

External assessments included supplier audits and benchmarking. From the data, external assessments are illustrated by:

when we look at suppliers, we look at uhm together making the assessment of the risks that they have. So do they rely on just one manufacturing site, where is it located, what’s the likelihood of strikes, what’s the likelihood of their raw and pack material suppliers going to be disrupted and on. (P7, Male, Head of Supply Chain)

As mentioned by the participants, the assessment methods used by the firms are not well established and formalised within South African grocery manufacturers. Assessment efforts and methods are implemented for financial risk but not commonly established for supply chain risks. These assessment systems do not match the assessment tools found in the literature such as FMEA (Bandaly et al. 2012:253) and simulations (Berle et al. 2013:261) for supply chain risks. Some of the participants claimed that these informal methods work for the firm, while others admitted that formal methods of assessment should be implemented for managing supply chain risks. These results are in line with the industry report compiled by the Global Supply Chain Institute, of the University of Tennessee (The Global Supply Chain Institute 2014:2).

**Risk mitigation**

Risk mitigation centres on formulating strategies that reduce the risk impact and likelihood or both (Liu et al. 2014:1203; Sodhi et al. 2012:6; Wagner & Neshat 2012:2888). These strategies are categorised according to redundant and flexible strategies which are appropriate for different types of risks (Kumar et al. 2014:887; Wieland 2013:662).

Redundant strategies identified included safety stock, strategic stock and centralisation. Examples of safety stock and strategic stock are illustrated respectively:
Yes. So example, the potential Transporter’s strike that’s happening now in August, we would definitely increase our stock levels in case it was going to be a full-blown strike that we couldn’t service retail. (P8, Male, International Supply Chain Manager)

In times we know there’s gonna be an event like strikes and stuff we will then preposition stock to then just lift the whole supply chain. We can’t keep it at one site so we’ve got a few key 3PL warehousing companies that helps us with flex. But obviously, you speak to your customer’s right? Again, you preload them as well. (P2, Male, Supply Chain Executive)

The second sub-theme of flexibility strategies is discussed in the following section.

The most frequently mentioned flexibility strategies were multi-sourcing and flexible distribution. These can be shown respectively in these participant quotes:

... we are always make sure that we have more than one supplier for a specific good or service ... and it’s normally up to three suppliers. (P12, Male, General Manager: Supply Chain)

So when we enter the contract with the 3PLs, within the 3PL contract we’ve got various models. So you move from a fixed dedicated fleet that is yours full-time that’s operated by a third party into a model where you only make use of a broker from external. So again it gives you flexibility as well. So if broker A can’t help you, you’ve got broker B, C, D, E, F on the books. (P3, Male, General Manager)

The use of flexibility and redundant mitigation strategies in reducing the impact and likelihood of risks faced in firm’s operations is supported in literature (Kumar et al. 2014:887; Wieland 2013:662).

One firm lacked multi-sourcing strategies, which increased their vulnerability shown by:

Yeah you have supplier risks in terms of so the biggest issue that we have is um kind of all our eggs are in one basket if you get where I’m coming from. We haven’t got a broad base of suppliers. So the risk is that the supplier can literally do with us what he wants to when he wants to. That’s the biggest risk right. (P11, Male, Integrated Business Planning Lead)

In the process of selecting mitigation strategies, there are some criteria on which strategies are assessed to find the most appropriate strategy for the risk at hand (Diehl & Spinler 2013:317; Kumar Sharma & Bhat 2014:1032). Some of the criteria mentioned by the participants included cost, risk and customer service. Cost and customer service were the most appropriate strategy for the risk at hand (Diehl & Spinler 2013:317; Kumar Sharma & Bhat 2014:1032). Some of the criteria on which strategies are assessed to find the most appropriate strategy for the risk at hand (Diehl & Spinler 2013:317; Kumar Sharma & Bhat 2014:1032). Some of the criteria on which strategies are assessed to find the most appropriate strategy for the risk at hand (Diehl & Spinler 2013:317; Kumar Sharma & Bhat 2014:1032).

These criteria are representative of the cost–benefit analysis shown by the literature as factors to consider when selecting a mitigation strategy (Diehl & Spinler 2013:317; Kumar Sharma & Bhat 2014:1032).

Risk monitoring

Risk monitoring is the final process of the SCRM process. Risk monitoring assesses the effectiveness of mitigation strategies, seeks to correct deviations and discovers new strategies that mitigate risks (Saghafian & Van Oyen 2012:835; Xie et al. 2011:480). Three themes were observed and are discussed in the following sections.

In the study, some of the tools mentioned included benchmarking, supplier site reviews and market analysis. These assisted them to monitor risks both within and outside their operations. The main focus of risk-monitoring activities was suppliers, although some firms identified monitoring activities that they carried out on their retailers. The use of assessment tools is highlighted below:

The other way we find out is that we oversee on a regular basis from time to time do benchmarking exercises so we go out there and do not benchmarking but we also do market analysis, try to figure out what’s going on out there in the market and bottom end, what is going to happen to it in the next couple of years and so forth you know. So and those factors tell us what’s going on in the market. (P12, Male, General Manager: Supply chain)

Therefore, some of the tools identified in this study are similar to those identified in literature (Curkovic et al. 2013:25; Scannell et al. 2013:372).

Firms perform monitoring activities on their partners and risks on a daily, weekly, monthly, quarterly and annual basis depending on the risk type. The participants’ statements showing their risk-monitoring activities in their operations and their partners are:

And those operational risks, there are some that we look at on a weekly basis, some we look at on a daily basis. (P9, Male, Plant Manager)

Well, again I don’t think we do a risk monitoring. But you say like a price increase or a promotion that’s likely to happen, it’s more that we sit together, we have like a, depends on what criteria you look. We have a 3-year outlook or 1-year or 3-months or a few weeks outlook. (P7, Male, Head of Supply Chain)

Grocery manufacturers in this study prioritise their monitoring activities of risks and their partners as discussed in the literature (Curkovic et al. 2013:25; Jung et al. 2011:624), based on the criticality of the suppliers. The monitoring process identifies new risks within the firm and its partners. This follows the literature on the role of the risk-monitoring process in identifying new risks (Saghafian & Van Oyen 2012:835; Xie et al. 2011:480).

Only one firm differed. They monitored their less reliable suppliers supported by this statement:
And then we’ve got some farmers who’s not as consistent, you would not, you’d probably pay more attention to them to be honest. You know you’d get the extension officers to spend more time with these farmers to make sure that they are doing the stuff right and their pivot hasn’t maybe fallen over or the pump broke and they can’t irrigate. So they might be more factors. (P6, Male, Integrated Business Planning Manager)

This is something to consider for several firms because programmes that increase the reliability of non-critical suppliers could be a benefit to the firm in cases where their more reliable suppliers may face a disruption.

**Supply chain resilience**

Supply chain resilience describes the capability of a firm to recover from a disruption back to its normal or a better state of operation (Johnson et al. 2013:325; Ponomarov & Holcomb 2009:131; Töyli et al. 2013:301). The participants showed the role of SCRM in creating resilience as follows:

I think that, or more than a hundred years that C5 is running. I think we have very limited, where we could say we had major impacts on the business, which we could not manage or mitigate. (P5, Male, Supply Chain Development Manager)

I know safety stock is probably our biggest our biggest that helps us recover. That that is the biggest strategy that helps us recover because that ensures continuous supply. (P11, Male, Integrated Business Lead)

The study shows that the SCRM process is a resilience capability as shown in literature (Breuer et al. 2013:332; Jüttner & Maklan 2011:255; Töyli et al. 2013:312).

Despite the effectiveness of the SCRM processes in several firms in the study, one firm suffered a disruption where it was not able to recover back to its normal steady state. Interestingly enough, this firm did not have a formal SCRM process in place. An illustrative quote follows describing the risk assessment tools implemented followed by an incident which occurred where the firm was unable to recover:

Um right now to be honest with you when you say tools, it’s very much, we have a management tool but a process that we use is excel based. So in other words, we don’t go there’s a system and we punch in something in the system and the system whips up something in, no. (P12, Male, General Manager: Supply Chain)

There was a particular item. Now I’m not technical so in the mill, like a compressor, somebody forgot to replenish in stock into stock. The one in the mill broke down and there was nothing. A mill was not operational uh for 12 hours. That in our industry, I don’t wanna say like it’s a cardinal sin. It’s a sin. It cannot allow that kind of thing to happen… The impact of that is remember we’ve got safety stock of two weeks, 12 hours. So you can say 2 weeks minus 12 hours. You can almost never recover that in our, from our perspective…. Unfortunately, we don’t produce it in the quantities that we produced it before so it’s much smaller quantities so yes that element is an impact our ability to supply the market this year. We just don’t know by how much right now. (P12, Male, General Manager: Supply Chain)

The above example illustrates that in cases where the SCRM process was absent in a few of its steps, the firm was unable to be resilient, thus confirming that the SCRM process is indeed a capability of supply chain resilience.

**Ethical considerations**

Each participant was required to read and sign an informed consent form before being interviewed. The consent form explained the study’s purpose and emphasised that participation was voluntary and that the participant could withdraw at any time. The informed consent form also provided anonymity and confidentiality assurance. Before each interview, the same information was verbally summarised to the participants. Pseudonyms shown in Table 2 were used to protect the identity of the participants, product categories and firms. A research ethics committee at a South African university approved the study prior to conducting fieldwork.

**Discussion**

**Outline of the results and theoretical implications**

The purpose of this research was to determine whether the SCRM process enables supply chain resilience within grocery manufacturers. By firstly identifying the risks faced by each grocery manufacturer, the study reveals three main risks, namely labour unrest, volatile demand and supplier risks. These risks were categorised by their frequency of occurrence and impact on the firm. It was discovered that the SCRM process elements of risk identification, risk assessment, risk mitigation and risk monitoring were present within the grocery manufacturing firms. Some risk identification methods used were feedback from customers, experience and brainstorming. Risk assessment tools included internal assessments such as joint scorecards, and external assessments included benchmarking. However, some of the firms lacked formal risk assessment tools, which is a crucial step of the SCRM process as this is the stage where risks are unidentified and the next steps are planned out. Moreover, it was discovered that supply chain risks specifically lacked attention from the firms’ executives. Priority is given to financial risks whereby formal procedures are in place.

The two main scales most often used for assessment were the likelihood of occurrence and impact of the risk. Mitigation strategies were several, and both redundant and flexible strategies were implemented by many grocery manufacturers, which are aligned with strategies for supply chain resilience. This is supported by previous literature showing that both types of mitigation are necessary for versatile risk mitigation (Kumar et al. 2014:887; Wieland 2013:662). Lastly, risk-monitoring methods identified included benchmarking and supplier reviews. These are acceptable as they directly relate to the main risks faced by the industry. Monitoring activities were carried out during different schedules such as daily, weekly, quarterly and annually, depending on the type of risk.
From the above process elements, the SCRM process and its role in facilitating resilience was shown, supported by literature from other countries (Breuer et al. 2013:333; Leat & Revoredo-Giha 2013:220). This study provides evidence for the existence of the SCRM processes of risk identification, risk assessment, risk mitigation and risk monitoring within grocery manufacturers, and it shows that aspects covered by the SCRM process are in fact in line with strategies that facilitate resilience among grocery manufacturers in South Africa. In so doing, the study adds to the scope of studies in supply chain management with regard to the SCRM process and resilience.

**Practical implications**

While most of the firms in the study implemented several SCRM processes, a few lacked formal assessment scales. Assessment scales are crucial because they prioritise risks. This, in turn, allows effective allocation of resources to mitigate the highest impact risks and prevents waste of resources on low impact, low likelihood risks. Therefore, it is imperative for firms especially those in the FMCG industry focusing on cost effectiveness to have proper risk assessment scales. Secondly, a structured approach to SCRM process is not in place at the firms although they use the process elements. A structured approach would benefit firms in the following ways; managers would have a similar basis of discussion and cooperate on risk mitigation. Thirdly, it would create a boundary between SCRM and other supply chain operations, which would assist in managing risks more effectively because there would be a focus division for risks. Fourthly, some firms could look at allocating a division specifically responsible for the SCRM process. This would create uniformity in dealing with disruptions. Lastly, supplier monitoring was most prevalent while their customers, retailers in this case, received less attention. Firms could increase their retailer monitoring through collaboration with retailers. This would, in turn, reduce some risks especially with regard to forecasting and would drive a resilient supply chain altogether.

**Limitations and future research**

The focus of this study was limited to FMCG grocery manufacturers. However, this provides several opportunities for future research, especially in other risk-prone contexts. Different manufacturers of consumer goods may be researched such as electronics and clothing or different industry contexts such as the automotive industry. Furthermore, the study could be replicated to include other tiers of the FMCG grocery industry, such as wholesalers and grocery retailers in order to paint a clearer picture of the SCRM processes for resilience. Because the research was based in South Africa, it would be interesting to see whether similar results would be obtained if the study were to be replicated in other countries in Africa with similar economies such as Kenya, Nigeria and Angola.

**Conclusion**

The main objective of the research undertaken was to provide insight into the SCRM process implementation within South African FMCG grocery manufacturers as well as to identify whether the SCRM process enables supply chain resilience. The study was executed using a descriptive qualitative research design through 12 semi-structured interviews conducted with supply chain practitioners within the South African grocery manufacturing industry. It was discovered that several methods for risk identification were used such as brainstorming and audits. Risk assessment included internal and external assessments with risk impact and likelihood as assessment scales. Risk mitigation methods of flexibility such as multi-sourcing and flexible distribution and redundant strategies such as safety stock and mapping; lastly, with the investigation of risk monitoring, supplier-monitoring prioritisation was identified along with risk-monitoring tools such as Key Performance Indicators.

Furthermore, the implementation of the SCRM process showed increased resilience among grocery manufacturers when faced with a disruption. Despite the success of the SCRM process in facilitating resilience, some firms revealed that the SCRM process as a whole has not received much attention as a formal process; instead, some elements of the process are used in isolation. One firm, in particular, especially lacked a formal SCRM process and was unable to recover from a disruption despite having some of the process elements in place. Risk assessment tools, specifically, were absent from the SCRM process. This implies that in some cases, firms are unable to avoid or mitigate risks despite having some systems in place to prevent them. Through processes such as SCRM, the firms can reduce the effects of these risks. Therefore, firms are encouraged to implement the SCRM process as a formal process as well as a supply chain resilience enabler because it reduces risk impact and likelihood which prevents loss of productivity and profitability as a result of disruptions.

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**Competing interests**

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

**Authors’ contributions**

This article is based on the MPhil dissertation of S.S. who was the main researcher. W.N. assisted as a supervisor with the conceptualisation, literature review, research instrument and review of the draft manuscript. T.K. provided methodological and technical guidance. A.A. made content revisions and additions.
Supply chain management best practices: A case of humanitarian aid in southern Africa

Introduction

Southern Africa has experienced a combination of natural disaster occurrences such as bush fires, floods, disease and epidemic outbreaks as well as droughts (McClintock 2009:297). These have resulted in the loss of lives and sustained injuries, with many affected communities displaced from their homes and thus prone to starvation and destitution (United Nations [UN] 2009).

At the highest level, humanitarian supply chain management during relief operations consists of activities such as the management of stakeholders, strategic planning and assessment efforts with the intention of facilitating efficient and effective responses (Talib & Hamid 2014:27). Initially, the relief organisations are faced with the challenge of acquiring the needed supplies from different donors. Then, at the next level, the success of the relief operation depends on the most productive supply chain management practices being put in place, relative to vital activities such as procurement, warehousing, transportation and distribution, planning and execution (Fritz Institute 2010; Tatham & Pettit 2010:609). Consequently, the donor supplies need to be delivered to the affected sites within the shortest possible period of time (Perry 2007:410).

Successful relief operations need to ensure that the appropriate supplies are procured and transported ‘in the right quantities, to the right people at the right location and at competitive prices’ (Herrmann 2007:12). The benefit of achieving supply chain efficiency during humanitarian operations is the minimisation of the extent of suffering of the affected communities (Zhao, Xie & Zhang 2002:34) and to avoid any further loss of lives. As a result, it is essential that the supply chain be agile, flexible and responsive.
Within the above context, the focus of this article is to provide an overview of how the United Nations World Food Programme (UNWFP) has made significant strides in successfully responding to natural disaster operations in southern Africa.

This article comprises four sections. The first section is the introduction, including the background and the literature review. The second section presents the research methodology utilised for the research, and the third section presents an explanation and analysis of the findings. Lastly, the fourth section concludes with a conclusion.

**Literature review**

**Context of humanitarian supply chains**

Humanitarian supply chains consist of a network of interaction between donor governments, international and locally based agencies, suppliers and numerous other stakeholders that co-ordinate the flow of supplies, services, finances and information for the purposes of responding to beneficiary needs (Howden 2009:5). The movement of supplies and materials should be cost-effective and therefore proper planning and control are essential (Herrmann 2007:12). Humanitarian logistics involve a set of supply chain activities carried out during disaster operations with the aim of attaining co-ordinated logistics excellence. These activities involve the task of transporting large volumes of supplies and materials that are essential during relief operations (Tatham & Pettit 2010:611; Thomas & Kopczak 2005:3; Tomasini & Wassenhove 2004:438). It is necessary that all the humanitarian events occurring before and after a disaster are appropriately conducted in order to meet the needs of the affected communities. This can be achieved when the factors influencing relief operations are taken into account during such operations (Minnich & Maier 2005:34). Table 1 presents some of the main disaster occurrences common in southern Africa and the beneficiary needs.

**Factors to be considered in designing humanitarian supply chain frameworks**

Humanitarian organisations face various challenges during relief operations. These challenges need to be identified in order for the ideal supply chain best practices to be implemented. Pateman, Hughes and Cahoon (2013:90) identified a number of the dominating challenges including the unpredictability of occurrences with respect to timing, geographic location and magnitude.

Two key issues have been identified to impact on the success of any supply chain – both are closely linked. Those are the flow of accurate information and effective and accurate demand management.

With the affected governments and relief organisations not being in a position to appropriately assess the damages (Balck et al. 2010:28) and with little or no demand information available, the respondents usually transfer supplies to the affected areas with the hope that such supplies will be adequate to meet the needs of those affected by the disaster (Kovacs & Spens 2007:104). This often leads to a congestion of the supply chain with unwanted and inappropriate supplies, as donors and relief organisations respond by transferring supplies into the supply chain, without having accurately determined the number of affected people, their geographic location and type and number of relief supplies required.

Humanitarian operations are often conducted in areas with destabilised infrastructure, including improper transportation channels, such as airports, road networks and railway lines (Kovacs & Spens 2007:100). These conditions affect the success of disaster operations exacerbating the accessibility of the affected areas. The majority of humanitarian disaster operations are usually under-funded, which results in most organisations not prioritising the adoption of key supply chain concepts. This affects and compromises the success of their disaster operation efforts (Moe & Pathranaruk 2006:400).

Another key variable in disaster relief operations is the availability of supplies. This includes supplies of sanitary medical products, foodstuffs and water plus clothing and shelter equipment, all of which need to be procured and

**TABLE 1: Main disaster occurrences and the corresponding beneficiary needs.**

| Disaster classification | Disaster occurrence | Main characteristics | Beneficiary needs |
|-------------------------|---------------------|----------------------|------------------|
| Hydro-meteorological disasters | Flooding, cyclones and flash floods | Massive torrential rains. Displaces households. Destroys infrastructure and communication networks. Limited access and movement between areas. | Relocation to unaffected areas. Provision of temporary shelter, clothing and sleeping material. Provision of food supplies and clean drinking water. |
| Droughts and widespread starvation | Acute food shortages triggered by a decline in cereal and crop production. More communities requiring food aid. Children are usually the most vulnerable group. | Transportation of food supplies to the affected communities. Main food supplies on demand – grains, cereals, tinned foods and high-energy biscuits. Implementation of measures aimed at improving food sustainability. |
| Biological disasters | Epidemic outbreaks | Outbreaks of diseases such as cholera, typhoid and malaria. Need to be properly managed. Affected individuals need medical and food supplies. | Provision of medical care and supplies to affected areas. Implementation of measures to prevent the diseases from spreading. Provision of consistent medical and food supplies. |

http://www.jtscm.co.za
distributed during operations (Patemen et al. 2013:93). Chakravarty (2010:3) indicates that natural disaster occurrences are characterised by a drastic increase in demand for supplies required by the affected population who are dependent on relief aid. This implies that organisations have to identify a credible pool of suppliers to cope with the increasing level of demand. The required set of supplies may vary greatly depending on the nature, type and impact of the disaster occurrence and the demographics, as well as social and economic conditions of the affected areas. In addition, as experienced by the UNWFP during the southern Africa droughts in the year 2000, supply patterns are further complicated by the increasing costs of relief supplies where the prices of grain and wheat have increased substantially because of the adverse conditions (WFP 2011).

Lead time refers to the total time required for an ordered product to be delivered (Heizer & Render 2014:524). Lead time is commonly used as a measure of efficiency with most customers preferring that the period between placing an order and receiving it be kept at an absolute minimum. Because of the unexpected and extraordinary nature of the disaster event, relief organisations require supplies to be delivered from either their donors or suppliers within the least possible time (Chopra & Meindl 2013:328) in order to alleviate the hardship of the people affected by the disaster. A key expectation from relief organisations is to source their supplies on a shorter lead time basis (Sheu 2006:687).

**Supply chain management practices applicable during humanitarian relief operations**

Considering the challenges explained above that are encountered during humanitarian disaster operations, it is necessary that a framework of supply chain practices is identified and adopted that will ensure that disaster operations are conducted effectively and efficiently. Concepts addressing *agility, flexibility and responsiveness* have been identified as relevant as they place an emphasis on customer focus (Aprile, Garavelli & Giannoccaro 2005:25; Stevenson & Spring 2007:685). Researchers acknowledge the significance of these concepts as they enhance the level to which an organisation adapts to changing customer needs. Key to achieving agility is the use of the supply chain concept of *postponement*, with access to *virtual integration* capability and through the effective *co-ordination* of all activities.

*Agility* is defined as the ability of an organisation to copy and remain successful in an unpredictable and continuously changing market environment. This implies the organisation’s supply chain is capable of absorbing and containing any arising uncertainties (Ismail & Sharifi 2006:43). Vonderembse et al. (2006:99) are of the view that agile supply chains enable organisations to rapidly respond to a changing, dynamic and highly uncertain environment by being context specific. This is particularly relevant in disaster relief operations.

*Postponement* is a supply chain management concept where activities are only performed when specific customer orders are received. It is a concept that is closely associated with *agility* and is usually implemented by organisations operating in conditions of uncertainty and is considered a building block towards achieving customer responsiveness (Charles, Lauras & Wassenhove 2010:725). Postponement as an agility tool is mostly implemented during inventory management processes, whereby humanitarian organisations hold stocks for specific generic products that are later customised as determined by the needs of the affected communities (Simchi-Levi, Kaminsky & Simchi-Levi 2008:218).

*Virtual integration* is responsible for ensuring that the organisation has the ability to implement improved process control measures and is also able to manage demand volatility. It is a common strategy, key in achieving agility and used in supply chains to reduce environmental uncertainty through emphasising inter-organisational co-ordination, information processing and control (Wang, Tai & Wei 2006:46). For supply chains to be considered agile and responsive, there is a need for the implementation of IT systems to facilitate common operations between response stakeholders such as purchasing, logistics and distribution. Virtual structures are dynamic and ensure that there is improved speed and flexibility through building a united information space with extensive and accurate communication services (Camarinha-Matos & Asfarmanesh 2004:12).

Moeiny and Mokhlesi (2004:8) define *coordination* as involving an atmosphere in which all humanitarian relief organisations and their stakeholders willingly share information that is key during relief operations. Co-ordination measures ensure that all the organisations and parties that are involved during disaster management make informed decisions based on information provided by suppliers, donor community and their partners. When numerous partners are involved in analysing the needs of the beneficiaries, there is usually an accurate reflection of the exact needs, while a number of the information that is freely exchanged involves beneficiary preferences and demand levels (Oloruntoba 2007:3).

Supply chain *flexibility*, is described as affecting specific organisational components such as the product mix and volume and is defined in terms of mobility, uniformity and range, referring to the different states in which a system can adopt and be able to switch efficiently from making one product to another (Jangga et al. 2015:265). This implies that the organisation is able to deliver and assemble a diversity of products within a specified range (Stevenson & Spring 2007:687). Although the concept of flexibility is derived from manufacturing organisations, efforts have been made to implement this principle in service and humanitarian organisations (Krajewski, Wei & Tang 2005:460).

The aim of agility and flexibility is to improve the *responsiveness* of the organisation in fulfilling the needs of its customers. The framework of agile, responsive and flexible supply chains is suitable for implementation in an environment that is characterised by rapidly changing customer demands (Chandra & Grabis 2009:12). The main challenges faced during disaster operations involve a combination of factors,
linked to the unpredictability of disaster occurrences in terms of time, nature and scope (Bean et al. 2011:40). Despite these, the main objective of humanitarian organisations is to respond timely to any disaster occurrences which can be achieved through different agile, flexible and responsive initiatives (Christopher & Towill 2001:550).

Humanitarian organisations can draw practical lessons from prior research on the concept of agility in relation to how it has been implemented in different organisational operations. As a result, an explanation of how agility has been implemented through postponement, virtualisation and coordination is appropriate.

Research methodology

A case study approach for this article was deemed appropriate as the aim was to identify the selected supply chain management practices that can be implemented during relief operations in southern Africa. Case study research is descriptive and exploratory and is defined as an approach to research that enhances the exploration of a set of variables within a specific context using a variety of data sources (Baxter & Jack 2008:544). Malhotra (2004:77) remarks the use of this technique as common with exploratory studies where the main focus is on gaining insight into a specific subject and especially on research problems where fewer studies have been conducted (Malhotra 2004:77). However, Malhotra (2007:82) writes that causal links in case study research are difficult to test and generalisations cannot be made from single case studies.

A non-probability convenience purposive sample was used and five participants at the UNWFP southern African regional office in Johannesburg were interviewed during this study (see Table 2).

Data were gathered through in-depth interviews using a semi-structured interview guide. The interview guide included both closed and open-ended questions and was flexible enough to allow the interviewer to be able to adjust the sequence in which questions were asked and to further probe the participants based on their responses.

In order to ensure reliability during the data collection process, interviews were recorded using a digital voice recorder and these recordings were later transcribed verbatim and checked against voice recordings for accuracy. The results generated from the interviews were analysed using the thematic data analysis approach. Thematic analysis is a general approach to analysing qualitative data. It involves identifying themes and patterns within the data (Wagner, Kawulich & Garner 2012:231). Once the recordings were transcribed, the data were unitised and categorised according to the study themes, and any data identified outside of the themes were discarded. The process involved the identification of themes through careful reading and re-reading of the data. This is a form of pattern recognition within the data, where emerging themes become the categories for analysis and allowed for the identification of supply chain management best practices patterns, such as agility, flexibility and responsiveness. Based on the results generated, the data were displayed in the form of a thematic map.

Results and discussion of findings

In order to identify the benefits associated with the implementation of supply chain management best practices during natural disaster operations, participants were asked to list and explain the various initiatives adopted by the UNWFP that aim to make sure that disaster relief operations are successful. Based on the themes generated from the in-depth interviews, supply chain best practices were mainly linked to the concepts of agility, responsiveness and flexibility. Figure 1 provides a thematic map outlining a summary of the different supply chain practices implemented by the UNWFP and what they aim to achieve during relief operations.

The results have been organised into different qualitative themes that are further explained using the categories below.

Theme 1: The adoption of flexible supply chain management practices

The level of complexity of humanitarian relief operations implies that the adoption of flexible supply chain practices is essential to ensure that organisations effectively respond to a variety of relief occurrences (Tomasini & Van Wassenhove 2009:550). For the

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**TABLE 2: Profiles of the participants.**

| Characteristics     | Description                                                                 |
|---------------------|-----------------------------------------------------------------------------|
| Gender              | A total of five participants were involved during this research study, of which four were male and one was female. |
| Qualifications      | Most of the participants have different university qualifications in the Engineering, Project Management and Supply Chain Management disciplines. They all have an average of 5 years work experience in the humanitarian environment. |
| Job title           | The job titles held by the participants at the UNWFP include Regional Logistics Officer, Procurement and Logistics Specialist and Logistics Planner. |
| Years with the company | The participants have been involved in many operations with the UNWFP and they have an average of 10 years each with the organisation. In those 10 years, an average of 7 years were involved in relief operations within southern Africa and the other 3 years to operations outside of the region. |

UNWFP, United Nations World Food Programme.
UNWFP, adaptation in these different conditions is attained through ensuring that flexible supply chain practices are adopted. The organisation has honoured the firm commitments it has made by being engaged in fragile environments despite the challenging circumstances it encounters.

The range of flexible supply chain management practices that the organisation has adopted encompasses its policies pertaining to how it manages partnerships created with other stakeholders and the infrastructure it has invested in. The benefits of adopting flexible supply chain practices are further explained in the following categories.

**Category 1: Customer or beneficiary needs**

Fulfilling the needs of the affected communities is the core objective of the UNWFP, which is achieved through the implementation of flexible supply chain practices. The focus of the UNWFP is on delivering food supplies and other related disaster needs to the communities at the appropriate time and ensuring that there are sufficient staff and materials available to distribute to the affected areas.

Examples provided by the participants represent a useful indication of the efforts made by the UNWFP towards improving customer or beneficiary responsiveness. The UNWFP considers all its beneficiaries as its main target customers. Thus, all efforts and attempts are directed towards fulfilling their required needs. For example, in 2012 the UNWFP distributed an estimated 230 862 metric-tonnes of food to 5 347 786 million beneficiaries.

The following is one of the verbatim quotes extracted from the various participants, which supports that disaster operations conducted by the organisation are sensitive to customer’ needs:

> As an organisation we have adopted a beneficiary focused approach, which is driven by being sensitive to all the needs of the communities that we are involved in. One of the key policies that we used during the Zambia food crisis (drought) involved ‘cash and vouchers’. (Participant 1, Male, Regional Logistics Officer)

The cash vouchers are mainly used in areas that are hard hit by food shortages (droughts). Cash vouchers are a substitution for the traditional ways of providing food and are more flexible.

The UNWFP is responsive to the needs of its intended beneficiaries through its strategic policies, which includes improved efforts to assess the needs of the affected communities and improved emergency communications. Efforts continue to be made to ensure that all the natural disaster occurrences experienced in the region are properly managed through carrying out proper assessments and information management in order to understand the needs of the beneficiaries and thereby promptly address them.

**Category 2: Access to the affected areas**

Most disaster occurrences cause infrastructural damage, such as the disruption of railway systems, bridges, roads, public dwellings and port systems. This means that the UNWFP struggles to find safe passages to provide aid through distributing relief supplies to the affected areas. The organisation, with an advanced transportation and logistics network in place, enables it to be more flexible in accessing different areas affected by various natural disaster occurrences.

The successes have been attained as a result of the implementation of measures such as the use of the United Nations Humanitarian Air Services (UNHAS) and the Rapid Response Mechanism. These successes have improved the UNWFP’s ability to access various areas. Within this context, the following are a selection of quotes from the participants:

> … the UNHAS programme has allowed UNWFP provision for access into important priority destinations enabling humanitarian staff to begin the work of assessing needs and initiating timely response operations. (Participant 3, Male, Logistics Planner)

Accessibility by the UNWFP is mainly achieved through a diversified pool of transportation infrastructure, which enables it to access the different areas in which a natural disaster occurs. Other determinants of access to affected areas include the ability of the organisation to identify the affected areas through effective information management and the collaborative efforts offered by the other partners through the Cluster Approach. These have a positive contribution towards ensuring that the flexible approaches implemented enhance the organisation’s access to all the affected areas.

**Category 3: Capacity to deliver successful operations**

As a result of adopting flexible supply chain management practices, the UNWFP is able to handle disaster operations of varying capacities. The participants described capacity as ‘the ability of the organisation to conduct operations of different volumes, in various areas, at different times and to provide a diverse range of services and relief supplies’ (Participant 1, Male, Regional Logistics Officer). This ability is mainly influenced by the increased presence of the organisation through its regional centres. In southern Africa, the regional office is in Johannesburg, with different country offices spread out throughout the region. These offices usually take charge in responding to disaster occurrences within their boundaries and, if need be, other regional and international offices may assist.

Capacity building is one of the main core competencies that the UNWFP has achieved over time through various tools. On participant quoted:

> Our mandate as an organisation lies in supporting natural disaster prevention, preparedness and response to vulnerable communities. We have therefore developed distinct comparative advantages in areas involving analysis, capacity development and operational capacity to strong inter-agency leadership. (Participant 2, Female, Logistics Officer)

Based on this quote, it can be inferred that the organisations’ logistics capacity is designed to be able to adapt to the various levels of demand resulting from the different disaster occurrences.
Theme 2: The adoption of agile supply chain management practices

The emphasis of the UNWFP is in ensuring that it has the ability to adapt to the changing response conditions because it is involved in conducting various disaster operations in different locations. Based on this theme, the insights are provided on how the organisation has implemented agile supply chain practices and how these practices enabled successful disaster operations.

Category 1: Increased market sensitivity

Market sensitivity implies that the UNWFP is able to initiate disaster operations in any location and at any given time. The ability with which the organisation is able to initiate disaster operations is dependent on factors such as the availability of funds, donors to support operations and other initiatives that enable UNWFP to respond to the increasing needs of the affected communities.

The organisation, in spite of the instability of the donor community, ensures that funds are available to support any emerging disaster occurrence. Their efforts include forging partnerships with the corporate and public sector, who are usually the first to respond when a disaster occurs. For example, during the 2014 floods in Mozambique, the government of the Republic of South Africa was one of the first donors to pledge funds and provide military infrastructure and personnel. One of the participants indicated how consistent streams of funds and donor contributions enhance agility within the organisation’s supply chain:

The erratic weather patterns that resulted in drought occurrences in Malawi, Zambia and Zimbabwe in 2012 resulted in the Department of Agriculture (South Africa) providing monetary aid to the UNWFP. The terms attached to this fund ensured that supplies should only be procured from small holder farmers registered with the Department. (Participant 1, Male, Regional Logistics Officer)

The funding element is mainly a contributor to the practices that the organisation implements to ensure that disaster operations are conducted successfully, despite the uncertain and dynamic humanitarian conditions. Some of the important initiatives highlighted include:

- The pre-positioning of supplies.
- The pre-positioning of supplies effectively reduces risk in anticipation. Generally, the UNWFP has invested in efforts to ensure that there are different hubs, which it manages. These are designed to facilitate action in response operations that may present various challenges.

A sensitivity needs assessment mechanism

The aim of a sensitivity needs assessment mechanism is to ensure that a proper assessment of the disaster needs is efficiently carried out so that relevant aid is provided to the affected communities. The UNWFP has an assessment team trained and equipped to identify the needs arising after any disaster occurrence. This is aimed at ensuring that the right information pertaining to a disaster is accessed before planning relief operations suitable for the affected area.

Category 2: Operating as virtual systems

Most of the participants indicated that supply chain agility is one of the most important pillars that determine the success of the UNWFP and this has effectively been achieved through the design of proper management of networks:

The UNWFP operates a global supply chain that needs to be highly agile, meaning that there needs to be an ability to deliver the right supplies to the affected areas, the visibility of the cargo and movement of deliveries is the main variable to running an agile network. (Participant 3, Male, Logistics Planner)

Some of the services provided by the system include constant updates on the status of the various shipments and the provision of relevant information to the different stakeholders involved in a disaster operation.

Theme 3: Incorporating responsiveness into the supply chain

This theme provides insight into the diverse advantages that are incurred by the organisation as a result of implementing responsive supply chain practices. The main categories that are identified in this theme describe (1) increased efficiency and (2) cost-effectiveness. The participants provided insight into how the disaster operations performed by the organisation to date achieved a desirable level of efficiency and cost-effectiveness.

Category 1: Increased efficiency

The efforts of the organisation in its supply chain focuses on ensuring increased efficiency during disaster operations. During disaster operations, every minute is vital when it comes to reaching out to the most vulnerable and providing them with essential food supplies:

… In ensuring that the UNWFP is responsive to natural disaster occurrences, we have made strategic and critical investments in infrastructure and technology which has encouraged innovation across the organisation and has been a visible means towards fostering efficiency. (Participant 4, Male, Regional Procurement Specialist)

The findings indicate that UNWFP considers efficiency as being the economic measure of how inputs and resources are converted into results. In other words, it illustrates how UNWFP is able to make use of diverse infrastructural resources and employee capability to deliver fast and timely response operations. In enhancing its ability to be responsive, some of the activities it has focused on include preparedness and forward planning in procurement, shipping, transportation, distribution and programme implementation. Some of
the critical strategies facilitating responsiveness can be derived from the statement below:

... Increased access to relief personnel and supplies is very important when faced with a sudden disaster occurrence. The UNWFP’s ability to efficiently respond to the growing disaster occurrences has been facilitated by the rapid response that is offered by the standby partners, humanitarian relief depots and the forward positioning of supplies. (Participant 2, Female, Logistics Officer)

**Category 2: Cost-effectiveness**

It was found that UNWFP, through the implementation of different supply chain management tools, has achieved increased cost-effectiveness. Although some of the participants openly discussed how the UNWFP has been able to achieve these cost benefits, this category presents cost as a critical advantage that has been improved by responsive supply chain practices:

Our organisation remains at the forefront in terms of delivering cost-effective humanitarian assistance and continues to contribute to greater efficiency throughout the UN system. (Participant 1, Male, Regional Logistics Officer)

The participants all agreed that cost is a key determinant during disaster operations. Because of insufficient funds being available to support operations, emphasis is directed towards increased cost savings, which ensures that all funds are put into proper use.

For example, cost efficiency has been incorporated into UNWFP’s procurement activities, such as the use of import parity, as explained by one of the participants:

... The import parity approach is aimed at ensuring that there is the efficient comparison of the local and international sourcing, delivery costs and lead times involved. Based on this comparison the organisation determines the best alternative, in cases where time is not an overriding issue, the lowest cost is chosen. (Participant 4, Male, Regional Procurement Specialist)

It was found that there are other supply chain responsive practices, such as logistics and transportation-related initiatives, implemented by the UNWFP. These initiatives result in the achievement of significant cost savings and effectiveness. For example, through the Global Vehicle Leasing Programme, the organisation is able to reduce the vehicle procurement bill for the individual country offices. Through this, UNWFP is able to improve its response capability by increasing the number of vehicles available to assist during disaster operations. The vehicles are procured centrally by the UNWFP’s international office and leased to the different country offices.

**Summary of the findings**

The research findings clarify the main benefits associated with the adoption of supply chain management best practices for implementation during natural disaster operations. Essentially, the main findings focused on what these concepts involve and what effects they have on the entire supply chain. A number of the advantages are illustrated in Figure 2, which offers a summary of the advantages associated with adopting agile, flexible and responsive supply chains during relief operations.
TABLE 3: Recommendations for supply chain best practices.

| Supply chain variable          | Visible gaps                                                                 | Recommendations                                                                 |
|-------------------------------|------------------------------------------------------------------------------|---------------------------------------------------------------------------------|
| Procurement                   | Failure to get supplies at the right time, price and quantities given the pool of available suppliers. | Establish alliances with key suppliers, in order to improve negotiating power and engage in collaborative strategic sourcing. |
|                               | Procurement should be transparent, accountable, efficient and cost-effective. | Focus on Total Cost of Ownership for all the materials that organisations procure from various suppliers. |
|                               |                                                                              | Optimise sourcing processes such as negotiation planning.                        |
|                               |                                                                              | Maintain long-term agreements with potential suppliers in order to improve the supply capacity needed during disaster occurrences. |
|                               |                                                                              | Maintain an updated database of suppliers that have been evaluated and qualified, in order to avoid going through the procurement process in the event of a disaster occurrence. |
| Logistics and transportation  | There are underlying challenges regarding the transportation of personnel, infrastructure and the timely distribution of supplies to the affected areas. | Humanitarian organisations could explore the opportunities of using both in-house and outsourced transportation facilities. |
|                               | Humanitarian organisations incur high costs in performing logistics and transportation costs, which is usually taxing considering the availability of funding. | Use of technology to improve transportation performance would include real-time tracking. This would allow carriers to identify the precise location and contents of their fleet. |
|                               |                                                                              | Organisations could evaluate the strengths and weaknesses associated with the different modes of transportation to different areas. This could enhance their decision making. |
|                               |                                                                              | Consider the use of transportation consultants in determining the effectiveness of current rates and carriers. This could result in humanitarian organisations negotiating best rates and carriers. |
| Information management        | Timely and accurately determining the needs of affected communities.           | Establish an information exchange infrastructure that should be properly utilised and managed by active humanitarian organisations. |
|                               | Lack of visibility between the supply chain partners.                        | Implement improved and tested Information and Communications Technology systems for information exchange and decision support across all humanitarian organisations, for example Disaster Resource Network and Relief Web. |
| Distribution network          | Supply chain networks need to be properly structured in order to be optimised. | Develop a common database that could be utilised by the humanitarian community in southern Africa to assist in organising disaster operations. |
|                               | Existing networks lack efficiency. They are costly to manage and deliveries are delayed, which negatively impacts efficient responsiveness. | Flexibility and uncertainty could be incorporated into the transportation networks. |
| Supply chain collaboration     | There is no evidence of humanitarian organisations that collaborate on strategic issues. This could result in benefits being attained during relief operations. | Humanitarian organisations could use Collaborative Planning and Forecasting tools, as this could assist in facilitating demand planning through using shared data. |

Insight has been provided into some of the main best of the main practices used by the UNWFP. In order for humanitarian supply chains to improve their performance and to successfully respond to disaster operations, it is suggested that they could improve on their procurement, logistics and transportation, collaborative efforts, information management and distribution networks.

The following suggestions that could be adopted by UNWFP and other humanitarian organisations active in southern Africa are recommended in Table 3.

**Conclusion**

There is an increased frequency in the occurrences of natural disasters in the southern Africa region, resulting in an increased number of disaster operations by humanitarian organisations (Lukamba 2010:484). The consequences of these occurrences vary from increased levels of suffering of the affected communities to loss of lives. Within this context, humanitarian organisations need to improve their supply chain management practices in order to ensure that they improve their speed and efficiency during disaster responses.

Supply chain management concepts such as agility, flexibility and responsiveness are relevant as they place an emphasis on customer focus (Aprile et al. 2005:25; Stevenson & Spring 2007:685). It is suggested that if similar practices are adopted within the humanitarian supply chains of the relief operations, this would result in speedier and more efficient and effective response and action. Not many studies have focused on the practices of the humanitarian supply chains in southern Africa, which lag behind those in the commercial world. Yet the gap between the two has been identified as a contributing factor towards the effectiveness of their supply chain and may negatively impact on the suffering of the affected communities and the loss of lives.

A limitation of this study is that the focus was on providing an overview of how the UNWFP successfully responds to natural disaster operations in southern Africa. As a result it
considers the viewpoint of the UNWFP only and not the viewpoint of other stakeholders. It is suggested therefore that a further study be conducted and that other key stakeholders such as the beneficiaries are included, so as to have a plurality of perspectives. This could further help in assessing how well the supply chain deployment is performing.

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Competing interests

The authors declare that they have no financial or personal relationships which may have inappropriately influenced them in writing this article.

Authors’ contributions

N.K.N. collected and analysed the data. M.J.A.N. was the project leader, made conceptual contributions and finalised the article.

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The composite supply chain efficiency model: A case study of the Sishen-Saldanha supply chain

Introduction

South Africa is a developing country with good economic development and rapid growth and forms part of the BRICS (Brazil, Russia, India, China and South Africa) countries (Chiu 2014). It is one of South Africa’s goals to become a key player in global trade; however, South Africa has a number of hurdles to overcome before it reaches its goal. South Africa’s total exports have only grown by 0.6% a year in real terms since 2005, whilst its BRIC counterparts have been growing rapidly (The World Bank 2014). Growth in South Africa’s exports of non-minerals and services are also lagging behind BRIC partners, whilst the volumes of minerals exported from South Africa remain virtually unchanged. According to The World Bank (2014), the majority of South African exports are concentrated in a few super firms that ship products to countries around the world. Approximately 1000 companies generate 93% of all of South Africa’s exports. The remainder of South Africa’s 20 000 exporting firms export products in small amounts and make up the residual 7%. In addition, these mega companies are losing impetus because they are creating fewer new products and not expanding into new markets (The World Bank 2014).

In addition, South Africa is facing socio-economic problems. South Africa is struggling with high levels of unemployment, which result in high levels of poverty (Everatt 2004; Statistics South Africa 2015). In addition, its workforce lacks skills, which intensifies the problem (Mkhwanazi 2012). Existing transport infrastructure is insufficient and is utilised at sub-optimal levels (Department of Government Communications and Information Systems 2015). These factors, along with numerous others, are hindering the country’s growth. Furthermore, logistics have been identified by the South African government in the Accelerated and Shared-Growth Initiative of South Africa (ASGISA) as a potential hurdle that may limit future growth in the country (Ittmann 2007).

The growth and development of South Africa’s economy and the subsequent welfare of its citizens are correlated with the country’s trade levels (Nkomo 2005). More than 95% of South Africa’s trade volume takes place via deep-sea transport (Chasomeris 2005; Z. Christians [Cape Town] pers. interview, February 2015). In addition, a number of export industries are dependent on imported inputs, so efficient import supply chains also play an important role in South Africa’s ability to compete globally (Page 2012). Therefore, to be a major force in global trade, it is important that existing maritime supply chains’ to and from South Africa function as efficiently as possible and new efficient supply chains are developed.
The importance of supply chains operating efficiently is a concept that has been understood and researched by governments and industries competing with South Africa for a number of years. However, South Africa’s government has only realised the importance of efficient supply chains since the turn of the century (Neill 2003).

The Composite Supply Chain Efficiency Model (CSCEM) introduced in this article proposes a set of guidelines that can assist South African industries in becoming internationally competitive. The CSCEM was developed by the author. It is a tool that can be used to evaluate a firm’s level of efficiency both as an individual firm and as a component in an overall supply chain. The CSCEM is tested in this article by applying it to the Sishen-Saldanha iron ore supply chain. The results from the case study indicate that the CSCEM can be used by South African firms to pinpoint the processes that need amendments to improve their overall supply chain efficiency.

The next section provides the problem statement and objectives investigated in the article. The literature review defines the terms ‘supply chains’ and ‘supply chain management’. It describes the challenges facing the measurement of supply chain efficiency and the benefits that can be achieved by firms that measure their levels of supply chain efficiency. It also provides an overview of existing models for measuring overall supply chain performance and introduces the mathematical technique used in the CSCEM, namely Data Envelopment Analysis (DEA). The literature review ends with a brief summary of the Sishen-Saldanha iron ore supply chain. The steps taken in the construction of the CSCEM are discussed as well as the methods used to verify and validate the CSCEM. A case study of the Sishen-Saldanha iron ore supply chain is used to test the robustness of the CSCEM. This article concludes with the benefits of the CSCEM.

**Problem statement**

Trade liberalisation has led to greater levels of competition throughout the international commodity and service markets as a result of (amongst other things) the globalisation of businesses, an increase in product variety, increasing complexity of supply networks, and the shortening of product life-cycles. Increased levels of competition globally means that supply chains as a whole need to be as efficient as possible in order to be successful (Naslund & Williamson 2010).

It is no longer sufficient for link providers to focus only on individual elements of the supply chain. They now need to take the efficiency of the entire chain into account (Holmberg 2000). For South African firms to be competitive in the global market, they have to be able to adapt to rapidly intensifying customer forces and changing customer needs. Firms that understand the full impact of logistics on supply chain management use as many opportunities as possible to apply enhancements to their structures and strategies to improve their overall efficiency (Dooley 2005).

The main objective of this article is to propose a model that can help South African industries improve their competitiveness in global markets. This article introduces the CSCEM, which can be used to evaluate the level of efficiency of South African industries both as individual firms and as a component in an overall supply chain. The CSCEM is tested in this article by using a case study of the Sishen-Saldanha iron ore supply chain.

**Literature review**

**Defining supply chains and supply chain management**

A supply chain is defined by Joseph and Mohapatra (2009:468) as ‘a chain or progression beginning with raw materials and ending with the sale of the finished product or service’. The links in the supply chain fulfil various functions that contribute, to a greater or lesser extent, to the success of the chain. Any link in the chain that does not perform optimally can reduce the overall efficiency of the entire supply chain (Chopra & Sodhi 2014).

In the global economy, the main focus of market competition is not only between products but between the supply chains delivering the products. As the satisfaction of the consumer is the ultimate test of success of the whole chain, the effective management of the link processes is crucial (Trkman, Indihar Stemberger & Jaklic 2005). A major task for ensuring that a supply chain operates efficiently is thus the management of the entire chain.

Supply chain management is defined by the Council for Supply Chain Management Professionals (2015) as:

> encompassing the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies. (n.p.)

According to Davis (1993), effective supply chain management can be achieved by optimising all the activities throughout the supply chain, and it plays an important role in providing a competitive business advantage. Consequently, a discussion has ensued as to whether all functions should be provided by one organisation or whether each function should be provided by a specialist in the specific field. One argument is that the separation of supply chain activities among different companies enables specialisation and economies of scale (Trkman et al. 2005), while the others argue that if a supply chain consists of more than one organisation, the companies often tend to optimise their own performance, disregarding the benefits of a supply chain as a whole (Awad & Nassar 2010). The situation is further complicated if the various parties involved in the supply chain have different objectives.

A closer look at the discussion shows that the two sides may be in favour of the same approach but are arguing for it from a
different angle. The central theme is that link providers need to focus on the entire process and not on individual elements. Link providers should thus strive to promote maximum efficiency throughout the entire chain rather than concentrate on their own goals (Naslund & Williamson 2010). Therefore, supply chain managers that operate a single, integrated chain have an advantage in the competition between supply chains (Sadler 2007). No supply chain in which autonomous links optimise their performance can achieve maximum efficiency. In contrast, a supply chain that is operating at sub-optimal efficiency reduces the market penetration of the product it carries (Sadler 2007).

Supply chain visibility (defined as ‘the awareness of, and control over, specific information related to product orders and physical shipments, including transport and logistics activities, and the statuses of events and milestones that occur prior to and in-transit’ [Heaney 2013:2]) and supply chain integration (defined as ‘an integrative philosophy to manage the total flow of a distribution channel from the supplier to the ultimate user’. [Cooper & Ellram 1990:1]) greatly increase the ability of managers to pinpoint the weaknesses in the chain in order to effect improvements. Integrating the links of the supply chain into a holistic, efficiently functioning system improves the flow of both products and information in the organisation (Heaney 2013). That leads to a more efficient supply chain. Thus, maximising efficiency should be the overall aim, whether a supply chain comprises links operated by several role players or is under the control of a single management (Braithwaite 2005).

Measuring supply chain efficiency
Efficient management of a supply chain has been increasingly recognised as a key factor in differentiating product and service offerings and gaining competitive advantage for firms (Christopher 1998). It demands the close integration of internal functions within a firm and efficient linkages with the external operations of channel members in the chain (Lee 2000). It is also essential that supply chains do not remain static, but rather evolve continuously based on the changing market and customer needs (Little 1999).

For the purpose of this article ‘supply chain efficiency’ will be defined as the economy in resource utilisation based on specific criterion while products are moved from one place to another, in the course of which movement the products may be changed through processing.

The need to improve efficiency in a supply chain has led to the development of models and methods to measure supply chain efficiency. These models can be used to evaluate the levels of performance along supply chains and help managers identify weaknesses in order to improve the overall functioning of the chains.

To raise the level of efficiency, it is necessary to be able to measure that level throughout all the links along the supply chain (Gunasekaran, Patel & McGaughey 2004). Spekman, Salmonds and Kamauff (1994) argue that the challenge for measurement is that chain efficiency cannot be measured by single transactions but only through the evaluation of the performances of all the link service providers along the entire supply chain. Therefore, when devising how to measure supply chain efficiency, it is important to choose a method that takes all relevant factors into account.

Langfield-Smith and Smith (2005) and Cuthbertson and Piotrowicz (2011) highlight a second obstacle to the measure of supply chain efficiency; namely, that performance measures are not always used in a balanced way that reflects all aspects of the supply chain. Frequently, one measurement or another is over-emphasised, leading to inaccurate measurements or sub-optimisation of the supply chain. Little (1999) argues that this risk increases if no single body oversees the entire chain. Thus, when measuring the supply chain, the method devised must evaluate each link in terms of the correct ratio of importance to the overall output of the supply chain.

Because firms often deal in different product lines, it is important that a supply chain exists for each and every commodity (Sadler 2007). Nigel Wright Group (2015) point out that supply chains from different sectors (of industry) have different characteristics that can vary within those sectors. Thus, supply chain design must clearly be tailored to both the specific industry and the individual circumstances of each business (Childerhouse & Towill 2000). It is also important that every service provider in the supply chain use the same method for measuring efficiency to provide meaningful results. Therefore, when choosing a tool for measuring supply chain efficiency, it is important that firms choose one that can be applied to all of their functions (Little 1999).

Another factor that must be taken into consideration when measuring supply chain efficiency is the strategy for the growth of the supply chain. Supply chains that work well with current volumes may become problematic in the future if flexibility, responsiveness and scalability have not been designed into the system (Barloworld Logistics 2005). Thus, it is important to plan proactively rather than reactively, to ensure that supply chains maintain their efficiency, lest they lose opportunities.

Existing models for measuring overall supply chain performance
A common challenge facing many firms is that a supply chain is often composed of independent business units and legal entities with separate owners and managers, each with differing business goals and objectives (Chandra & Grabis 2007). However, there is sufficient evidence to support the notion that both private and public firms can benefit from the integration and synchronization of cross-enterprise processes, such that various firms cooperate to optimise the supply chain (van der Laan 2010). Consequently, numerous efforts have been made to develop methods for measuring system-wide supply chain performance (Davis & Spekman 2004).
Three of the best known proposals for co-ordinated chain-wide performance measurement are (Davis & Spekman 2004):

- The Supply Chain Operations Reference (SCOR) model.
- The Supply Chain Performance Scorecard developed by the Performance Measurement Group (PMG).
- The Balanced Scorecard (BSC) for SCM.

The SCOR model was developed by the Supply Chain Council. It is a strategic planning tool that assists senior managers to simplify the complexity of supply chain management (Huan, Sheoran & Wang 2004). The aim of the SCOR model is to provide a standardized method of measuring supply chain performance and use a common set of metrics to benchmark against other organisations (Forbes.com 2006).

The SCOR model starts by measuring the current state of the process being examined. This information is then utilized to determine the desired future state of the process. Subsequently, the operational performance has to be quantified and compared to that of similar companies, to determine internal targets based on ‘best-in-class’ results. Finally, best practice analysis is performed to identify management practices and software solutions that can result in ‘best-in-class’ performance. The main goal of SCOR is the description, measurement and analysis of supply chain configurations (Kussing 2009).

SCOR is based on six distinct management processes namely, Plan, Source, Make, Deliver, Return and Enable. It also facilitates inter and intra supply chain collaboration and horizontal process integration, by explaining the relationships between processes (i.e. Plan-Source, Plan-Make) (Badr & Stephan 2007). In addition, the SCOR model is beneficial for entering data to analyse various configuration options better, for example Make-To-Order and Make-To-Stock. The SCOR model makes this possible by describing, measuring, and evaluating the supply chain. It also supports strategic planning and encourages continual improvement of the chain.

Although the SCOR model has a number of benefits, according to Wong and Wong (2008), SCOR fails to address the issue of integration synchronization. One of the findings highlighted by Samuel, Sunl and Wang (2004) was that:

although the SCOR model provides a common supply-chain framework, standard terminology, common metrics associated benchmarks and best practices, the approach on the utilization of SCOR seems to be rather rigid and needs further enhancement. (p. 28)

As supply chains become increasingly complex and levels of competition between firms continue to rise, firms are looking for a way to achieve or maintain a competitive advantage. One solution to the problem is a dynamic performance measurement that is able to evaluate a variety of different variables and scenarios. However, SCOR does not currently have the ability to meet all those needs (Samuel et al. 2004).

According to Wong and Wong (2008), SCOR needs a network modelling tool to support the change management decision. In addition, SCOR needs to meet a firm’s need to address supply chain benchmarking from a holistic approach. Thus, in order for the SCOR model to more accurately evaluate integrated supply chains, it is important to include some change management. To date, SCOR has only been using deterministic performance metrics, measures that managers can control and determine accurately (Wong & Wong 2008). However, in an integrated supply chain, the levels of the chain become more complicated, and managers have to be accountable for various performance measures (Samuel et al. 2004).

The SCOR model is currently used as cross-industry standard for supply chain management, both internationally and in South Africa. Although it can be used successfully to measure supply chain performance, it does not measure supply chain efficiency. The CSCEM introduced in this article can measure supply chain efficiency.

The second model commonly used to measure supply chain performance is the Supply Chain Performance Scorecard. The Supply Chain Performance Scorecard was developed by the PMG in 1994. Four broad areas of performance measurement are addressed, namely, customer satisfaction, cost, time and assets (Davis & Spekman 2004).

The scorecard originally contained eight measurements, but has evolved into a balanced set of four measurements including two customer-facing (delivery performance to commit and upside production flexibility) and two internally-facing metrics (cash-to-cash cycle time and net asset turns) (Davis & Spekman 2004). The Supply Chain Performance Model is not able to measure supply chain efficiency.

The third model often used to measure supply chain performance is the BSC method, which was developed by Kaplan and Norton during the early nineties. The BSC is a management system that enables organisations to identify their goals and then develop a strategy that helps meet the goals. It provides feedback around both the internal business processes and external outcomes to improve strategic performance and results. Subsequently, managers are able to identify all the important aspects of the business in order to minimise the tendency to improve one area of the business at the expense of another (Abu-Suleiman, Boardman & Priest 2004). However, the BSC has a weakness in that it does not take competitors into account (Neely, Gregory & Platts 1995). The CSCEM introduced in this article includes the benefits of the BSC method, i.e. it ensures that one link or node in the supply chain is not improved at the expense of another, however, it also takes competitors into account.

Data envelopment analysis

DEA was first introduced by Charnes, Cooper and Rhodes (1978) as a linear programming (LP)-based methodology for performing the analysis of how efficiently a firm operates
(Wong & Wong 2007). DEA is a data-oriented approach for evaluating the performance of a set of peer entities called Decision Making Units (DMU), which have the ability to convert multiple inputs into multiple outputs (Cooper, Seiford & Zhu 2004). It is a nonparametric approach to frontier estimation, i.e. DEA does not rely on the definition of the specific role that the variables perform to specify the relationships or trade-offs among the performance measures in the calculation of efficiency. Moreover, it utilises the concept of efficient frontier as an empirical benchmark. (Mathematically, the efficient frontier ‘is the intersection of the set of portfolios with minimum variance and the set of portfolios with maximum return’ (Chen et al. 2008). It is defined by Granite Financial Group (2009) as:

\[
\text{a statistical result from the analysis of the risk and return for a given set of assets that indicates the balance of assets that may, under certain assumptions, achieve the best return for a given level of risk. (n.p.)}
\]

These advantages of DEA enable managers to evaluate any measures efficiently as they do not need to find any relationship that relates to them (Wong & Wong 2007).

DEA is an extreme point method and compares each variable with only the ‘best’ variable (University of Phoenix 1996). Because it only requires a few assumptions, DEA can be used in cases that have been resistant to other approaches, because of the complex (often unknown) nature of the relationships between the multiple inputs and multiple outputs involved in the DMUs (Cooper et al. 2004).

The basis of DEA is in finding the optimal virtual variable for each real variable. If the virtual variable is better than the original variable, because it either makes more output with the same input or the same output with less input, then the original variable is inefficient (University of Phoenix 1996).

DEA does not require assigned numeric weights or modelling preferences for analysis. However, it is possible to introduce these numeric weights if the information is available, and it is believed to be helpful. The DEA model automatically computes weights that give the highest possible efficiency score to a DMU whilst keeping the efficiency scores of all DMUs less than or equal to one under the same set of weights (Wong & Wong 2007). This helps to prevent the bias of different analysts from influencing the selection of the criteria used in the analysis (Wong & Wong 2007).

The main limitation of DEA is that the efficiency measured is a relative efficiency. DEA determines the efficiency of different units within the supply chain relative to each other and rather than to a set target value. This can be misleading to managers and stakeholders (Agami, Saleh & Rasmy 2012). In addition, DEA requires large amounts of data to provide meaningful results, and it can be difficult to gain access to enough data to measure the efficiency of a supply chain.

The Sishen-Saldanha iron ore supply chain

The origin of the Sishen-Saldanha iron ore supply chain dates back to 1953 when Iron and Steel Corporation (Iscor) now known as ArcelorMittal started mining iron ore near Sishen in the northern Cape. Due to the depletion of some of South Africa’s gold reserves in the 1960s, mines were compelled to find alternative mineral resources. After the discovery of a 4000-Mt deposit of high grade iron near Sishen, the feasibility of a new, large-scale iron ore export project was explored. These investigations led to Saldanha Bay being chosen as the best port of export for the ore. The railway line connecting the ore-mines with the port was subsequently built (Truter 2004).

Construction on the railway line started on 01 June 1973 and the first ore train arrived at the Port of Saldanha on 14 May 1976. On 27 September of the same year, the first ore carrier left the Port of Saldanha, bound for Europe (Truter 2004). The supply chain has subsequently been acquired and developed by Transnet Freight Rail. It is now known as Orex.

The major links and nodes in the Sishen-Saldanha iron ore supply chain are (N. Ramchand [Stellenbosch] pers. interview, 13 February 2007):

- the mines (Kumba Resources Ltd and Associated Manganese [ASSMANG] iron ore mine)
- vehicles carrying the products in the mine (often diesel-electric trucks or trains)
- loading apparatus to build stockpiles
- beneficitation plant at the mine (e.g. washing plant)
- the railway line (Orex)
- the storage and handling equipment
- the Port of Saldanha (Transnet National Ports Authority [TNPA], Transnet Port Terminals [TPT] and Kumba Port Operations Saldanha)
- the ship
- the documentation required throughout the supply chain.

Each element of the supply chain plays a significant role in determining the overall efficiency of the supply chain. The supply chain is only as efficient as its weakest link. Therefore, steps must be taken to ensure maximum efficiency not only at each link or node, but also throughout the entire supply chain (Sadler 2007).

Research method and design

The primary research was interviews that were conducted with experts in the field (the respondents held either managerial, director or general manager positions) to determine the various concerns that exist along South African supply chains and to develop a better understanding of the workings of South African supply chains. The interviews were also used to obtain independent views on the usefulness of the present modelling systems used along supply chains in South Africa, as well as to acquire impartial views on the efficiency of South African supply chains as a whole. Participants were identified by dividing South Africa’s supply chains into different categories according to product characteristics, that is, bulk commodities,
containerised goods, fast moving consumer goods, the textile industry, the automotive industry and perishable products. Senior executives from 10 leading firms from each category (60 in total) were contacted and asked questions about the factors that affect their companies. Factors that influence supply chain efficiency in South Africa, as identified through personal interviews, are:

- the ratio of idle time to productive time
- throughput, lead time and utilisation of the supply chain capacity
- infrastructure availability and utilisation
- low transport productivity
- method of freight handling
- interface arrangements
- labour competency
- communication throughout the supply chain
- incidence of damage to goods and pilferage
- imbalances in cargo flows
- documentation required
- customer co-operation.

After identifying the main factors that influence supply chain efficiency in South Africa, the factors had to be incorporated into the CSCEM. Supply Chain Efficiency Measures or Logistics Performance Measures are used to classify the above factors in the CSCEM. Three parameters were chosen to determine efficiency across a supply chain, namely: reliability, speed and cost. These three parameters were chosen under the guidance of the experts that were interviewed. This also includes determining whether or not these factors are considered to be inputs or outputs (i.e. consumables or deliverables) of the supply chain. It is possible that factors selected for the inclusion in the CSCEM can differ from supply chain to supply chain.

The next step in the CSCEM involved subdividing a supply chain into links and nodes. Information was collected about various performance measures that could potentially be used to calculate the performance of each of the five links and nodes in terms of reliability, speed and cost. Measures were also identified that could be used to calculate the influence that these factors have on the overall efficiency of a supply chain. Generic links and nodes identified for the CSCEM are: sources or suppliers, points of production, transportation links, points of storage and transhipment and markets or customers.

Next, formulae were used to convert the factors that influence supply chain efficiency into measurements of efficiency within each link or node in the supply chain in terms of reliability efficiency, speed efficiency, and cost efficiency. The calculations indicate how the individual firms along the supply chain are performing.

Finally, DEA is used to take the information gathered in the previous step to compare the reliability efficiency, speed efficiency and cost efficiency across the individual links or nodes in the supply chain with similar links or nodes of other supply chains. This is used to determine the ‘frontier’ or most efficient supply chain, which can consist of a combination of various different supply chains. Finally, each individual supply chain is compared with the frontier to determine how efficient it is and where bottlenecks occur. Figure 1 is a graphic representation of how the CSCEM was developed.

Historical data was collected from the Sishen-Saldanha iron ore supply chain to test the CSCEM. Six years of historical data was collected from the mine, 8 years of historical data was collected from the rail transport operator, and 9 years of historical data was collected from the port. The data collected was insufficient to obtain meaningful results, because for the method used in the CSCEM (namely DEA) the number of input and output variables need to be less than half of the number of DMUs, which in this article represents 1 year for either the mine, rail transport operator or port. In order to make the model as inclusive as possible, 14 input variables and four output variables (18 variables in total) were used. This meant that for the CSCEM to provide significant results, at least 36 years of historical data was required from each link or node in the supply chain.

Due to the fact that the example used in this article is for explanatory purposes only, (random) data was generated using the statistical program R 2.9.2 (2009). The random data was generated from the original, real data sets using multivariate normal distribution. Since the data was generated using a recognised statistical method, it can be
assumed that the data meets the necessary requirements for testing the validity of the CSCEM.

The CSCEM can be used on a range of diverse supply chains due to its generic nature. It is possible to make changes to the input factors selected, by either including additional factors or removing some of the factors included, should a firm want to make changes. Different variables can be used to calculate its efficiency, depending on the focus on the supply chain under investigation. For example, speed is an important factor in a supply chain carrying perishable products and, therefore, variables will be included to calculate the efficiency of the supply chain in terms of speed. However, for a supply chain carrying low-value bulk products, speed is not important and can be left out of the calculation.

No two supply chains are exactly the same and therefore, it is not possible to compare supply chains that are exactly the same. However, benefits are still achieved by comparing supply chains with similar characteristics. For supply chains to be considered to have similar characteristics, it is important that they have three common factors. First, they must have the same drivers. This means that they must focus on the same focal points (in terms of this article, they must arrange reliability efficiency, cost efficiency and speed efficiency in the same order of importance). Second, geographical context must be the same, i.e. they must all be either local supply chains or all international supply chains. Finally, the supply chains must handle goods with similar commodity characteristics. For example, they all handle perishable products or they all handle dry bulk goods.

Model construction

The final step of the CSCEM uses DEA, a mathematical programming technique that calculates the relative efficiencies of multiple DMUs based on multiple inputs and outputs (Wong & Wong 2007). DEA has been demonstrated to be a suitable mathematical method for measuring efficiency in a variety of academic literature (Bell & Morey 1995; Seiford 1994; Talluri & Sarks 2001; Wong & Wong 2007, 2008). DEA measures the relative efficiency of each DMU in comparison with all other DMUs. It, therefore, has the ability to establish the effect that the DMU has on the overall efficiency of the supply chain under investigation. The efficiency score of a specific DMU is defined as the weighted sum of outputs divided by the weighted sum of inputs (for which weights need to be assigned). DEA automatically calculates weights that provide the highest possible relative efficiency score to a DMU. At the same time, DEA keeps the efficiency scores of all DMUs less or equal to 1, under the same set of weights (Wong & Wong 2007).

DEA is a form of LP. Therefore, one of the simplest ways of solving the problem is by writing it in its canonical form:

Maximize $z = \sum_{j=1}^{n} u_j y_{j0}$  \hspace{1cm} [Eqn 1]

Subject to:

$\sum_{i=1}^{m} v_i x_{i0} = 1$  \hspace{1cm} [Eqn 2]

$\sum_{j=1}^{n} u_j y_{jq} - \sum_{j=1}^{n} v_j x_{j0} \leq 0 \hspace{0.5cm} j = 1,2,\ldots,n$  

$u_j \geq \epsilon \hspace{0.5cm} r = 1,2,\ldots,s \hspace{0.5cm} v_j \geq \epsilon \hspace{0.5cm} i = 1,2,\ldots,m$

In LP, it is possible for DEA to formulate a partner linear program or LP using the same data. The solution to either the original LP (the primal) or the partner (the dual) is the same. According to Emrouznejad (2001), the dual model is constructed by assigning a variable (dual variable) to each constraint in the primal model and constructing a new model based on these variables.

The main reason for using a dual to solve a DEA model is that the primal model has $n + s + m + 1$ constraints, whilst the dual model has $s + m$ constraints. As $n$, the number of units, is usually considerably larger than $s + m$, the number of inputs and outputs, the primal model will have considerably more constraints than the dual model (Emrouznejad 2001). For LPs in general, the more constraints there are, the more difficult it is to solve the problem. The dual for equation 1 can be given as follows:

$\theta' = \text{Minimise } \theta$  \hspace{1cm} [Eqn 2]

Subject to:

$\sum_{j=1}^{n} \lambda_j x_{j0} \leq \theta x_{k0} \hspace{0.5cm} i = 1,2,\ldots,m,$  

$\sum_{j=1}^{n} \lambda_j y_{jq} \geq y_{k0} \hspace{0.5cm} r = 1,2,\ldots,s,$  

$\lambda_j \geq 0 \hspace{0.5cm} j = 1,2,\ldots,n$

By virtue of the dual theorem of LP, $z' = \theta'$. Therefore, either equation 1 or equation 2 can be used to calculate the solution. The optimal solution, $\theta'$, returns an efficiency score for a particular DMU. The process can be repeated for each DMU. DMUs for which $\theta' < 1$ are classified as inefficient, while DMUs for which $\theta' = 1$ are classified as boundary points.

Some boundary points may be classified as ‘weakly efficient’ because they include non-zero slacks (non-zero slack values represent a substantial amount of inefficiency) (Morita, Hirokawa & Zhu 2005). This may result in lower confidence levels in the solutions identified because alternative optima may have non-zero slacks in some solutions, but not in others. Input slacks indicate the surplus number of inputs that are needed to be assigned. DEA automatically calculates weights that provide the highest possible relative efficiency score to a DMU. At the same time, DEA keeps the efficiency scores of all DMUs less or equal to 1, under the same set of weights (Wong & Wong 2007).

Maximise $\sum_{j=1}^{n} S_{j}^- + \sum_{j=1}^{n} S_{j}^+$ \hspace{1cm} [Eqn 3]
Subject to:
\[ \sum_{j=1}^{s} \lambda_j y_{rj} - s_r = y_{r0} \quad r = 1, 2, \ldots, s \]
\[ \lambda_j \leq 0 \quad \forall i, j, r \]

where the choices of \( s^- \) and \( s^+ \) do not affect the optimal \( \theta^* \) which is determined from equation 2.

According to the definition for DEA efficiency by Cooper et al. (2004) the performance of DMU\(_i\) is only fully (100%) efficient if and only if both (1) \( \theta^* = 1 \) and (2) \( s^- = s^+ = 0 \). The definition for weakly DEA efficient states that the performance of DMU\(_i\) is weakly efficient if and only if both (1) \( \theta^* = 1 \) and (2) \( s^- \neq 0 \) and/or \( s^+ \neq 0 \) for some \( i \) and \( r \) in some alternate optima (Cooper et al. 2004).

The variable \( \theta \) gives the technical efficiency, which is what the model is trying to calculate and \( s^- \) and \( s^+ \) are the input and output slacks, respectively. When DMU\(_i\) is proven as either strongly or weakly DEA efficient, then no further calculations are required. However, when DMU\(_i\) is identified as inefficient, appropriate adjustments (equations 4 and 5) can be applied to the inputs and outputs to make DMU\(_i\) more efficient:

\[ x_{ri}' = \theta^* x_{ri} - s_r^- \quad i = 1, 2, \ldots, m \quad [\text{Eqn 4}] \]
\[ y_{r0}' = y_{r0} + s_r^+ \quad r = 1, 2, \ldots, s \quad [\text{Eqn 5}] \]

The dual model of the above formulation (also known as the envelopment model) has the ability to identify possible solutions to improve the efficiency of a DMU. As a result, it highlights ways in which managers can make improvements to the supply chain. An additional convexity constraint:

\[ \sum_{j=1}^{s} \lambda_j = 1, \]

can be added to equation 3 to yield a measure of the pure technical efficiency if the constant return-to-scale (Banker, Charnes & Cooper 1984) assumption does not apply, that is, there is not a constant ratio between inputs and outputs. The above model (equation 3) is used to calculate the technical efficiency of a supply chain and can therefore be referred to as the technical efficiency model.

The next step in developing a model to measure supply chain efficiency across an entire supply chain is to minimise costs along the supply chain without reducing the level of outputs achieved. This can be calculated by the cost efficiency model shown below:

\[ \text{Minimise } \sum_{j=1}^{s} c_{ijo} x_{ij} \quad [\text{Eqn 6}] \]
is used to compare competing supply chains (with similar characteristics), the results represent the leading supply chain and an indication of how the other supply chains compare. It is important to note that the leading supply chain identified is not necessarily an actual working supply chain. The leading supply chain can be made up of a mixture of links or nodes from different supply chains. When DEA is used to compare one supply chain over time, that is, with historical data, it shows how the efficiency of the supply chain has improved or deteriorated over time.

**Example**

To validate the robustness of the CSCEM, it was applied to the iron ore supply chain from Sishen to Saldanha.

The example used is an input-oriented model with variable returns to scale. An input-oriented model was developed to determine whether the supply chain is achieving the current level of outputs given the minimum level of inputs. If so, the supply chain can be considered efficient. However, if it is possible to decrease the inputs while retaining the required level of outputs, then the supply chain is operating inefficiently. Mines operate according to demand. Therefore, as the demand from customers rises, mines endeavour to increase their extraction. However, when demand remains unaffected, mines improve their efficiency levels by diminishing the resources needed to meet the output. Variable returns to scale is the best option to use, because various links and nodes in the supply chain may exhibit increasing, constant and decreasing returns to scale.

A variable in the CSCEM is categorised as an input if it is a ratio used to measure resources placed into the link or node or used in its operation to achieve an output or a result. A variable in the CSCEM is classified as an output if it is a ratio used to measure the work done by the link or node. The variables used in the CSCEM were placed into categories based on the appropriate link or node. They were then further divided into subcategories to measure the efficiency of the link or node in terms of reliability efficiency, cost efficiency and speed efficiency. All variables that were identified as being either utilised in the working of the supply chain or as having an impact on the working of the supply chain were classified as inputs, while all variables that were identified as a consequence of the supply chain were classified as outputs.

The main limitation of the CSCEM is that it requires large amounts of data to provide meaningful results. For DEA to provide meaningful results, the number of input and output variables needs to be less than half of the number of DMUs. In the case study, 14 input variables and four output variables (18 variables in total) were used. This meant that in order for the CSCEM to provide significant results, at least 36 years of historical data was required from each link or node in the supply chain.

**Analysis of results**

The study showed that the average efficiency of the rail leg for the Sishen-Saldanha iron ore supply chain was 97.34%, while the average efficiency of the mine and the port were 97% and 95.44% respectively (Table 1). All three links or nodes performed well, which corresponds to the fact that the iron ore supply chain is one of the most efficient supply chains in South Africa.

The three areas on which the mine needs to focus to improve efficiency, identified through the research, are utilisation (in terms of reliability efficiency), system uptime (in terms of reliability efficiency) and communication (in terms of cost efficiency). The three areas of importance for the rail operator are throughput efficiency (in terms of reliability efficiency), cost per tonne of iron ore transported (in terms of cost efficiency) and communication (in terms of cost efficiency). The port needs to focus on infrastructure (in terms of cost efficiency), communication (in terms of reliability efficiency) and labour (in terms of cost efficiency).

The slack analysis depicted in Tables 2, 3 and 4 are presented in the virtual form. This allows the firm to identify exactly what variables are causing bottlenecks in the supply chain and, in so doing, allows them to take the necessary steps to improve their efficiency. For example, within DMU6 of the mine, i.e. year 6, slack variable $s_8$ or system uptime is the biggest problem area for the mine, followed by slack variable $s_7$ (utilisation) and slack variable $s_8$ (labour in terms of cost).

| Nodes | Efficiency (%) |
|-------|----------------|
| Mine  |                |
| DMU1  | 98.61          |
| DMU2  | 99.15          |
| DMU3  | 97.58          |
| DMU4  | 94.78          |
| DMU5  | 94.73          |
| DMU6  | 97.03          |
| Rail  |                |
| DMU1  | 100.00         |
| DMU2  | 90.44          |
| DMU3  | 100.00         |
| DMU4  | 100.00         |
| DMU5  | 94.30          |
| DMU6  | 100.00         |
| DMU7  | 93.98          |
| DMU8  | 100.00         |
| Port  |                |
| DMU1  | 98.67          |
| DMU2  | 93.37          |
| DMU3  | 95.63          |
| DMU4  | 96.55          |
| DMU5  | 89.34          |
| DMU6  | 100.00         |
| DMU7  | 95.45          |
| DMU8  | 100.00         |
| DMU9  | 89.98          |

Source: Goedhals-Gerber, L.L., 2010, The Measurement of Supply Chain Efficiency: Theoretical Considerations and Practical Criteria, PhD dissertation, Stellenbosch University, Stellenbosch.
Within DMU5 of the rail leg, slack variable $s_5$ (throughput efficiency in terms of reliability) is the main cause for concern followed by slack variable $s_6$ (cost per tonne) and slack variable $s_7$ (communication in terms of reliability). Within DMU2 of the port, slack variable $s_6$ (labour in terms of cost) is the biggest problem followed by slack variable $s_4$ (documentation errors) and slack variable $s_7$ (idle time).

Comparison of the slack results for the historical data of the three links or nodes identifies the areas of concern within each link or node. Table 2 shows that, for the mine, improved efficiency must focus on the three areas of system uptime (in terms of reliability efficiency), utilisation (in terms of reliability efficiency) and communication (in terms of cost efficiency). Table 3 shows that the three areas of importance for the rail operator are communication (in terms of cost efficiency), throughput efficiency (in terms of reliability efficiency) and cost per tonne of iron ore transported (in terms of cost efficiency).

The results obtained from the CSCM were compared to results obtained by an independent company who used the BSC method to measure the efficiency of the Sishen-Saldanha supply chain. Due to confidentiality constraints, the results of the other study cannot be provided in this article. However, similar results were obtained by both studies. Historical data was used in this research to internally assess the supply chain, comparing its own results over time. It would be interesting to compare the Sishen-Saldanha supply chain with the Pilbara iron ore supply chain in Australia in future research.

**Validity and reliability**

The reliability of the CSCM was tested by test-retest reliability and alternative-form reliability. The test-retest reliability estimates were obtained by using the CSCM to analyse the same set of data more than once and analyse another set of generated data. Similar results were obtained from each evaluation, thus proving test-retest reliability. Alternative-form reliability was tested by comparing the

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**TABLE 2: Mine node slacks analysis results.**

| Measure            | Variable | Slack | DMU1 | DMU2 | DMU3 | DMU4 | DMU5 | DMU6 |
|--------------------|----------|-------|------|------|------|------|------|------|
| Utilisation        | V301     | $s_1$ | 0.0  | 0.0  | 0.0  | 0.0  | 1.303| 13.947| 14.481|
| Idle time          | V302     | $s_2$ | 3.359| 11.450| 0.0  | 0.0  | 0.0  | 0.0  | 0.0  |
| Communication      | V303     | $s_3$ | 14.685| 7.574| 32.918| 28.638| 17.015| 15.497| 27.081|
| Document errors    | V304     | $s_4$ | 3.227| 15.141| 4.591| 0.482| 0.0  | 10.128| 8.283 |
| Cost per ton       | V305     | $s_5$ | 3.765| 0.0  | 15.273| 0.0  | 9.208| 0.0  | 12.43 |
| Inventory carry cost| V306    | $s_6$ | 0.0  | 1.264| 4.926| 0.0  | 28.914| 0.224| 0.0  |
| Infrastructure cost| V307     | $s_7$ | 19.763| 53.325| 38.384| 3.802| 29.689| 16.571| 23.401|
| Labour             | V308     | $s_8$ | 0.151| 0.0  | 6.649| 16.946| 14.886| 3.494| 4.239 |
| Communication      | V309     | $s_9$ | 0.0  | 0.0  | 20.822| 11.154| 0.0  | 3.046| 9.332 |
| Port throughput    | U301     | $s_{10}$| 0.0  | 0.0  | 0.0  | 0.0  | 11.29| 14.708| 1.061 |
| Handling efficiency| U302     | $s_{11}$| 0.0  | 7.336| 0.0  | 3.883| 0.0  | 0.0  | 1.476 |

Source: Goedhals-Gerber, L.L., 2010, *The Measurement of Supply Chain Efficiency: Theoretical Considerations and Practical Criteria*, PhD dissertation, Stellenbosch University, Stellenbosch

**TABLE 3: Rail node slacks analysis results.**

| Measure            | Slack | DMU1 | DMU2 | DMU3 | DMU4 | DMU5 | DMU6 |
|--------------------|-------|------|------|------|------|------|------|
| Variability (R)    | $s_1$ | 0    | 8.611| 0    | 0    | 0    | 0    |
| Utilisation (R)    | $s_2$ | 1.1  | 5.314| 0    | 0    | 0    | 0    |
| Idle time (R)      | $s_3$ | 1.473| 2.445| 0    | 0    | 0    | 0    |
| Communication (R)  | $s_4$ | 26.139| 11.314| 32.182| 0    | 0    | 0    |
| Cost per ton (C)   | $s_5$ | 11.402| 12.349| 10.845| 0    | 0    | 0    |
| Infrastructure cost(C) | $s_6$| 13.634| 4.529| 14.913| 0    | 0    | 0    |
| Labour (C)         | $s_7$ | 9.378| 4.943| 0    | 0    | 0    | 0    |
| Perfect shipments (R) | $s_{8 \text{R}}$ | 0 | 0 | 0 | 0 | 0 | 0 |
| Throughput efficiency (R) | $s_{9 \text{R}}$ | 14.871| 21.29| 18.504| 0    | 0    | 0    |
| Transit time (S)   | $s_9$ | 0    | 0    | 0    | 0    | 0    | 0    |
| Goods handling efficiency (S) | $s_{11 \text{S}}$ | 18.559| 7.144| 5.134| 0    | 0    | 0    |

Source: Goedhals-Gerber, L.L., 2010, *The Measurement of Supply Chain Efficiency: Theoretical Considerations and Practical Criteria*, PhD dissertation, Stellenbosch University, Stellenbosch

**TABLE 4: Port node slacks analysis results.**

| Measure            | Slack | DMU1 | DMU2 | DMU3 | DMU4 | DMU5 | DMU6 |
|--------------------|-------|------|------|------|------|------|------|
| System uptime (R)  | $s_1$ | 17.673| 4.575| 15.238| 21.438| 25.266| 39.565|
| Idle time (R)      | $s_2$ | 0    | 2.297| 0    | 3.477| 0    | 0    |
| Utilisation (R)    | $s_3$ | 14.287| 3.153| 10.968| 16.738| 24.347| 31.416|
| Communication links (R) | $s_4$ | 0 | 0 | 0 | 2.098| 0 | 0 |
| Document errors (R) | $s_5$ | 4.372| 2.697| 0    | 8.567| 13.452| 8.747 |
| Extraction cost/ton (C) | $s_6$ | 5.671| 1.728| 4.23 | 14.206| 15.325| 11.651|
| Infrastructure cost (C) | $s_7$ | 1.521| 0.344| 0    | 17.971| 25.706| 0    |
| Labour (C)         | $s_8$ | 7.416| 0    | 11.37| 1.764| 0    | 18.137|
| Communication (C)  | $s_9$ | 6.571| 2.528| 6.275| 29.174| 33.999| 11.149|
| throughput efficiency (R) | $s_{10 \text{R}}$ | 7.874| 2.479| 6.826| 10.012| 13.681| 17.577|
| Extraction time (S) | $s_{11 \text{S}}$ | 0 | 0 | 0 | 18.123| 7.0947| 0 |
| Goods handling efficiency (S) | $s_{12 \text{S}}$ | 0 | 0 | 0 | 1.841| 0 | 0 |

Source: Goedhals-Gerber, L.L., 2010, *The Measurement of Supply Chain Efficiency: Theoretical Considerations and Practical Criteria*, PhD dissertation, Stellenbosch University, Stellenbosch
results obtained by the CSCEM when run through the program written by Gerber (2009) with results obtained when it was run through the well-known computer program DEA-P (2003) as well as a program written for Excel by Naude (2009). Similar results were obtained in all three cases, thus proving alternative-form reliability.

Concurrent validity and content validity were used to test the validity of the CSCEM. The content validity of the CSCEM was proven, because the variables included in the model were chosen based on literature review as well as interviews conducted with business executives who work with supply chains on a daily basis and are aware of the main problems faced by South African supply chains. Feedback was given to the firms involved in the case study and they agreed with the obtained results, proving the concurrent validity of the CSCEM.

**Advantages of the composite supply chain efficiency model**

The CSCEM adds value for a number of reasons. Firstly, the CSCEM was specifically developed for South African, i.e. it includes the factors identified by industry experts that are the main causes of inefficiency along South African supply chains. Secondly, the CSCEM is simple to use and does not require either an advanced degree in mathematics or extended training for employees before it can be implemented by a firm (this is an advantage over the SCOR model, which is currently used as the cross-industry standard for measuring supply chain performance both internationally and in South Africa). Once the data has been collected by a firm or supply chain, the computer program developed by Gerber (2009) can be used to obtain results at the click of a button. Thirdly, it is an inexpensive model and, therefore, can be utilised by small firms with a limited budget (this is another advantage over the SCOR model). Fourth, its generic nature means that it can be used to measure supply chain efficiency across various different types of supply chains. The efficiency results generated by the CSCEM can be used to identify and analyse weaknesses and bottlenecks in supply chains. Fifth, it can either be used to compare different supply chains or it can be used to compare the same supply chain over time to determine whether any improvements have been made. Finally, the CSCEM has the ability to compare individual nodes both separately and as part of an entire supply chain. Therefore, a firm wanting to know how it compares to similar firms will be able to use the CSCEM as well as a firm wanting to determine the most efficient supply chain in a specific sector or industry.

The CSCEM is a simple, systematic and inexpensive model that can be applied to South African supply chains handling a wide variety of products that are either local or export oriented, to determine whether they are operating efficiently or not. The results obtained from the CSCEM are easy to understand and can, therefore, help firms and entire supply chains identify areas to focus on to improve their overall levels of efficiency and in so doing make them more competitive.

**Conclusion**

International and local companies are facing an increasingly challenging market position. There are higher levels of competition, higher customer expectations and complex supplier relationships. As the levels of competition and complexity have increased, supply chain management has emerged as an increasingly important issue for all the parties concerned. The challenge of supply chain management is to identify and implement strategies that minimise costs, while maximising flexibility in an increasingly competitive and complex market.

South African supply chains cannot be viewed in isolation. For South African firms to compete globally, they must meet international standards. This can only be achieved if South African firms are aware of how they perform in comparison to international benchmarks. The results show that the CSCEM can be used by South African firms to measure their levels of supply chain efficiency and can therefore provide South African supply chains with the information necessary to identify bottlenecks as well as make recommendations of ways to improve their shortcomings.

The CSCEM is systematic and easy to use. It can be used to measure supply chain efficiency across various types of supply chains due to its generic nature. The CSCEM can be used to compare different supply chains or to determine whether a supply chain’s efficiency has improved or deteriorated over time. It can be applied to supply chains handling a wide variety of products that are either local or export oriented, to determine whether they are operating efficiently or not. The results obtained from the CSCEM are easy to understand and can therefore assist South African firms and entire supply chains to identify areas to focus on to improve overall levels of efficiency and in so doing make them more competitive.

**Recommendations**

South African firms need to comprehend the significance of evaluating their performance and determining their efficiency levels. Without acknowledgement of this fact, South African firms are going to continue to miss the opportunity of gathering valuable information about their operations and learning from their mistakes.

South African firms need to become more vertically integrated along a supply chain. The supply chain used in the case study of this article is made up by both public (Transnet Freight Rail, Transnet National Ports Authority and Transnet Port Terminals) and private enterprises (Kumba Resources Ltd and Associated Manganese (ASSMANG) iron ore mine and Kumba Port Operations Saldanha); each of which strive for different objectives. Private firms strive to maximise
profit, while public firms take social costs into account as well. For South African supply chains to be competitive internationally, all firms along a supply chain will have to agree on and strive towards the same objectives.

Future work
The supply chain used in the case study of this article was only assessed internally through the use of historical data. It would be interesting to be able to compare the Sishen-Saldanha iron ore supply chain with the Pilbara iron ore supply chain in Australia. The Pilbara iron ore supply chain is the benchmark for iron ore supply chains in the world. It exported 439.6 Mt of iron ore between January and June 2015 (Validakis 2015), compared to the 23.2 Mt exported along the Sishen-Saldanha iron ore supply chain (AngloAmerican 2015). A comparison between the Sishen-Saldanha iron ore supply chain and the Pilbara iron ore supply chain would provide a true reflection of just how efficient the Sishen-Saldanha iron ore supply chain really is.

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Competing interests
The author declares that she has no financial or personal relationships which may have inappropriately influenced her in writing this article.

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Supply chain resilience in a developing country context: a case study on the interconnectedness of threats, strategies and outcomes
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Supply chain resilience in a developing country context: a case study on the interconnectedness of threats, strategies and outcomes

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Abstract

Purpose – In few prior empirical studies on supply chain resilience (SCRES), the focus has been on the developed world. Yet, organisations in developing countries constitute a significant part of global supply chains and have also experienced the disastrous effects of supply chain failures. The purpose of this paper is therefore to empirically investigate SCRES in a developing country context and to show that this also provides theoretical insights into the nature of what is meant by resilience.

Design/methodology/approach – Using a case study approach, a supply network of 20 manufacturing firms in Uganda is analysed based on a total of 45 interviews.

Findings – The perceived threats to SCRES in this context are mainly small-scale, chronic disruptive events rather than discrete, large-scale catastrophic events typically emphasised in the literature. The data reveal how threats of disruption, resilience strategies and outcomes are inter-related in complex, coupled and non-linear ways. These interrelationships are explained by the political, cultural and territorial embeddedness of the supply network in a developing country. Further, this embeddedness contributes to the phenomenon of supply chain risk migration, whereby an attempt to mitigate one threat produces another threat and/or shifts the threat to another point in the supply network.

Practical implications – Managers should be aware, for example, of potential risk migration from one threat to another when crafting strategies to build SCRES. Equally, the potential for risk migration across the supply network means managers should look at the supply chain holistically because actors along the chain are so interconnected.

Originality/value – The paper goes beyond the extant literature by highlighting how SCRES is not only about responding to specific, isolated threats but about the continuous management of risk migration. It demonstrates that resilience requires both an understanding of the interconnectedness of threats, strategies and outcomes and an understanding of the embeddedness of the supply network. Finally, this study’s focus on the context of a developing country reveals that resilience should be equally concerned both with smaller in scale, chronic disruptions and with occasional, large-scale catastrophic events.

Keywords Developing Countries, Resilience, Supply Chain disruptions

Paper type Case study

1. Introduction

Recent research has emphasised the importance of supply chain resilience (SCRES) for surviving the adverse effects of disruptive events (Carvalho et al. 2012; Brandon-Jones et al. 2014). SCRES is based on the premise that not all risks are avoidable (Jüttner and Maklan, 2011; Hohenstein et al. 2015), but by building resilience, firms can manage the threat of disruption to their supply chains and continue delivering goods and services to customers (Ambulkar et al. 2015; Scholten and Schilder, 2015). Although we are yet to reach full consensus on a definition of SCRES (Scholten et al., 2014; Kim et al. 2015), most scholars agree that it is concerned with a supply chain’s readiness, effective response to and recovery from a disruption – returning to the previous level or, preferably, an even better level of operational performance (Hohenstein et al. 2015; Tukamuhabwa et al. 2015).

SCRES is an important topic in the operations and supply chain management literature that is in need of more research (Ambulkar et al. 2015; Hohenstein et al. 2015; Kim et al. 2015; Scholten and Schilder, 2015). To date, few empirical studies on SCRES have been reported in the literature; and those that have been published were mainly conducted in Western Europe and North America (Zsidisin and Wagner, 2010; Gölugci and Ponomarov, 2013; Scholten and Schilder, 2015), leaving developing countries severely underrepresented. Yet developing countries, which constitute a significant part of global supply chains and the world’s population, have similarly experienced the devastating effects of supply chain failures (Chika et al. 2011). Further, there are grounds for believing...
that the most catastrophic effects of supply chain failures (particularly on human life) have been experienced in developing economies. Recent research on SCRES has examined the resilience of supply chains to product counterfeiters (Stevenson and Busby, 2015), and this can be a particularly acute problem in developing countries (Chika et al. 2011). Indeed, it was reported that the infiltration of counterfeit drugs into pharmaceutical supply chains led to the death of 2,500 people in 1995 and 192,000 people in 2001 in Nigeria and China, respectively (Chan et al. 2010). In addition, developing countries are more vulnerable to particular supply chain risks such as political turmoil, including rebel activities and post-election violence, and to bribery, poor transportation infrastructure, corruption and other unethical business practices (Lakovou et al. 2007; Transparency International, 2013). In 2011, Uganda suffered a severe crisis in fuel and raw material supply chains that disrupted the production and delivery of many goods and services. This sparked massive country-wide protests, and was followed by a violent police crackdown and many fatalities (The Independent, 2011). It therefore follows that we should be concerned with the resilience of developing world supply chains not only because, in a globally-connected world, their failure has repercussions elsewhere (Pereira et al. 2014; Kim et al. 2015; Levalle and Nof, 2015), but because the human consequences can be so significant.

The literature has presented many strategies for improving the resilience of supply chains, such as increasing flexibility and creating redundancy. But there is a noticeable lack of research on the relationships between the various strategies. Some scholars consider these strategies to be independent (Sheffi and Rice, 2005; Zsidisin and Wagner, 2010); others argue that they are interrelated (Jüttner and Maklan, 2011; Johnson et al. 2013), with their outcomes either complementing or contradicting each other. Thus, it becomes important to study resilience systemically. In other words, investigating the inter-relationships between threats of disruption (and the conditions that lead to threats), strategies and outcomes rather than analysing them individually and separately.

Against this backdrop, we adopt a case study approach, conducting interviews across a supply network of 20 manufacturing firms in Uganda, to address two research questions:

**RQ1.** What do manufacturing firms in a developing country perceive to be the threats to their supply chains? What strategies they adopt to build resilience? What are the outcomes of implementing these strategies?

**RQ2.** How are such threats of disruption and strategies interrelated; and what does this mean for supply chain resilience?

The study finds that threats of disruption, strategies and their outcomes are strongly interconnected, with threats commonly being side-effects of strategies, and attempts to build resilience commonly producing unexpected, further adaptations within the supply chain that themselves require intervention. Thus, to build resilience, it becomes important to appreciate the interconnectedness of threats, strategies and outcomes. We also find that it is important to understand the context in which the supply chain is located to explain such inter-relationships. Therefore, we draw on the embeddedness framework to examine how the political, geographical and cultural context contributes to a phenomenon of supply chain risk migration and influences SCRES.

The remainder of this paper is organised as follows. In Section 2, the relevant literature on SCRES is reviewed before Section 3 outlines the research method used. Section 4 presents a first-level analysis of the data according to threats, SCRES strategies, and outcomes. This is followed by Section 5, which presents a second-level analysis that reveals the interconnections between threats, strategies and outcomes and which adopts an embeddedness perspective to explain how and why such interconnectedness comes about. Conclusions are thereafter provided in Section 6.

### 2. Literature review

SCRES has emerged from the broader concept of resilience studied in a number of other disciplines, from ecology to organisational studies (Ponomarov and Holcomb, 2009). To date, the literature specifically on SCRES is dominated by modelling and theoretical work on strategies for building resilience. Recent modelling work includes that of Kristianto et al. (2014) on supply chain design and redundancy; Levalle and Nof’s (2015) on network formation and configuration; Rajesh and Ravi’s (2015) on appropriate supplier selection; and Das and Lashkari’s (2015) on risk readiness and planning. Recent theoretical contributions include those of Day (2014) on a complex adaptive systems framework that links SCRES to disaster relief and of Pereira et al. (2014) on the link between procurement and SCRES. Meanwhile, Kim et al. (2015) highlighted how different types of supply chain structural relationships affect SCRES, arguing that resilience should be analysed from a network perspective. Many of these studies highlighted the need for more empirical work on SCRES.

Tukamuhabwa et al. (2015) recently conducted a systematic literature review on SCRES based on 91 articles and found that the number of empirical papers – case studies or surveys – was limited to just 19 articles. Further, most of this empirical work was conducted in developed countries, particularly in Western Europe and North America (Gölgeci and Ponomarov, 2013; Wieland and Wallenburg, 2013; Scholten and Schilder, 2015). This prior work has also focused on high-profile catastrophic, discrete events, e.g. terrorist attacks (Rice and Caniato, 2003), the global financial crisis (Jüttner and Maklan, 2011), rail crashes (Johnson et al. 2013), war (Urciuoli et al. 2014) and Hurricane Katrina (Scholten et al. 2014). A similar focus on large-scale disasters can also be found in conceptual papers on SCRES (Day, 2014; Saenz and Revilla, 2014). This focus is understandable, but large-scale disasters are rare and common definitions of SCRES do not connect it solely to such disasters. Most supply chains are much more likely to be dealing with chronic, repeated threats of disruption, and it is such threats that are arguably more likely to be undermining their capabilities.

Much of the empirical work on SCRES has focused on investigating factors that could facilitate the building of SCRES, referred to variously as antecedents, enablers, practices, capabilities and competencies. Hohenstein et al. (2015) recently...
argued that all of these can, in some way, be considered SCRES strategies and include broad ideas such as improving flexibility, creating redundancy, building collaborative supply chain relationships, improving supply chain agility and enhancing visibility. More specific practices highlighted in the literature, such as information sharing (Brandon-Jones et al. 2014) and reconfiguring resources (Ambulkar et al. 2015), can be considered components of collaboration and flexibility, respectively.

In Table I, the various SCRES strategies that have so far been proposed in the literature are summarised according to whether they are employed proactively or reactively, i.e. whether they are used ahead of a potential threat to avoid the disruption or limit its impact or whether they are used after a disruption has occurred to respond or aid recovery. This approach has been adopted by many other authors, including Hohenstein et al. (2015) and Dabhikar et al. (2016), while others refer to the use of proactive, reactive and concurrent strategies (Hollnagel, 2011; Ali et al. 2017). Concurrent strategies are quick, first responses during or in the immediate aftermath of a disruption and reactive strategies are focused on post-disruption recovery. This is similar to the readiness, response and recovery phases referred to by other authors Ponomarov and Holcomb (2009). The simpler reactive/proactive classification however is sufficient for the purposes of our paper. Other alternative classifications of strategies that do not focus on when a strategy is deployed could include examining whether they support the robustness and/or agility of the supply chain to a threat (Wieland and Wallenburg, 2013) or examining the actors involved, e.g. whether a strategy is deployed by a single firm or collaboratively, such as with other members of the supply chain (Scholten and Schilder, 2015).

Some particular strategies can be either proactive or reactive depending on when and why they are applied. Collaboration, for example, can help to mitigate before disruptions occur, e.g. by enabling information sharing and the deployment of other strategies, including supplier development. But collaboration can also support post-disruption recovery by enabling supply chain actors to share resources and provide a coordinated response (Nishiguchi and Beaudet, 1998; Scholten et al. 2014). Meanwhile, some strategies may be planned and crafted before a disruption but only applied after the disruption. For example, redundant suppliers may be selected before the risk event but only contracted afterwards.

The relationships between the strategies in Table I are clearly complex and remain ambiguous (Jüttner and Maklan, 2011; Johnson et al. 2013; Hohenstein et al. 2015). For example, while scholars such as Soni et al. (2014) considered information sharing, visibility, and collaboration as separate strategies for building SCRES, others Gunasekaran et al., (2015), Kamalahmadi and Parast (2016) have considered information sharing to be a component of collaboration. It is also argued that forming collaborative supply chain relationships and creating redundancy can improve flexibility (Jüttner and Maklan, 2011; Scholten and Schilder, 2015) and that both flexibility and collaboration can improve agility, allowing companies to react faster and select a suitable option for mitigating the effects of disruptive events (Carvalho et al. 2012; Gunasekaran et al. 2015). In addition, strategies like building social capital and relational competences can be regarded as facilitators of collaboration (Tukamuhabwa et al. 2015). This clearly points to a need to investigate the relationships among these constructs more systematically.

Flexibility also facilitates other independent SCRES strategies from Table I, such as supply chain redesign and the creation of a risk management culture (Kamalahmadi and Parast, 2016). It has been further argued that a risk management culture is important in building SCRES through, e.g. helping to institutionalise innovation, which requires an organisation-wide set of shared beliefs and understanding about innovation. Moreover, a culture of innovation and having innovative individuals can facilitate an effective and immediate response to a supply chain disruption (Kamalahmadi and Parast, 2016). Another SCRES strategy – visibility – which involves incorporating true sensors at different parts of the supply chain and monitoring them regularly is sometimes considered a key component of agility (Wieland and Wallenburg, 2013; Kamalahmadi and Parast, 2016). According to Kamalahmadi and Parast (2016), making timely and informed decisions on the status of a disrupted supply chain and the courses of action to be taken is only possible when there is complete visibility, i.e. when decision-makers have complete knowledge of the status of their supply chains. Although complete visibility seems unlikely to achieve in practice, the greater the level of visibility and the more readily information is made available, the more able a firm will be to prepare for or respond to a disruption. For example, Saenz and Revilla (2014) explained that supply chain visibility helped Cisco to improve its agility and resilience to the Japanese earthquake and tsunami of 2011, whereby Cisco was able to map out its supply base beyond tier one suppliers and to field 118 customer enquiries. Visibility is also related to another strategy, i.e. that of using information and communication technology. For example, it is argued that such technology plays a major role in the continuous monitoring of supply chains by increasing visibility (Gunasekaran et al., 2015).

Furthermore, the SCRES strategy of appropriate supplier selection from Table I is related to the SCRES strategy of supply chain re-design. More specifically, appropriate supplier selection helps to appropriately re-design the supply chain by incorporating competent suppliers to mitigate supply-side disruptions (Gunasekaran et al., 2015). Moreover, redundancy, which involves the duplication of capacity to continue operations during a failure, has been linked to flexibility (Jüttner and Maklan 2011; Kristianto et al. 2014). Redundancy avails resources needed to facilitate supply chain flexibility, which facilitates response through the adaptable deployment of resources, avoiding delays and thereby increasing SCRES (Jüttner and Maklan, 2011). Flexibility can also be achieved through another strategy, that of appropriate contracting, e.g. by creating flexible contractual arrangements (Tukamuhabwa et al. 2015).

Although the above strategies appear to potentially complement each other, they can also conflict. For example, building particularly close collaborative relationships can conflict with some aspects of flexibility (Stevenson and Spring, 2007; Scholten and Schilder, 2015) while creating redundancy to facilitate flexibility may result in liquidity risk (Jüttner and Maklan, 2011). Also, collaboration may cause additional threats, e.g. through sharing sensitive
Table I: Summary of proactive and reactive SCRES strategies

| SCRES strategies | References |
|------------------|------------|
| **Proactive strategies** | | |
| **Appropriate supplier selection/Procurement.** Using selection criteria that can help to minimise disruptions and their impact, such as political stability in suppliers’ territories, quality, capabilities (e.g. technological), financial stability, business continuity, reliability, etc. | Pereira et al. (2014), Rajesh and Ravi (2015) |
| **Building logistics capabilities.** Capabilities for managing supply and information flows necessary for minimising vulnerabilities, e.g. risk-hedging capabilities, information technology upgrades, and information sharing | Ponomarov and Holcomb (2009) |
| **Building security.** Measures to protect the supply chain against deliberate disruptions, e.g. theft, terrorism, and the infiltration of counterfeits | Rice and Caniato (2003), Barksh and Kleindorfer (2009), Pettit et al. (2010) |
| **Building social capital and relational competences.** Effective communication and information sharing before the risk event increases risk awareness and limits vulnerability, e.g. communication, cooperation, trust, reciprocity, etc. | Johnson et al., (2013), Wieland and Wallenburg (2013) |
| **Co-opetition.** Creating and maintaining collaboration between competitors so as to gain from synergies, e.g. sharing resources for building security and resilience | Barksh and Kleindorfer (2009), Borekci et al. (2014) |
| **Creating appropriate contractual agreements.** Long term and short-term contracts that can enable flexibility in supply to minimise shortages | Urciuoli et al., (2014) |
| **Collaboration with the government/Creating public-private partnerships.** Contractual agreement between a public agency and a private sector entity to share skills and assets, risks and rewards to deliver services or facilities to the general public. It increases government interest in private entities’ supply chains | Gong et al. (2014), Urciuoli et al. (2014), Yang and Xu (2015) |
| **Creating a risk management culture.** Ensuring that all organisational members embrace supply chain risk management, and this involves, e.g. top management support and firm integration/team work | Christopher and Peck (2004), Sheffi and Rice (2005), Leat and Revoredo-Giha (2013) |
| **Increasing innovativeness.** The motivation and capability to seek and invent new business ideas, e.g. new products, technologies, processes and strategies that can reduce vulnerability | Gölgeci and Ponomarov (2013) |
| **Increasing visibility.** The ability to see through the entire supply chain (all nodes and links), which helps to identify potential threats | Pettit et al., (2010), Zhang et al. (2011), Saenz and Revilla (2014) |
| **Inventory management.** The strategic alignment of inventory management using a system-wide approach to minimise inventory risks | Boone et al. (2013) |
| **Knowledge management.** Developing knowledge and understanding of supply chain structures (i.e. physical and informational), and the ability to learn from changes as well as educate other entities | Rice and Caniato (2003), Christopher and Peck (2004), Ponomarov and Holcomb (2009), Jüttner and Maklan (2011), Ponis and Koronis (2012), Scholten et al. (2014) |
| **Portfolio diversification.** Indulging in different products to reduce dependence on particular products and suppliers | Urciuoli et al. (2014) |
| **Supplier development.** Facilitating suppliers with incentives, e.g. financial, training and technical knowledge to improve efficiency, commitment and reliability | Tang (2006), Leat and Revoredo-Gihahlea (2013) |
| **Supply chain collaboration.** The ability to work effectively with other supply chain entities for mutual benefit, e.g. sharing information and other resources to reduce vulnerability | Rice and Caniato (2003), Christopher and Peck (2004), Bakshi and Kleindorfer (2009), Ponomarov and Holcomb (2009), Pettit et al. (2010), Jüttner and Maklan (2011), Zhang et al. (2011), Ponis and Koronis (2012), Leat and Revoredo-Giha (2013), Brandon-Jones et al. (2014), Scholten et al. (2014), Scholten and Schilder (2015) |
| **Supply chain network structure/design.** Constructing the supply chain network for resilience, e.g. balancing redundancy, efficiency, vulnerabilities, etc. | Leat and Revoredo-Giha (2013), Kristianto et al. (2014), Geng et al. (2014), Scholten et al., (2014), Cardoso et al. (2015), Levalle and Nof (2015) |
| **Sustainability compliance.** Compliance to economic, social and environmental requirements to mitigate associated supply chain risks, e.g. reputational risks | Soni and Jain (2011) |
| **Use of information technology.** Information technology enhances connectivity and supports other resilience strategies, e.g. visibility and collaboration, which can help in signalling potential disruptions | Kong and Li (2008), Mensah et al. (2015) |

(Continued)
There is a need for further empirical work on SCRES, literature: many branches by firms may also culminate in liquidity risk (Jüttner and Maklan, 2011) and horizontal collaboration between suppliers may increase supply chain risk through collusion (Choi and Krause, 2006). Finally, flexibility through multiple sourcing and the opening of many branches by firms may also culminate in liquidity risk (Jüttner and Maklan, 2011).

In summary, two important gaps can be identified in the literature:

1. There is a need for further empirical work on SCRES, particularly across a network of firms and in a developing country context. Developing countries are an important player in global supply chains and face supply chain disruptions, yet they are underrepresented in the literature. As will be briefly highlighted in Section 3.2, developing countries have specific practices and conditions that may either produce threats of disruption or hinder the implementation of certain resilience strategies.

2. There is a need to understand the relationships between the various strategies proposed for building resilience. It is not just that such strategies may reinforce or contradict each other, but that some seem to subsume others, and all have various kinds of unintended consequences once organisations start to implement them in particular situations.

### 3. Method

#### 3.1 Research design

This paper responds to the need for more empirical research into SCRES and the need to expand current understanding of SCRES to include developing country contexts. The nascent state of the literature on SCRES in general, and particularly in developing countries, calls for a qualitative, exploratory study (Saunders et al. 2009). We are interested in what...
manufacturing firms perceive to be the threats to their supply chains; the strategies they adopt to build resilience; the outcomes of implementing these strategies; and, importantly, how threats of disruption, resilience strategies and outcomes are interrelated. These are favourable conditions for adopting the case study approach (Stuart et al. 2002), as it enables a thorough examination of complex, real-life phenomena leading to new, in-depth insights (Eisenhardt, 1989; Yin, 2009). Exploring the interrelatedness of threats, strategies and outcomes would be much more difficult using other common empirical methods, such as a cross-sectional survey. The value of the case study approach to our research will become further evident in our findings. In particular, informants disclosed some of the unethical practices that occur in supply chains that affect SCRES, including corruption, theft and product counterfeiting. Obtaining this insight was possible by meeting the informants face-to-face and building a rapport with them. It is unlikely that this insight would have been obtained using, for example, an online survey.

Our qualitative case study approach generates explanation from analysis rather than testing prior hypotheses, and this allows us to develop our particular line of theorising about SCRES (Ketokivi and Choi, 2014). A multiple case study approach is adopted. This aids external validity, guards against observer bias (Voss et al. 2002; Barratt et al. 2011), aids triangulation and creates more testable and robust theory (Eisenhardt, 1989; Yin, 2009).

3.2 Context and case selection
We studied a network of 20 manufacturing firms located in Kampala (the capital of Uganda) and the surrounding industrial areas of Wakiso and Mukono – where the majority of Uganda’s manufacturing firms are located (Uganda Bureau of Statistics Report, 2011). Uganda is a landlocked country in sub-Saharan Africa located between Southern Sudan, Kenya, Tanzania, Rwanda and the Democratic Republic of Congo. It has a population of approximately 34.9 million and an income per capita of $706, with 19.7 per cent of people living below the poverty line (World Bank Report, 2015). Uganda’s manufacturing sector is growing, but it currently accounts for just 18.4 per cent of GDP – compared to 48 per cent for services and 26.2 per cent for agriculture (World Bank Report, 2015). Manufacturing is heavily reliant on imported materials and is faced with challenges like high interest rates, poor transportation infrastructure, inadequate skills and power shortages (Obwona et al. 2014). Further, unethical behaviour in commercial transactions is common. Employees in Uganda are said to value their social identity more than professionalism, and pressures within social relations sometimes produce dishonest behaviour between buyers and suppliers (Ntayi et al. 2012). Other problematic practices include adulterating products, mixing good and poor-quality products and refusing to pay suppliers post-delivery (Ntayi et al. 2012). More generally, Uganda is considered one of the world’s most corrupt countries, suffering from the politics of patronage and interference with the rule of law (Mbabazi and Yu, 2015).

The firms participating in the study have been anonymised and are referred to as AU, BU and so on through to TU, with Figure 1 illustrating the network of firms studied and their brief profiles, including the number of interviewees per firm and the formal and informal linkages between the firms. Following the principles of theoretical sampling (Eisenhardt, 1989; Dubois and Araujo, 2007), the studied firms had to be in a developing country and connected to one another in a supply network. Sampling was also based on emerging findings. For example, it was decided that competitors and part-government-owned firms should be incorporated to reflect the recurring themes from the initial interviews of unfair competition and corruption. Access began with JU, a brewery where one of the authors had previously worked and where it was known that several supply chain disruptions had been encountered. Employees from JU later facilitated access to three of their suppliers: two sugar manufacturers (FU and GU) and one packaging materials producer (DU). The data collected from DU, which is the largest manufacturer of packaging materials and other paper products in Uganda, revealed disruptions that affected their customers. Hence, their customers were contacted (i.e. BU, FU, PU, IU, TU, QU, SU, EU, OU, RU, CU, AU, NU, MU and EU). Some of these companies also supplied one another. For example, GU and FU supplied beer manufacturers IU, JU and TU and EU supplied HU, which also supplied OU. The number of companies studied (20) was determined following the principle of theoretical saturation – when no new categories or dimensions emerged from additional data (Manuj and Pohlen, 2012).

3.3 The interview protocol
Open-ended questions (for semi-structured interviews) were formulated to probe new areas that would emerge in the course of data collection, as suggested by Manuj and Pohlen (2012). The first main theme concerned what manufacturing firms in Uganda perceived to be the threats of disruption to their supply chains. This theme probed different categories of threats of disruption, e.g. supply-side threats, customer- or demand-side threats, firm-level threats and threats external to the supply chain. For each threat discussed, interviewees were also asked about the strategies adopted to build resilience and, for each strategy, they were further asked about the outcomes of implementation, i.e. whether a strategy was successful or had adverse effects. Further probing was undertaken where informants’ accounts suggested threats and strategies were connected, to understand how and why such interrelatedness came about and what it could mean for SCRES. A pilot study was conducted using face-to-face interviews with three professional managers who had occupied senior positions in manufacturing firms. This helped refine the protocol in terms of its clarity and focus. The final version of the semi-structured interview guide is provided in the Appendix.

3.4 Data collection
In total, 45 semi-structured, audio-recorded, face-to-face interviews lasting approximately 1 h each were conducted with managers and other key personnel knowledgeable in supply chain-related functions. Multiple interviewees per firm were used wherever possible to minimise bias. Interviewees were chosen from different authority levels and consisted of 1 managing director, 1 general manager, 33 managers and 10 officers in functions related to supply chain, procurement, logistics, operations, marketing and distribution. Interviews were transcribed before the transcripts were sent back to the
interviewees for validation. We moved back and forth between data collection and analysis so the ideas emerging from the data were reconfirmed in new data and new ideas were further confirmed by the already collected data, as recommended by Morse et al. (2002).

3.5 Data analysis
The unit of analysis was a supply network fragment, i.e. some portion of the supply network that respondents referred to as their "supply chains". Data were analysed following grounded analysis principles. The aim was to avoid being constrained by prior theory, to remain open to being surprised by the data and to make sense of the emerging surprises (Ketokivi and Choi, 2014). Repeated readings of the transcripts were first conducted to understand the data and identify data fragments that referred in some way to certain aspects of our research questions. Data analysis was then undertaken at two levels, as described below.

First, there was a reductionistic analysis to develop a category structure for the data. There were three high-level categories: supply chain threats, resilience strategies and strategy outcomes. A lower-level set of categories was also developed through cross-case analysis (Barratt et al. 2011), comparing different instances of the same code. The category structure was refined by identifying differences and similarities among the categories (Strauss and Corbin, 1990), followed by merging and eliminating to reach consistency, as recommended in Miles et al. (2014).

The second integrative level of analysis involved using the transcripts to identify the dynamic, causal connections between the threats (and conditions that lead to threats), strategies and outcomes that had been described by the interviewees. This produced a second network – not of firms but of conditions leading to a threat, threats, strategies and outcomes – that cut across firms. In this additional network, each node is a condition, threat, strategy or outcome with incoming and outgoing links. The edges linking the nodes are causes. The full network was constructed using Gephi software but this network is too large and densely populated to enable the clear labelling of nodes and links, and so presenting it in its entirety would add little value. In Section 5, we will present Table IV that summarises the data, and we will describe two fragments of the full network to illustrate the nature of the interconnectedness. It was at this point in the analysis that we found many of the inter-relationships themselves also needed explanation – and the importance of context in explaining these inter-relationships led us to adopt an embeddedness perspective (Section 5.3). For example, threats such as corruption, product counterfeiting, unfair competition and dishonest employees originated from the supply network’s embeddedness in a developing country characterised by weak political and legal controls.

4. First-level analysis: categorisation of threats, strategies and outcomes
This section briefly outlines the first-level analysis, where data are categorised according to supply chain threats, SCRES strategies and corresponding outcomes. This categorisation is illustrated in Table II.

Supply chain threats were divided into the following two types:

![Network of firms studied and their profiles](Image)
Endogenous threats originating from within the supply chain, which were then further divided into: supply-side threats of disruption originating from upstream; firm-level threats originating from within the focal company; and demand-side threats originating from downstream.

Exogenous threats originating from outside the supply chain, which were further divided into: geopolitical and economic threats.

From the interview data, it became clear that interviewees had a broad understanding of the term “threat”. Some responses
Table II also includes a detailed list of the SCRES strategies applied by the firms, and the outcomes of implementing strategies where possible – not all strategies had specified outcomes in our data. From the outcomes, it is clear that the interviewees were mostly concerned with adverse or unexpected outcomes of adopting a particular strategy, e.g. side-effects or new threats, although clearly there will be positive outcomes of adopting SCRES strategies. Further, the strategies reported are also evidently inter-related – threats lead to strategies, which can sometimes have adverse outcomes that require further strategies to deal with them, and potentially further negative side-effects. This inter-relatedness of outcomes, like the inter-relatedness of threats, appears fundamental to how supply chains behave when any attempt is made to intervene in them. The second-level analysis, in the next section, is therefore focused on the interconnectedness of threats, strategies, and outcomes.

5. Second-level analysis: interconnectedness of threats, strategies and outcomes

The interviews and first-level analysis revealed instances of interconnectedness between threats, strategies, and outcomes. The second-level analysis therefore involved:

- identifying all instances in the data when informants described a causal connection between, or among, the threats (and associated conditions), strategies and outcomes identified in Section 4; and
- assembling these into a causal network, as briefly described in Section 3.5.

The most important nodes in this network, in terms of the number of incoming and outgoing links to the nodes, are given in Table IV. The network consists of 90 nodes in total, but space precludes showing the entire table. Therefore, Table IV is limited to the nodes with over ten links (22 nodes) and a further five nodes that are particularly relevant to our discussion. There are certain nodes with large numbers of both incoming and outgoing links – such as the threats of raw material delays and shortages (25 links in or causes and 29 links out or outcomes), financial difficulties (for the focal firm: 18 links in and 12 links out) and poor-quality raw materials (8 links in and 13 links out). Such nodes have many antecedents and many consequents, e.g. being a side-effect of a strategy aimed at managing some
other threat. Such highly connected threats (or hubs) are difficult to control because they influence resilience in multiple ways. Interestingly, the top-ranked nodes in Table IV are all threats that are internal to the supply chain, which suggests that the most important threats to SCRES are perceived to be endogenous rather than exogenous. Moreover, most are chronic, continuous problems, e.g. product counterfeiting, machine breakdowns, demand variations, supplier delivery failures, etc. A discrete and potentially catastrophic threat like natural disasters, for example, had only five outgoing links (and no clear causes).

An analysis of the links between nodes showed that there are a relatively small number of nodes with a large number of links. For example, there is only one node with over 30 links, 2 nodes with 26-30 links, but 68 nodes with 10 or less links each. To give a better idea of the qualitative nature of the relationships in this network, we describe two fragments of the network in Sections 5.1 and 5.2.

### 5.1 Example network fragment one: effects of limited local supply market on SCRES

The first example starts with the threat of a limited local supply market (see Figure 2, beginning from the box to the left-hand side labelled “limited local supply market”). Sixteen firms (AU, CU, EU, FU, HU, IU, JU, KU, LU, MU, NU, PU, QU, RU, SU and TU) highlighted the threat of a limited local supply market. Twelve of these firms argued that this leads to long-distance sourcing, resulting in the upstream threat of delays and shortages of raw materials and spares. If a firm runs out of raw materials, this can halt production, which then disrupts the downstream network. In CU, long-distance sourcing causes communication and information flow problems, which make it difficult to establish collaborative relationships with suppliers, causing further delays and shortages. Some firms (e.g. AU, FU, LU and PU) respond to raw material shortages from long-distance sourcing by maintaining strategic stocks. But this increases stock holding costs, including the costs of theft, and ties up working capital, particularly for expensive materials and spares. This results in the threat of running into financial difficulties. AU’s Marketing Manager stated:

> Our source of raw materials is far away. So we keep stocks for at least five months to cater for delays. For example, materials arriving from Japan can take three months, which ties [up] our capital and creates financial problems.

Further, the financial difficulties resulting from maintaining strategic stocks mean firms fail to pay suppliers or customs on time, resulting in a circular effect – the return of (further) material delays and shortages. JU’s Procurement & Logistics Officer explained:

> We place orders, but deliveries are delayed due to a lack of finances, for example to pay for customs clearance – sometimes because money is tied [up] in inventory [...] [we] lack enough raw materials and this affects our production.
Firms such as IU, KU, PU and RU indicated that they use local sourcing to mitigate the disruptions caused by long distance suppliers, but they conceded that this compromises quality, which negatively affects their downstream customers. Some companies (e.g. AU, CU, JU, LU, MU, PU, RU and SU) indicated that they mitigate delays by developing collaborative relationships with suppliers, but AU, JU and PU argued that forming deep relationships limits flexibility to switch suppliers when faced with a crisis, causing further delays and shortages.

LU, PU and RU also reported that co-opetition, a form of collaboration with rival firms, helps create resilience against raw material delays and shortages. Interviewees claimed that they borrow materials from other firms (without interest) and replace the goods when their consignment arrives. PU’s Procurement Manager stated:

> We work together with our competitors by getting raw materials from them and replacing them when ours are delivered [...] This kind of arrangement is facilitated by our networks as managers. We know each other and we communicate during crises to bail each other out.

This co-opetition strategy, based on informal networks and social relations, is not part of the formal supply chain. It therefore shows how SCRES may emerge from a mutual interaction between the system and other independent, rival systems. The data also show that this is facilitated by the embeddedness of the supply network, as will be explained in Section 5.3. Informants from LU, for example, reported that they exchange information with competitors to mitigate threats, e.g. reporting on dishonest distributors. But it was also revealed that co-opetition can present confidentiality risks. For example, PU’s Brand Manager stated: “We do not collaborate with some of our competitors for confidentiality reasons”. PU’s Procurement Manager also indicated that some competitors use their informal, social networks to bribe government officials to evade or pay fewer taxes, which results in unfair competition.

The effects described above produce non-linearity, in that there is no simple, linear relationship between the disturbances experienced by the supply network and the reliability and availability of the final product – because they are mediated by a series of adaptations and effects within the network. This non-linearity seemed clear to the informants. For example, IU’s Finance Manager explained:

> [...] a quality problem was initially seen as small but later turned out to affect the whole supply chain. It started from the supplier with poor quality materials, meaning we produced poor quality items, which we delivered to customers. The complaints that followed, including litigation, affected our entire system.

The threat of a disturbance (delays and shortages of spares and raw materials) is shaped by another threat (limited local supply market), which triggers a condition (long distance sourcing), with the adaptation to this (e.g. maintaining strategic stocks) creating other threats (such as financial losses from tying capital up in stock). This in turn can lead to other threats and circular effects, including the reoccurrence of the original threat (e.g. raw material delays and shortages) but with different antecedents (e.g. a failure to pay suppliers or customs). Firms such as CU further revealed that they find it difficult to implement SCRES strategies (e.g. collaboration with suppliers) against other threats due to communication barriers and poor information flow created by long distances from suppliers. Thus, a particular condition can affect resilience through multiple routes – first, by producing threats; and second, by constraining the implementation of other resilience strategies.

This analysis shows that the consequences of a particular threat and/or condition, as well as the mitigating strategies, can propagate through the supply network. Thus, in the process of trying to attain resilience, risk shifts or migrates rather than being resolved, e.g. as one threat becomes transformed into another. This migration of one kind of risk to another is generally accompanied by a movement from one point in the supply network to another (e.g. from upstream to downstream) – and this will be further revealed in the second example. In this first example, an attempt to mitigate a threat originating from the supply side caused firm level threats, such as financial difficulties, which affected both the upstream and downstream supply chain.

### 5.2 Example network fragment two: the threat and consequences of dishonest employees

The second example starts with the threat of dishonest employees (see Figure 3, beginning from the box to the top left-hand side labelled “dishonest employees”). Twelve firms (GU, LU, IU, TU, JU, KU, EU, HU, BU, AU, NU and PU) indicated that dishonest employees disrupt the production and...
delivery of their products through, for example, product adulteration, which leads to poor-quality products that affect a firm’s reputation with its customers; malicious machine damages (leading to breakdowns), which also affect product quality and require stock holding (with its associated problems); and stock theft, which has direct financial implications for the firm. Firms such as BU, EU and HU argued that the culture of dishonesty through connivance is deeply entrenched in employees. But dishonest behaviour is sometimes caused by the late payment of salaries (due to financial difficulties). For example, JU’s Regional Sales Manager explained that their field-based sales personnel sometimes disappear with company money when salaries are delayed. Likewise, the Procurement Manager of JU, a brewery, commented that workers: “[...] stop working, destroy machines, destabilize the processes and produce poor quality beer intentionally. Sometimes, we are unable to supply or we supply spoiled beer”. Such behaviour produces an obvious non-linearity for the network, whereby relatively minor perturbations become amplified through cycles of repeated delay and protest, as evident in the closed loops of causation in Figure 3. Indeed, TU’s Trade Marketing Manager explained:

Late staff payment is a problem that started small but has eventually affected the whole supply chain. Production is affected, the market is affected and we fail to get cash inflows to pay our suppliers.

Firms such as BU attempt to overcome financial difficulties so they can pay employees by using financial management strategies (e.g. by reducing customer credit limits and demanding cash payments). But this leads to reputational risk and the loss of customers, further reducing financial inflows.

BU’s Export Manager noted: “The company policy makers have decided to demand cash transactions and this has made some customers abandon us and shift to our competitors, further reducing our sales revenue”.

Employee misbehaviour is a disruption threat in its own right, but it also produces other threats, e.g. financial difficulties, and limits the implementation of SCRES strategies against other threats. For example, stock theft hinders the use of strategic stocks for safeguarding against shortages and delivery failures, as noted by BU’s Marketing Manager:

Sometimes, we store a lot of cement but we have thieves [employees] [...] sometimes we run out of stock unexpectedly, affecting clients and the company [...] we cannot fulfil the orders, which reduces our cash flows.

Respondents from JU argued that a loss of income owing to employee misbehaviour results in further staff payment problems, which in turn leads to further misbehaviour – a vicious cycle, as illustrated in Figure 4 (beginning from the top left of the figure).

In general, the data again showed that interventions in the form of strategies aimed at responding to threats do not have simple, self-contained outcomes. Adaptations and consequences propagate over time and space. And the relationships between the threats experienced by the network and the ultimate effects are evidently non-linear and generally stochastic. The result is the migration of supply chain risks and a process of continuing adaptation. This still leaves the question of what lies behind this interrelatedness. We have observed how the initiating threats in our examples above, and many of the causal influences that have been discussed, characterise the Ugandan context. It is the context that seems to produce the difficulty of partitioning the different elements of resilience – the multiple threats and strategies. This is supported by Table IV, where most of the nodes that have no incoming links are grounded in the context, e.g. government policy, corruption, insufficient skilled manpower and geographical location (landlockedness). Hence, an embeddedness theoretical framework is adopted in Section 5.3 to understand how the presence of the supply network, or part of it, in a developing country affects its resilience. Section 5.4 then focuses in more detail on the phenomenon of risk migration, which appears to arise from the embeddedness of the supply network.

5.3 The embeddedness perspective on SCRES

Embeddedness is a multi-disciplinary concept that has been given a number of different meanings (Polanyi, 1944; Granovetter, 1985; Halinen and Törnroos, 1998; Hess, 2004). For example, Hess (2004) defined embeddedness:

Figure 3 The threat and consequences of dishonest employees

Figure 4 A vicious cycle – dishonest employee behaviour constraining other SCRES strategies
networks of relationships in that location (Halinen and Törnroos, 1998).

Table V summarises the key aspects of embeddedness contained in the data, where much of the focus is on cultural embeddedness and the associated threats. As can be observed from Table V, the three categories can overlap. For example, although a factor such as corruption can be analysed from a cultural perspective – where people may view it as a norm – it can also be argued to be a political factor arising from a weak legal system, government policy or a lack of political will. Similarly, factors such as a weak legal system could be perpetuated by culture, such as when the civil society legitimises bribery. Further, a supply network may be embedded in political and cultural milieus due to its territorial embeddedness, e.g. being located in a generally underdeveloped continent experiencing political immaturity and economic constraints.

We found some evidence in our data that embeddedness can enable SCRES. For example, we described earlier a specific kind of co-opetition, where competitors borrow raw materials from each other to mitigate raw material delays. This co-opetition is facilitated by the actors’ involvement in informal networks, which develop in a supportive cultural context. However, it was also found that embeddedness is a source of threat. Firms such as BU and CU attributed specific threats, such as delays and damage to fragile consignments – as a result of poor transportation infrastructure – to the embeddedness of the supply network in a political and cultural context that exacerbates corruption. JU’s Procurement Manager argued:

“… when there was political violence in Kenya, all manufacturing companies in Uganda ran out of stocks of raw materials […] They could not be delivered via Mombasa”.

It was also found that some SCRES strategies yielded unexpected adverse outcomes as a result of embeddedness. For example, maintaining strategic stocks to guard against the raw material delays and shortages that result from long-distance sourcing can become ineffective owing to the cultural acceptability of theft by employees. Further, although informal networking can create resilience against certain threats (e.g. financial difficulties and raw material delays) and reinforce strategies (e.g. co-opetition), it can also act as a barrier to SCRES due to cultural and political embeddedness (e.g. when firms use their informal networks to avoid taxes). JU’s Procurement and Logistics Officer stated:

Some competitors lobby the government and dodge or pay low taxes. There is corruption in government where beneficiaries pay less or no tax and end up charging a lower price, which affects our customer base.
Table V Aspects of embeddedness revealed in the data: political, cultural and territorial embeddedness

| Category                        | Components and sample evidence from the data                                                                 | Examples of associated threats                  |
|---------------------------------|-------------------------------------------------------------------------------------------------------------|-------------------------------------------------|
| Political embeddedness         | Political instabilities e.g. within Uganda and the neighbouring countries like Kenya                         | Raw material delays and shortages               |
|                                 | National politics e.g. political networks and patronages perpetrating corruption                            | Unfair competition                              |
|                                 | Government policy e.g. on counterfeits where the government standards body (Uganda National Bureau of Standards) recommends the use of counterfeits rather than fight them | Product counterfeiting                           |
|                                 | Weak legal system, e.g. Weak or absence of laws, including on copyright, and judicial corruption causing copyright infringements | Product counterfeiting                           |
| Cultural embeddedness          | Corruption, e.g. bribery, conflict of interest, connivance, political favouritism and lack of transparency  | Poor transport infrastructure                   |
|                                 | Informal sector, e.g. managers in some industries are not willing to formerly register their businesses mainly to avoid taxes. About 80% of actors in the dairy industry are unregistered | Reduced customer base and financial difficulties |
|                                 | Unfair competition, e.g. firms use connivance to sabotage their competitors’ supply chain operations. For example, they collude with suppliers so as not to deliver raw materials to their competitors or at least to deliver late | Raw material delays and shortages               |
|                                 | Product counterfeiting, e.g. compounded by a culture where government employees responsible for fighting counterfeiting are themselves counterfeiters and local suppliers who deliver counterfeit raw materials | Reputational risk                               |
|                                 | Dishonest suppliers, e.g. some local suppliers are dishonest and unreliable. They are deceptively about their capacity and they accept orders that they fail to deliver | Supplier delivery failure                        |
|                                 | Dishonest customers/Distributors, e.g. some customers connive with company employees and either manipulate the prices and share the difference or load more quantity into lorries/containers than bought | Financial difficulties                          |
|                                 | Negative perceptions of overseas suppliers, e.g. some overseas suppliers have a negative perception of firms from African countries (e.g. corrupt, likely to collapse) leading to denying them trade credit | Reputational risk and raw material delays and shortages |
|                                 | Dishonest employees, e.g. employees steal company money, deceive customers, deliberately produce poor-quality products and cause machine breakdowns, sometimes as a retaliation against low and delayed salaries | Poor customer delivery performance              |
|                                 | Owner/Management behaviour, e.g. owner managers have a culture of intervening in professional activities, such as procurement, making duplicate purchases or purchasing poor-quality items | Procurement risk                                |
|                                 | Customer characteristics, e.g. many Ugandan customers are willing to buy counterfeit products knowingly (as long as they are cheaper) | Product counterfeiting and reduced customer base |
| Territorial embeddedness       | Geographical location/Landlockedness, e.g. Political chaos in Kenya disrupts the flow of raw materials      | Raw material delays and shortages               |
|                                 | Spatial proximity, e.g. overseas sourcing of most raw materials and long distances from the suppliers          | Communication barriers                          |

Being voluntarily embedded in one aspect sometimes implies automatic embeddedness in another. In the data, for example, being (voluntarily) territorially embedded in a landlocked country (e.g. as a location decision) implies also being embedded in the conditions of the transit neighbouring country involuntarily. This shows that embeddedness can be complex (e.g. a combination of territorial and political), and this can produce threats that would not occur if the embeddedness were simple. Being embedded in a landlocked country need not be a threat to a firm’s SCRES in itself or political instability in a neighbouring country.

5.4 Supply chain risk migration
Our findings demonstrate that threats and strategies are interrelated in a more complex way than a given threat simply leading to the adoption of a particular strategy. The strategies adopted to build SCRES may produce adverse outcomes in the form of new or former threats, either at the same or a different point of the supply network. Equally, resilience strategies may conflict or mutually reinforce each other. The relationships between supply chain phenomena, and the points where they occur in the supply chain, were reportedly caused by the factors emanating from the context in which the supply chains are situated. This suggests that the way the supply chain becomes a
system is explained by its embeddedness – because it is the embeddedness that produces or explains the nature of many of the relationships between threats, strategies, etc. This embeddedness contributes to the phenomenon of risk migration in the supply chain that was noted earlier; risk migration implies that resilience is an unending process of responding and adapting both to threats and to the outcomes of prior adaptations.

The supply chain risk migration matrix introduced in Figure 5 illustrates that, in the process of creating SCRES, a threat can migrate from one form to another and/or from one point in the supply network to another. The horizontal axis in Figure 5 represents the threat (T), while the vertical axis represents the point in the supply network (N), e.g. in the upstream or downstream. The bottom left-hand quadrant (T1NA) represents the initial network point NA, which is threatened by T1. An attempt is therefore made to mitigate threat T1. Risk migration may manifest in three forms, i.e. T2NA, T1NB or T2NB. The bottom right-hand quadrant, T2NA, shows the transformation of a threat T1 into another threat T2 at the same point in the network NA. For example, mitigating the upstream threat of raw material delays and shortages by keeping strategic stocks resulted in financial difficulties, leading to another upstream threat of loss of reputation for suppliers owing to a failure to pay them. The top left-hand quadrant, T1NB, shows the migration of original threat T1 to a different point in the network (NB). For example, mitigating the threat of financial difficulties resulting from defaulting customers by demanding cash payments resulted in a reduced customer base and cash inflows – leading to an upstream threat of failure to pay suppliers (financial difficulties). Finally, the top right-hand quadrant, T2NB, shows the migration of a threat (T1 to T2) and of the point in the network where the threat is experienced (NA to NB). For example, to mitigate the upstream threat of dishonest suppliers who adulterated products and supplied poor-quality materials, some companies screened quality at suppliers’ sites and conducted audits. But this caused raw material delays, which disrupted production schedules and led to the downstream threat of late delivery to customers and a reduced customer base.

It is important to be aware of the phenomenon of risk migration when implementing strategies to build SCRES. The matrix in Figure 5 reminds us that threats and strategies are interconnected. The fact that SCRES strategies produce unexpected adverse outcomes informs managers that SCRES should not be viewed as a static phenomenon; the capacity to adapt should be built into the system so it has the flexibility to respond to different manifestations of threats.

6. Discussion and conclusions

Few empirical studies on SCRES have been reported in the literature, and those that have been conducted have focused on a developed country context. There has been a need to investigate the perceived threats of disruption to supply chains in developing countries and developed countries and to examine how firms attempt to create resilience to these threats. While prior SCRES empirical studies have emphasised large-scale, discrete, catastrophic and exogenous threats (Rice and Caniato, 2003; Jüttner and Maklan, 2011; Johnson et al., 2013), our findings suggest that firms in a developing country are mainly concerned with smaller in scale, chronic threats of disruption, many of which are endogenous. Non-linearities inherent in the supply networks mean that these chronic threats may have considerable consequences for resilience. This adds to our understanding of what is perceived to be important to building SCRES.

Against this backdrop, our study makes the following main contributions:

- Our findings show that resilience, and the conditions that influence it, requires an understanding of the interconnectedness of threats, strategies and their outcomes. This is different to the perspective typically adopted in the extant literature where it appears to be suggested that resilience is about identifying threats and determining corresponding strategies (Petit et al., 2010). In contrast, our study suggests that resilience is not linear and is a continual process, which logically suggests that it is non-stationary and can be gained or lost over time. This relates to the phenomenon of supply chain risk migration, whereby implementing a resilience strategy may produce another threat, either at the same or a different point in the supply network. The concept of risk migration can be traced to the risk literature (Grabowski and Roberts, 1997; Alcock and Busby, 2006), but it has not previously been expressly considered in SCRES research.

- Our findings highlight that resilience requires that consideration be given to the context in which the supply chain is embedded. The embeddedness perspective emphasises how the environment brings about the connections between threats, strategies, and outcomes. Prior empirical SCRES research has focussed only on the strategies for building SCRES (Hohenstein et al., 2015) without systemically considering the threats that provoke such strategies and their outcomes. Moreover, our study goes beyond previous supply chain research where embeddedness has been portrayed as a purely positive concept, and beyond its prior primary focus on the structural and relational dimensions of embeddedness (Choi and Kim, 2008; Gligor and Autry, 2012; Kim, 2014). Further, although embeddedness has been linked to supply chain risk (Song et al., 2012), and to both adaptation and responsiveness (Uzzi, 1997), it has not
6.1 The importance of context

The literature on SCRES has thus far focused on the developed world; hence, this work contributes towards providing greater representation in the SCRES literature of developing country contexts. These countries typically lag behind, for example, in terms of the level of industry maturity, business practices, governance structures and infrastructures. Thus, the threats faced by firms and supply chains in developing countries, and the way in which these threats are handled, may differ from the developed country context that has been largely studied in the SCRES literature, but further research has been required in developing country contexts to explore this.

The particular setting for this study has been the developing country of Uganda where informants were especially concerned about the resilience of their supply chains to relatively small-in-scale, chronic problems – far less so with the large-scale, catastrophic events emphasised in the literature (e.g., hurricanes, terrorism, etc.). The theory frame of embeddedness has proven to be an important lens for making sense of the conditions, threats, strategies and outcomes encountered in the Ugandan context. Table V, for example, identified the political, cultural and territorial aspects of embeddedness that were revealed in the data and that contributed in some way to the threats that manifested in the fragment of the supply network that we have studied. In this work, important territorial aspects included landlockedness, political aspects included political instability and a weak legal system, and cultural aspects included corruption and product counterfeiting. It seems likely that the combination of aspects contained in Table V will be relatively unique to Uganda, but other contexts will feature some of these aspects and potentially others that are not identified in these data. Hence, further research is required in other developing country contexts, including from an embeddedness perspective. Of course, aspects of embeddedness were also evident in how firms responded to the threats, including co-optation, whereby competitors borrow raw materials from each other to mitigate raw material delays, which was linked to the importance of social ties and informal networks that develop in Uganda’s cultural context. It is important that this, more supportive aspect of the context that we have studied is not overlooked.

Although the work is situated in Uganda, it is argued to be of wider relevance, and not only because of the global nature of supply chains and the flow of goods into and out of Uganda to other nations around the world. We have demonstrated how understanding the political, cultural and territorial context in which a supply network is embedded is key to understanding the threats of disruption to the supply chain and the interrelatedness of threats, strategies and outcomes. Embeddedness creates complexity in the threat-strategy-outcome network, and this constrains resilience, as it means it is difficult to intervene in the system in a definite way – aspects of embeddedness create unanticipated outcomes from an intervention. This reflects the more general principle of the importance of context and its influence on operations- and supply chain management-related phenomena such as resilience. Moreover, although the particular underlying causes of the phenomenon we have identified may be specific to Uganda, supply chain risk migration is argued to be a much more widely relevant phenomenon that will be important in other settings than Uganda.

6.2 Managerial implications and future research

This study revealed that threats of disruption and SCRES strategies are interconnected. Strategies should thus not be considered in isolation because their implementation may either reinforce or contradict other strategies. If they reinforce each other, such strategies could be applied together as a bundle to maximise their complementarity. Managers should be aware of potential risk migration from one threat to another when crafting strategies to build SCRES. Equally, the potential for risk migration across the supply network means that rather than looking at their operation in isolation, managers should look at the supply chain holistically because actors along the chain are so interconnected. Managers should also be aware that the threats to the resilience of their supply chains are not necessarily large-scale discrete events – they are also events of continuous possibilities. Hence, they should not underestimate seemingly small but chronic events because they are capable of gradually weakening the supply network, resulting in either major consequences (due to non-linearity) or a reduced capability to respond to future catastrophic events. Furthermore, this study is not only of relevance to managers in developing countries but also to global sourcing managers buying from developing countries. Managers in general need to be aware of the context in which their supply chains are embedded if they are to understand the potential threats and the conditions that might render their SCRES strategies ineffective; mapping out the kind of network we have used in our analysis may be a useful approach for managers in understanding the interconnectedness of threats and the consequences of their interventions.

Although our case study approach provides rich data, it has focused on a specific network of firms in a narrow range of industries and within a single country. It thus has limited generalisability. It was also cross-sectional in nature, which limits our understanding of the longitudinal process of adaptation in building SCRES. We found that SCRES involves continuously adapting to smaller-in-scale, chronic threats and to the consequences of such adaptations, which depict SCRES as a dynamic process rather than a static attribute of a supply chain. This requires longitudinal observation to understand fully, and longitudinal data are also needed to understand how resilience is gained or lost over time. Finally, Figure 5 illustrated the supply chain risk migration phenomenon identified in the data. This could be further developed in future research. For example, the vertical axis refers to the point in the supply network where a threat is located (or has migrated towards), i.e. NA vs NB. This could be expanded to reflect both up- and downstream migration or to indicate the proximity/distance from the previous point where the threat was located. The horizontal axis refers to the threat encountered and whether this is the same threat as before or whether mitigation has created a new threat, i.e. T1 vs T2. This could be expanded, for example, to reflect changes in the probability or impact of a threat on the supply network.
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Supply chain resilience

Benjamin Tukamuhabwa, Mark Stevenson and Jerry Busby

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Appendix. Semi-structured interview guide

General information

1. Interviewee information.
2. Job title and description.
3. Years spent in the position and company.
4. How does your role link in with the supply chain decision-making processes?
5. Company information.
6. Company name and industry sector.
7. Business starting date.
8. Number of employees and average turnover for the last two years.
9. Nature of operation (incl. multinational or domestic, mode of entry).
10. What is the nature of your products, e.g. standard, variety, customised?
11. Your major suppliers (main countries/regions).
12. Your major customers (main countries/regions).
13. Strategic objectives of this company (e.g. cost leadership, differentiation, focus on a particular segment, etc.)
Supply chain resilience

Benjamin Tukamuhabwa, Mark Stevenson and Jerry Busby

Supply chain threats, resilience strategies, and outcomes
1. Please describe the threats to your supply chains.
2. Supply related threats originating from suppliers.
3. Firm-level threats originating from the focal firms but affecting the upstream or downstream.
4. Customer-related threats originating from the downstream.
5. External threats originating from outside the supply chain.
6. What strategies do you apply to build resilience against each of the threats you mentioned?

7. Demand management strategies.
8. Supply management strategies.
9. Relationship management strategies.
10. Information management strategies, etc.
11. What are the outcomes of implementing each of the resilience strategies?

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