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Abstract

Purpose – This research investigates the implications of supply chain strategies that manufacturing companies can use to minimise or overcome natural resource scarcity, and ultimately improve resource efficiency and achieve competitive advantage. The relationship between resource efficiency and competitive advantage is also explored.

Design/methodology/approach – The proposed research model draws on resource dependence theory. Data were collected from 183 logistics, purchasing, sustainability and supply chain managers from various manufacturing companies and analysed by applying the PLS (Partial Least Squares) structural equation modelling technique.

Findings – The results indicate that both buffering and bridging strategies improve resource efficiency; however, only bridging strategies seem to lead to firm's competitive advantage in terms of ownership and accessibility to resources. The relationship between resource efficiency and competitive advantage is not supported.

Research limitations/implications – Future research could confirm the robustness of these findings by using a larger sample size and taking into account other supply chain members.

Practical implications – This research provides guidance to managers faced with the growing risk of resource scarcity to achieve a resource efficient supply chain and an advantage over competitors.

Originality/value – Studies have explored the appropriate strategies for minimising dependencies caused by the scarcity of natural resources in the field of supply chain management; however, there is limited empirical work on investigating the impact of these strategies on resource efficiency and competitive advantage.

Keywords Natural resource scarcity, Resource efficiency, Competitive advantage, Supply chain management

Paper type Research paper

1. Introduction

The scarcity of natural resources (e.g. water, oil, and metals) can have a serious impact on supply chains and particularly on manufacturing companies (Blunck and Werthmann, 2017). According to Cleveland and Stern (1998, p.1), scarcity refers to "the reduction in economic well-being that results from a decline in the quality, availability, or productivity of natural resources". For many years, the progress of technology mitigated the challenges posed by resource constraints (Neumayer, 2000); however, there are growing concerns that technology-based substitutes alone will not prevent a resource crisis (Neill, 2005) as natural resource scarcity stems from multiple dimensions including physical, geopolitical and economic ones (de Winter, 2014).

As natural resources become scarcer, companies need to develop a systematic approach to mitigate the associated risk of disruption and to design more resource efficient supply chains. In doing so, they need to identify the dependencies and the regulatory risks, so as to implement specific supply chain strategies that could result in achieving competitive advantage by accessing and using these resources (Brown, 2012). Supply chain strategies can be defined as a pattern of decisions related to product or service production and delivery for example, decisions related to the sourcing of products or conversion of raw materials (Narasimhan *et al.*, 2008). Supply chain decisions can be classified into three categories in terms of time horizon: strategic (long-term), tactical (medium-term), and operational (short-term and real-time). For this research, the term “supply chain strategies” refers to strategic (long-term) product decisions and strategies aiming to mitigate natural resource scarcity’s potential implications.

While there have been some efforts put forth in identifying the implications of resource scarcity on supply chain management and exploring the mitigation strategies that could be utilised (e.g. Bell *et al.*, 2013; Lapko *et al.*, 2016), these efforts come with shortcomings and gaps. For example, in the research by Bell *et al.* (2012; 2013); Matopoulos *et al.*, (2015); Kalaitzi *et al.*, (2018) the links among supply chain strategies, resource efficiency and competitive advantage lacked empirical validation. In general, research on the impact of supply chain strategies on organisational performance and particularly on resource efficiency and competitive advantage is scant. In light of this gap in the extant literature, this research makes a valuable contribution by providing empirical evidence from the manufacturing sector in the presence of natural resource scarcity. Specifically, the following research question guides this research:

RQ. What are the implications of natural resource scarcity on supply chain strategies, resource efficiency and competitive advantage?

This research provides several distinct contributions to the supply chain literature. First, it investigates the implications of different supply chain strategies applied on organisational performance in reaction to natural resource scarcity. This research is also extending supply chain management literature by providing new empirical insights on the role between resource efficiency and competitive advantage. Finally, this research builds on Kalaitzi *et al.'s* (2018) conceptualization of the strategies applied to change the resource scarcity level and develops and validates new constructs.

The remainder of this paper is structured in six sections. First, the literature review followed by the research model and the proposed hypotheses. Subsequently, the methodology including the survey instrument, sampling and measurement assessment are described, followed by the results which are critically discussed in relation to previous literature. Finally, the paper concludes with a summary of the theoretical, managerial implications and the limitations and suggestions for future research opportunities.

2. Literature review and theoretical underpinnings

In the following sub-sections, studies that have explored the issue of natural resource scarcity on manufacturing companies are discussed, then the main elements of Resource Dependence Theory (RDT) and studies that applied this theory in the field of supply chain management are reviewed.

2.1 Implications of natural resource scarcity on manufacturing supply chains

Although there is some earlier research looking at the issue of material scarcity in the manufacturing industry with a focus on rare earth elements (REEs) as scarce resources (Alonso *et al.*, 2008; Alonso *et al.*, 2010), there are very few papers that evaluate raw material supply risks and particularly the subsequent impacts of natural resource scarcity (Bell *et al.*, 2013; Kalaitzi *et al.*, 2018).

In addition, major supply chain research studies by Autry *et al.*, (2012); Bell *et al.*, (2012; 2013) on natural resource scarcity were purely conceptual. For example, Bell *et al.* (2012) developed a typology proposing several mitigation strategies such as utilisation, compilation, preservation and cultivation. Bell *et al.* (2013) based on the Resource Advantage (R-A) theory developed a framework that explores how closed-loop supply chain management in times of natural resource scarcity enables comparative advantage in resources for firms seeking market-based competitive advantage.

To date, only two empirical studies have been published on a related topic. The first one is by Lapko *et al.* (2016) who examined material criticality and how manufacturing companies mitigate supply disruptions; several strategies such as postponement, hedging, avoidance, and security were identified. The other one is by Kalaitzi *et al.* (2018) and by drawing on RDT, they identified factors that determine large organisation's dependence on scarce natural resources and identified supply chain strategies that can be used to overcome or minimise the implications of natural resource scarcity. Both studies however, neglected the impacts of these strategies on performance in times of natural resource scarcity.

2.2 RDT

In recent research, the importance of RDT has been stressed particularly in describing the inter-organisational arrangements applied from joint ventures, mergers and acquisitions in order firms to minimise or overcome resource dependencies and improve their organisational autonomy (Hillman *et al.*, 2009; Davis and Cobb, 2010).

RDT is used as the primary theoretical basis for this research because it supports the fact that companies are dependent on their external environment for scarce resources and the degree of dependence stems from the importance of the resource, supplier's substitutability and the discretion over the resource (Pfeffer and Salancik, 2003). RDT suggests that companies utilise buffering and/or bridging strategies to minimise resource dependence (Pfeffer and Salancik, 1978) and to access critical limited resources (Hollos *et al.*, 2011); thus minimizing supply chain disruptions.

Buffering strategies try to protect and minimise the impacts of any disturbance in the relationship with suppliers (Bode *et al.*, 2011). Companies utilizing this strategy establish safeguards by building up slack resources or by seeking alternative sources of supply (Bode *et al.*, 2011; Caniëls and Gelderman, 2005). Thus, buffering strategies entail the maintenance of inventories at proper levels, locations and product/process improvement strategies (Mishra *et al.*, 2016). Bridging strategies on the other hand 'manage uncertainty through boundary-spanning and boundary-shifting actions with an exchange partner' (Bode *et al.*, 2011, p. 834), such as a partnerships, joint ventures, mergers or acquisitions (Mishra *et al.*, 2016).

2.3 Application of RDT on supply chain management

Several authors have investigated the implications of RDT in supply chain management (e.g. see Table I), but some aspects of RDT have not been fully explored. More particularly, past studies (Bode *et al.*, 2011; Kalaitzi *et al.*, 2019) did not investigate how buffering and bridging impact performance or focused only on the implications of bridging strategies on organisational performance (Lai et *al.*, 2013). Drees and Heugens (2013) argued that the ultimate goal of these inter-organisational arrangements is to improve organisational performance in terms of generating profits or to increase market value. Thus, this research draws attention to establishing possible credible links between both buffering and bridging strategies and organisational performance in times of natural resource scarcity.

Previous literature also supports the need for research that shows how different strategies applied to minimise resource dependencies may interact and influence one another

(Hillman *et al.*, 2009; Lai et *al.*, 2013). As previously stated, buffering and bridging are independent decisions; a manufacturing company can simultaneously utilise both of these strategies or neither of the strategies. The way in which these two strategies interact with each other and influence one another has not yet been investigated. Thus, this research will explore how buffering and bridging strategies interact with one another and whether this interplay influences resource efficiency and competitive advantage.

Table I. Key Previous Research Related to RDT in supply chain management

Sources	**Research Objective**	**Theoretical perspectives used to support SCM**
Bode *et al.* (2011)	Recognise different responses to mitigate supply chain disruptions	Bridging or buffering responses from RDT are used
Chu and Wang (2012)	Explore the drivers of relationship quality and its impacts on performance in logistics outsourcing	RDT used to support the fact that a higher level of dependence leads to higher relationship quality
He *et al.* (2013)	Explore power among actors and the impact on knowledge acquisition	RDT used to support the idea that dependence in a firm will increase, if the other firm does not have access to alternative sources.
Touboulic *et al.* (2014)	Investigate sustainable supply chain relationships	RDT used to explore imbalanced in multi-tier supply chain relationships in the field of sustainable supply chain management
Selviaridis *et al.* (2016)	Investigate how reverse resource dependencies are managed in the service supply chain	RDT used to show how resource dependencies are managed
Kalaitzi *et al.* (2019)	Explore dependencies during the ramp-up of production volume	RDT is used to analyse and explain the changing dependencies

3. Research model and hypotheses development

In examining manufacturing companies' response to the environmental uncertainty that derives from natural resource scarcity, a RDT perspective is utilized and the buffering and bridging supply chain strategies outlined by Kalaitzi *et al.* (2018) are adopted. Both strategies have previously been examined in the context of scarce resources.

Buffering strategies act as safeguards outside the current buyer-supplier relationship by minimising the importance of the resource through ***product and process (re-) design*** (Su *et al.*, 2014; Tang, 2006a). The literature supports that the (re-) design of new product, and process should be done simultaneously with ***supply chain (re-) design*** such as large quantities of inventories and closed-loop supply chain (Bode *et al.*, 2011; Su *et al.*, 2014) as it improves the operating performance and it can be a source of competitive advantage (Bakås *et al.*, 2016; Ellram *et al.*, 2007). When companies do not explicitly acknowledge and manage supply chain (re-) design as a concurrent activity to product and process (re-) design, they face problems such as delayed product launches, and increased production costs (Ismail and Sharif, 2006).

In contrast, bridging strategies "involve developing relationships and formal connections with other organisations" (Jaffee, 2001, p.220) to acquire critical natural resources. Bridging strategies entail: ***transactional mechanisms*** (i.e. contracts that establish supply and price over an extended period), ***relational mechanisms*** (i.e. when different firms or interdependent entities work together to achieve common goals and interests) and ***hierarchy mechanism*** (i.e. when the company controls (through ownership) the suppliers that produce some of the inputs used for its products (e.g. a car manufacturer may own a metal company) (Jaffee, 2010, p.8).

From an RDT perspective, the implementation of buffering and bridging strategies improves resource efficiency. This includes the company's ability to make good use of resources in relation to the output (Delmas and Pekovic, 2013). Resource dependence also helps in achieving competitive advantage in the market by accessing, controlling and utilising scarce resources (Pfeffer and Salancik, 1978; Nienhüser, 2008). Table II provides the definition of buffering and bridging strategies, resource efficiency and competitive advantage adopted in this study.

Table II. Buffering and Bridging supply chain strategies, resource efficiency and competitive advantage

Supply chain strategies	Description
Buffering strategies	**Product and process (re-) design**: (re)design that reduces, avoids and substitutes scarce natural resources or recovering, reusing, remanufacturing, recycling these scarce resources (Singhal, 2012; Eltayeb and Zailani, 2009).
	Supply chain (re-) design: changes in facility location or/and keeping safety stock of scarce resources (Fine, 1998).
Bridging strategies	**Transactional mechanisms**: formal contracts that are based on transaction-specific assets. Both sides invest in an exchange relationship and are motivated to continue this relationship (Liu *et al.*, 2009).
	Relational mechanisms: contracts that are based on relational norms (shared norms and values) and trust. Companies trust each other, feel assured that the other firm will cooperate in good faith (Liu *et al.*, 2009).
	Hierarchy mechanism: the focal company controls (through ownership-vertical integration) the supplier (-s) that produce some of the inputs used for its products (e.g. a car manufacturer may own a metal company) (Guldbrandsen and Haugland, 2000)
Resource efficiency	**Resource efficiency**: economic efficiency (e.g. minimising costs) and environmental effectiveness (i.e. producing the desired quantity of products with the minimum amount of scarce natural resources and waste) (OECD, 2008).
Competitive advantage	**Competitive advantage:** securing the needed external natural resources at a lower price (Bell *et al.*, 2013).

Considering the tenets of RDT and the literature, a two-part research model is proposed. The first part of the model entails the buffering and bridging strategies that comprise five constructs namely product and process (re-) design, supply chain (re-) design, transactional mechanisms, relational mechanisms, and hierarchy mechanism. The second part shows the implications of these strategies on resource efficiency and competitive advantage. The model and the relationships among the constructs are shown in Figure 1. The literature supports buffering and bridging strategies as independent concepts although they may also complement each other. The relationship between buffering and bridging strategies is further explored as is the impacts on resource efficiency and competitive advantage (see Figure 2). The development of the hypotheses is presented below.

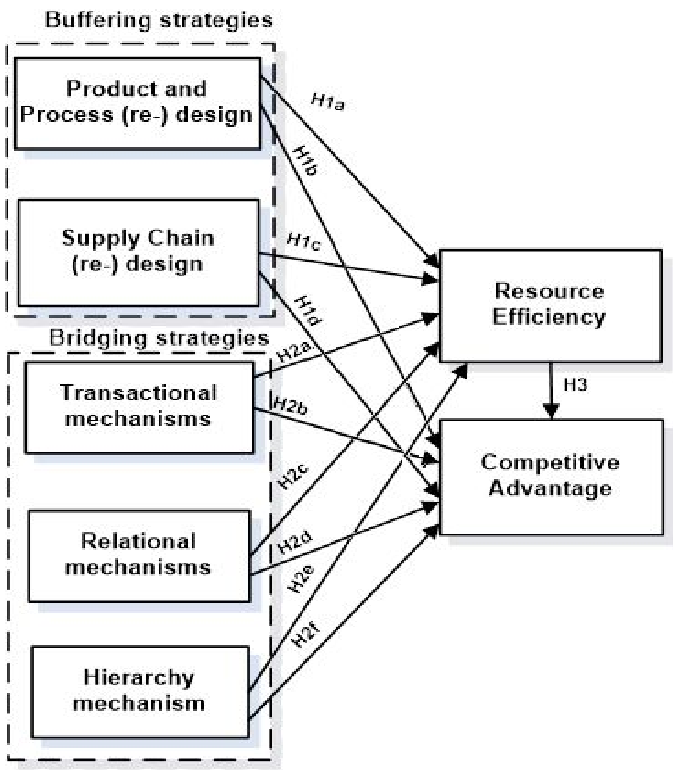

Figure 1. Research model and hypotheses

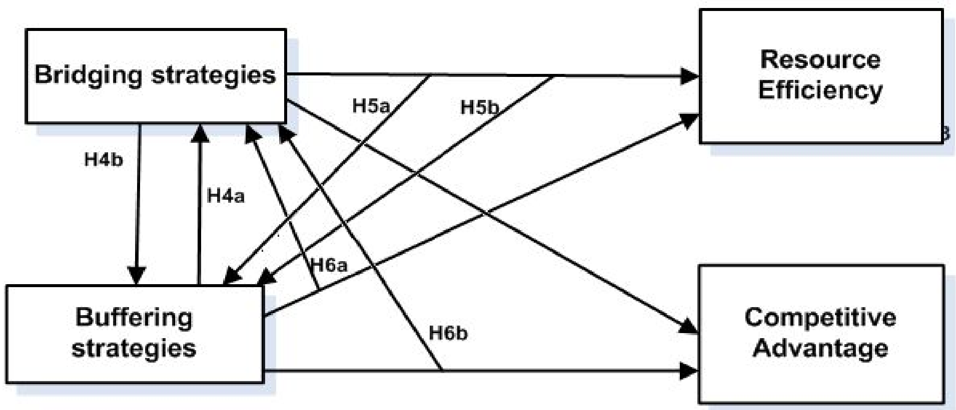

Figure 2. Research model and hypotheses that show the interplay between buffering and bridging strategies

3.1 Product and processes (re-) design, resource efficiency and competitive advantage

Buffering strategies entail the use of flexible production processes and product designs to mitigate resource dependencies (Bode *et al.*, 2011). Companies (re-) design their products in order to reduce natural resource usage (Delmas and Pekovic, 2013). Strategies that try to minimise the quantity of natural resources required in production have been recognised with the potential for significant cost savings (Kalaitzi *et al.*, 2015; Schleich, 2009). Previous studies have highlighted that companies are changing product design and/or substituting scarce resources (e.g. not easily accessible or high cost) to minimise the use of those resources and the overall cost (Alonso, 2010; Lapko *et al.*, 2016).

An example of this in practice is Ford, the car manufacturer, replacing its nickel-metal-hydride batteries with lithium-ion alternatives and cutting 500,000 pounds of rare earth elements from its manufacturing process annually (Currie, 2013). Apart from product (re) design, companies try also to minimise resources/waste during the production phase, so they reuse it, or they sell it to other companies (Tsoulfas and Pappis, 2006) and achieve lower manufacturing costs by eliminating that waste (Allen, 1992). In this regard, South Africa is facing a water crisis and Ford used reverse-osmosis processes to recycle water in Pretoria increasing water reuse by up to 15% (IChemE, 2014). By implementing these strategies, a cost reduction is achieved and fewer natural resources are wasted. Therefore, it is hypothesised when natural resources are scarce:

H1a. Product and process (re-) design positively affects resource efficiency.

New product and process development are key requirements for long run competitiveness. Incorporating environmental considerations into product and relevant manufacturing process design leads to an additional advantage i.e. reducing inefficiencies during the production process, recycling, or innovating which may also lead to cost or differentiation advantages (Siegel, 2009). Continued availability of natural resources has been taken for granted in the returns processes; however, these processes should be adapted in order to capture the future constraints posed by natural resource scarcity and enable the recapture of products from the marketplace (Bell *et al.*, 2013). By improving the processes of secondary material production and collection, companies can minimise cost, and also access these scarce natural resources or sell these recycled resources; thus, achieving competitive positions (Alonso, 2010; Bell *et al.*, 2013). An example of competitive advantage can be seen in Hewlett Packard (HP)'s cartridges which contain between 50% and 75% recycled content (Nichols, 2014). Product redesign enabled HP to access resources where other competitors were facing spiking prices, thus HP reduced the average price of its new product (around 42% and 40%) and gained market share (Terkar *et al.*, 2013). Therefore, it is hypothesised when natural resources are scarce:

H1b. Product and processes (re-) design positively affects competitive advantage.

3.2 Supply chain (re-) design, resource efficiency and competitive advantage

Apart from product and processes (re-) design, companies have to concurrently consider supply chain (re-) design decisions (e.g. facility location, safety stock) in order to achieve high organisational performance (Fine, 1998; Tsoulfas and Pappis, 2006). Companies establish closed-loop supply chains to minimise the extraction of natural resources in times of natural resource scarcity (Bell *et al.*, 2013). A closed-loop supply chain changes the supply chain configuration as companies make decisions regarding their collection/acquisition centres, inspection/sorting centres, disposal facilities etc. (Ene and Ozturk, 2014). Closed-loop supply chains enable improvements in eco-efficiency in the companies' operational systems by recycling materials, minimising waste, and reusing natural resources (Stock, 1998). For example, with the increasing energy price volatility and a carbon-constrained environment, Novelis, a producer of aluminium products, opened an aluminium recycling centre in 2014 located close to the company's rolling mill in Nachterstedt in Germany (WMW, 2014). Novelis achieved resource efficiency by processing up to 400,000 metric tons of aluminium scrap annually. Therefore, it is hypothesised when natural resources are scarce:

H1c. Supply chain (re-) design positively affects resource efficiency.

Natural resources play an important role in the decision of the location of manufacturing companies and particularly in the face of natural resource scarcity as natural resources can be globally scarce such as platinum or locally scarce such as water (Bell *et al.*, 2012). The depletion of natural resources has led many manufacturing companies to relocate to access new supplies of resources (Venkataraman and Pinto, 2017) and achieve a competitive advantage (Autry *et al.*, 2012). Moreover, competitors could face difficulties in accessing resources as closed-loop supply chains would help a firm to leverage its access to natural resources (Bell *et al.*, 2013). For example, by investing in a new aluminium recycling centre, Novelis enhanced both tangible (i.e. state-of-the-art technology for aluminium scrap sorting, de-coating, melting and casting) and intangible internal resources (i.e. technical skills, knowledge etc.) that other competitors may find difficult to replicate; thus, achieving a competitive advantage (WMW, 2014).

Stockpiling certain natural resources is also used by companies to ensure that the supply chain can continue to function smoothly against any supply disruption and particularly to overcome the issue of natural resource scarcity (Bell *et al.*, 2012; Tang, 2006b). This is particularly the case in manufacturing, where safety stocks are used to maintain continuous production helping companies to achieve a competitive advantage (Kutsch, 2018). For example, competition for water particularly in water-scarce areas increased among various stakeholders in the agriculture and manufacturing industries. (FAO, 2017). Companies in the brewing and beverage sector mitigate water scarcity risks by keeping water reserves in advance and minimising their resource usage (Larson *et al.*, 2012). For instance, Heineken, in its six plants in water-stressed areas of Mexico, minimise water consumption by harvesting rainwater (Heineken, 2015). Based on these arguments, when natural resources are scarce the following hypothesis can be derived:

H1d. Supply chain (re-) design positively affects competitive advantage.

3.3 Transactional mechanisms, resource efficiency and competitive advantage

Transactional mechanisms entail the use of contracts that pre-specify roles, rules, responsibilities and specific efficiency-oriented performance criteria i.e. decrease in costs, process lead times or defects and minimisation of waste (Clauss and Spieth, 2016; Mayer and Argyres, 2004; Li *et al.*, 2010a). Previous research has indicated that these mechanisms are used mainly for water and energy suppliers in times of natural resource scarcity (Kalaitzi *et al.*, 2015). There are regulations in place to protect the exploitation of these natural resources and; thereby manufacturing companies set certain requirements in contracts to improve the usage of resources through the supply chain (Sancha *et al.*, 2015) and request that suppliers follow particular standards (i.e. step by step process outlines and measurable process indicators (Mayer and Argyres, 2004). For example, a pharmaceutical company has formal contracts in place to provide an alternative water supply; and in these contracts; there are rules and standards that aim to minimise water consumption throughout the supply chain (Yatskovskaya *et al.*, 2018). The following hypothesis is presented:

H2a. Transactional mechanisms positively affect resource efficiency.

Several studies support the idea that relational mechanisms enable competitive advantages while transactional mechanisms are considered as mechanisms with limited strategic value

(Dyer and Singh, 1998). However, by implementing transactional mechanisms, companies are constantly trying to take advantage of lower prices or superior conditions offered by another supplier (Cottam, 2015). Transactional mechanisms enable manufacturing companies to achieve short term cost reductions and secure scarce resources at a lower purchasing price than competitors (Skjøtt-Larsen *et al.*, 2003; Stevens-Huffman, 2011). Transactional mechanisms enable companies (particularly SMEs) to identify new markets and support radical product innovations as problem solving activities and knowledge creation in such ties are exploratory (Cottam, 2015). Thus, in the presence of natural resource scarcity, the use of these mechanisms can block competitors from accessing the resources of a specific supplier and can result in short-term competitive advantages (Monczka *et al.*, 2016). Knowledge creation may occur frequently within these relationships due to the high frequency of such exchanges (Cottam, 2015). Based on these arguments when natural resources are scarce it is hypothesised that:

H2b. Transactional mechanisms positively affect competitive advantage.

3.4 Relational mechanisms, resource efficiency and competitive advantage

In times of natural resource scarcity, companies closely work with their suppliers in product design by substituting scarce resources such as REEs that contain high cost material or in the recycling process to address natural resource scarcity (Kalaitzi *et al.*, 2018; Lapko *et al.*, 2016). By following these strategies, resource focused collaboration and supplier involvement may give the opportunity for firms to achieve resource utilisation, cost savings, involvement in innovation and create win-win outcomes (Birou and Fawcett 1994; Deloitte, 2012; Mishra and Shah, 2009; Bell *et al.*, 2013).

Jaguar Land Rover (JLR) and Novelis Inc., a global leader in aluminium rolled products, established a partnership to minimise the use of aluminium mitigating risks related to aluminium's fluctuating prices and rising production costs. As a result of this partnership, during 2015/16, 50,000 tonnes of aluminium scrap were reclaimed equalling the weight of nearly 200,000 Jaguar XE body shells, which got back into JLR's production process (Novelis, 2016). Thus, relational mechanisms enable manufacturing companies to "achieve resource efficiency by exchanging technical information and mutual willingness" (Vachon and Klassen, 2008, p.303). Therefore, when natural resources are scarce we hypothesise that:

H2c. Relational mechanisms positively affect resource efficiency.

Relational mechanisms build on close collaboration between companies and are one of the strategies firms use to minimise resource dependences and achieve a competitive advantage (León-Bravo *et al.*, 2017). In managing closed-loop supply chains, Bell *et al.* (2013) supported that manufacturing companies should build strong relationships with their suppliers to recapture scarce natural resources from the marketplace and develop relational competences. Companies can access valuable resources from other organisations through strategic alliances and joint ventures (Das and Teng, 2000).

Dow Chemical Company (a leader in speciality chemicals) established a joint venture with Saudi Aramco (an energy supplier) and gained a competitive advantage due to availability of vast crude oil and natural gas resources; subsequently, it achieved lower production costs (Financial Times, 2011). Also, a competitive advantage can be achieved when companies identify resource scarcity threats and improve closed-loop supply chains with the support of suppliers (Bell *et al.*, 2012). These collaborative relationships provide buyers access to scarce resources that cannot be developed internally and would not be able to be acquired by utilising transactional mechanisms (Chicksand, 2015). For example, MillerCoors a brewing company in the United States minimised water usage by 2.500m3 a year, by collaborating with US barley farmers and the Nature Conservancy (MillerCoors, 2016). We therefore hypothesise that when natural resources are scarce:

H2d. Relational mechanisms positively affect competitive advantage

3.5 Hierarchy mechanism, resource efficiency and competitive advantage

Centralised decision-making companies tend to invest in resource efficiency because hierarchy mechanism (e.g. vertical integration) could offer the coordination needed to overcome any barrier to energy efficiency processes facilitating the minimisation of costs, and energy usage (Delmas and Pecovic, 2013; Sorrell *et al.*, 2004). Manufacturing companies are considering similar mechanisms to facilitate the exchange of needed information to apply resource efficiency strategies which is difficult to obtain outside vertical integration (Delmas and Pecovic, 2013). Companies, particularly in the aluminium industry, are considering vertical integration with suppliers to control their raw material supply and prices for primary and secondary production.

For example, Novelis, an industrial aluminium company acquired Aleris (a supplier of rolled aluminium products) to integrate assets in Asia in order to achieve resource efficiency and avoid cyclicality and volatilities of the London Metal Exchange (Novelis, 2018). Regarding secondary production, Slicker Recycling Limited, a British waste management company, acquired AVISTA Oil Services (a UK oil collection business) to bring additional infrastructure, expertise and resources to manage the waste of oil (Slicker Recycling, 2018). Thus, a hierarchy mechanism enables control efficiency gains and cost reductions (Guan and Rehme, 2011). Therefore, when natural resources are scarce it is hypothesised that:

H2e. Hierarchy mechanism positively affects resource efficiency

The environment of scarce resources is generally characterised by severe competition (Bell *et al.*, 2013). Companies are considering integration with their suppliers to access and control strategic resources and mitigate the risks related with the upstream supply chain

(Zsidisin and Smith, 2005). The main reason that companies implement the hierarchy mechanism is to access rare, difficult to imitate and costly resources and achieve competitive advantage by introducing entry barriers for competitors and, by subsequently generating excess profits (Barney, 2002; Gian and Rehme, 2011). Moreover, by implementing this mechanism, companies are investing in highly specialised assets and reduce transaction costs by increasing the control over input through supply chain integration (Monsur and Yoshi, 2013). For example, Alcoa, an aluminium producer, acquired a titanium supplier that helped the company gain a competitive advantage by accessing low cost resources, offering a near-complete process portfolio from aluminium to titanium and becoming one of the largest aerospace suppliers (Alcoa, 2015). Companies can gain advantage over rivals by accessing and using scarce resources and preventing competitors from accessing these valuable resources (Bell *et al.*, 2013). Therefore, when natural resources are scarce the following hypothesis is proposed:

H2f. Hierarchy mechanism positively affects competitive advantage.

3.6 Resource efficiency and competitive advantage

Matopoulos *et al.* (2015) supported the need for finding the links between resource efficiency and competitive advantage for scarce resources. A competitive advantage can be achieved through resource efficiency as companies have greater perceived benefits for the same cost (differentiation) or same perceived benefits for a lower cost (Brahma and Chakraborty, 2011). Companies with lower manufacturing costs have been shown to exhibit better performance than their competitors (Morgan *et al.*, 2004). Reactive players will face a competitive disadvantage that stems from increased costs, higher intensity and emissions (Herrmann, 2011). A competitive advantage is the unique position of an organisation against rivals due to the efficient usage of natural resources (Shahmansouri *et al.*, 2013). Companies not only need to have access to resources, but need to use them efficiently in order to obtain a competitive advantage. Hence, when natural resources are scarce, the following hypothesis is posited:

H3. Resource efficiency positively affects competitive advantage.

3.7 The interplay between buffering and bridging strategies

The hypotheses above test the direct implications of buffering and bridging strategies on resource efficiency and competitive advantage. The direct and indirect effects of buffering strategies to bridging strategies and vice versa should be also explored. The literature indicates that buffering is an uncooperative approach and companies utilise buffering strategies to achieve more autonomy whereas bridging is a cooperative approach that builds relationships with the suppliers (Bode et *al.*, 2014). Bridging may make buffering redundant and vice versa (Arnoldi et *al.*, 2012) but these two strategies are not mutually exclusive (Fennell and Alexander, 1987). Companies can emphasize one strategy over the other and other companies may try to apply both strategies (Hillman *et al.*, 2009).

Also, there are situations where the initiation of one strategy can trigger the need for practicing the other strategy. A recent study that explored the dependencies during ramp up production found that companies utilising buffering strategies (i.e. the design and product specifications) that leads to bridging strategies (i.e. early involvement of suppliers to product design process) aiming to minimise resource dependencies, cost and to enable the scale up of production (Kalaitzi *et al.*, 2019). In the face of natural resource scarcity companies follow buffering strategies (i.e. re-design their products or initiate a closed-loop supply chains) which leads to bridging strategies i.e. collaboration with their suppliers (Lapko *et al.*, 2016). The reason behind this relationship is that companies may face difficulty to achieve an innovation based only on their own resources and capabilities or cannot obtain resources efficiently in the market (Fossas-Olalla *et al.*, 2015).

H4a. Buffering strategies positively affect bridging strategies.

Several studies (e.g. Moreira, 2005; Jajja *et al.*, 2017) identified that effective integration of suppliers in product development entail several benefits such as cost reduction at product development, minimisation of failure risk and time taken in product development that can lead to a competitive advantage. When natural resources are scarce, the adoption of buffering strategies (e.g. in the re-design of the product buffering strategies) triggers the implementation of bridging strategies namely collaboration with suppliers to minimise the usage of natural resources in the final product (Kalaitzi *et al.*, 2018). It also results in achieving competitive advantage by securing access to raw material and blocking competitor entry (Roscoe and Cousins, 2015). Hence, the following hypotheses are posited:

H5a. Bridging strategies mediate the relationship between buffering strategies and resource efficiency.

H5b. Bridging strategies mediate the relationship between buffering strategies and competitive advantage.

In recent years many manufacturers are adopting green sourcing strategies that include recycled materials, which has led many suppliers to pursue internal eco-design initiatives (Zhu *et al.*, 2013) and to increase the use of recycled materials (e.g. González-Benito and González-Benito, 2006). When natural resources are scarce suppliers will initiate specific investments e.g. recycling of aluminium (Kalaitzi *et al.*, 2018) only if they have a long-term relationship with this buyer (Caniëls *et al.*, 2010). Hence, when natural resources are scarce, the following set of hypotheses are posited:

H4b. Bridging strategies positively affect buffering strategies.

Bridging strategies such as collaboration enable effective information sharing which leads to an efficient process and supply design i.e. minimisation of production costs and the waste of raw materials (Qrunfleh and Tarafdar, 2013). When natural resources are scarce, manufacturing companies collaborate with their suppliers to better utilise inputs by using buffering strategies such as recycling that lead to efficient use of resources and achieve differentiating competitive advantages through product and process innovation (Kim, 2017; Lapko *et al.*, 2016).

H6a. Buffering strategies mediate the relationship between bridging strategies and resource efficiency.
H6b. Buffering strategies mediate the relationship between bridging strategies and competitive advantage.

4. Research Methodology

4.1 Measures and survey development

The item generation of constructs was based on the literature review and theoretical foundation (Cao and Zhang, 2011; Churchill, 1979). The constructs were modelled as reflective latent variables. A list of the reflective items used to measure each construct in this study is provided in Appendix 1. Each item was measured using a five-point Likert scale. To validate the items, a pre-testing of the questionnaire with experts (4 academics and 2 industry contacts) was conducted. The experts suggested minor changes for all constructs.

Based on these constructs and their items, an online questionnaire with three parts was developed. In the first part, respondents were asked to consider a specific natural resource (e.g. water, energy, rare earth metal, metal, mineral or other) that was highly relevant to their company (i.e. a ‘‘critical’’ scarce natural resource used in their production). In the second part, the questionnaire included questions about the supply chain strategies employed by the company. The third part was related to the implications of those strategies on organisational performance.

4.2 Sampling

Purposive sampling was used to identify and select eligible respondents since it enabled the selection of cases that have the required information to answer the research questions and accomplish the research objectives (Maspaitella *et al.*, 2017). Considering the focus on natural resource scarcity, the purposive sampling in this study meant that participants had to satisfy the following criteria: being employed in product-based manufacturing firms worldwide that are mainly materials intensive and thus they are more likely to face natural resource scarcity risks than service firms (Brouthers *et al.*, 2002). In addition, target respondents were employed in purchasing, logistics, product design or even being responsible for managing resources and work in any sector aiming to increase observed variance and generalisability of findings (Silva *et al.*, 2015). In this way, respondents were targeted based on their knowledge and ability to provide insights on the issue of scarcity of natural resources. This type of sampling enables a moderate level of external validity and generalisation of results (Cook and Campbell, 1979). In line with Krause *et al.* (2018), the use of single key informants was deemed appropriate for this research, enabling the researchers to sufficiently interpret the phenomenon under investigation.

Four primary sources were used to find the appropriate respondents. The first one was LinkedIn where personal messages were sent to managers after considering their experience based on their published professional profile. A search was also conducted for relevant groups on LinkedIn; access was gained to several groups namely Manufacturing UK, Electronics Manufacturing, Food & Beverage Supply Chain Professionals, Sustainability professionals, Food & Drink Manufacturing UK and Purchasing & Materials Management and Beer Industry Members. Subsequently, a discussion started that included the link in a few groups. The second source of potential participants was two email lists which were acquired through Qualtrics and SmartSurvey. The third source was email lists that were purchased from Electric marketing and Unison Data Solutions. Reminders were sent excluding those who had already responded. To ensure a reasonable response rate, a message was sent to non-responding managers, three weeks after the first message. The Chartered Institute of Purchasing and Supply (CIPS) newsletter also had a link with the survey.

In total, 6,015 managers were contacted and after removing 3 invalid responses (for example, when human resources were identified as scarce because this is not the focus of this study), a total of 183 questionnaires were used, resulting in a response rate of 6.2 percent. Studies suggest that low response rates are typical in industrial research (Inman *et al.*, 2011). In this research, the targeted group was mainly high-level managers that know about the strategic topic of natural resource scarcity and the strategies that companies follow. High response rates are rare when the target respondent groups are top managers as they do not usually have time for answering the questionnaires (Abareshi *et al.*, 2008; Inman *et al.*, 2011). Mid-level managers were also targeted in most cases; these respondents probably perceived the topic as not relevant to their position and may have felt that they were not the appropriate person to answer it. Another reason for the low response rate is the method of data collection; questionnaires were sent by email, which in most cases tend to be ignored by receivers (junk mail) (Wu, 2009). Apart from time pressures and receiving many surveys through email, other studies added that company policy does not allow managers to respond to voluntary surveys (Baruch and Holtom, 2008). The respondents were from a broad spectrum of manufacturing companies (see Table III) and the sample composition has the largest representation in food and kindred products (23%), chemical and allied products (13%).

Table III. Respondents by Industry

Industry	Frequency	Percent
Food and kindred products	42	23%
Chemicals and allied products	24	13%
Electronic and other electric equipment	22	12%
Transportation Equipment	21	12%
Primary metal industries	20	11%
Industrial machinery and equipment	16	9%

Other	15	8%
Fabricated metal products	10	5%
Petroleum and coal products	6	3%
Rubber and miscellaneous plastic products	5	3%
Textile mill products	2	1%
Total	183	100%

Most respondents were managers (19%) followed by supply chain managers (15%) and sustainability as well as purchasing managers (10%) (see Table IV).

Table V shows that most companies were large and medium sized companies. Organisation size has been measured based on one of the most common measures, the number of employees (as per Gambi *et al.*, 2015; Ulusoy and İkiz, 2001). Approximately one third (33%) of the companies were medium-sized companies, 21% of companies were small-sized and 46% of companies were large-sized companies (more than or equal to 500 employees). Energy (32%) and water (27%) were identified as the two most scarce resources by the interviewees (see Figure 3).

Table IV. Respondents by job title

Industry	Frequency	Percent
Manager	34	19%
Supply Chain Manager	27	15%
Purchasing Manager	18	10%
Sustainability Manager	17	9%
Supply Chain Director	11	6%
Head of Procurement	10	5.5%
Director	10	5.5%
Senior Purchasing Manager	9	5%
VP of Procurement	7	4%
Purchasing Director	6	3%
Procurement Manager	6	3%
Operations Manager	6	3%
Logistics manager	6	3%
Senior Buyer	5	3%
Analyst	4	2%
Commodity Manager	3	2%
Category Manager	2	1%
Sales Representative	2	1%
Total	183	100%

Table V. Number of Employees

Percent	Number of Employees	Number of responses
Small (21%)	Less than 25 25– 99	22 16
Medium (33%)	100 – 499	63
Large (46%)	500 – 999 1,000 – 4,999 5,000–9,999 10,000 and more	31 12 16 23

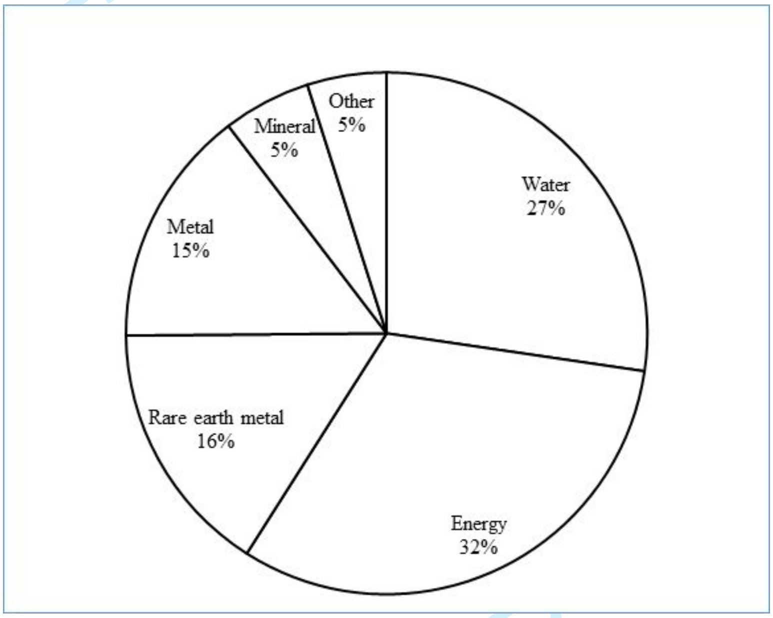

Figure 3. Natural resources indicated as scarce companies' resources by survey participants

4.3 Non-response bias and common method bias

Two types of bias were analysed namely non-response bias and common method bias to test the validity of the questionnaire. Regarding non-response bias, Armstrong and Overton (1977) supported that the late return responses of surveys are similar to the opinion of non-respondents. The results of an independent t-test show no significant difference, which implies that non-response bias is not a major concern for this study.

Regarding common method variance, Harmans single factor (one-factor) test was conducted (Podsakoff *et al.* 2003). Following this approach, exploratory factor analysis (EFA) was performed. Seven factors emerged with eigenvalues greater than 1 that accounted for 70.7 percent of the total variance (the first factor in EFA results accounted only for 32.5% of the total variance). These results suggest that common method variance is unlikely to exist in this study.

4.4 Data analysis method

The Partial Least Squares (PLS) technique and the software package SmartPLS version 3.0 (Ringle *et al.*, 2015) were applied to test the proposed convergent and discriminant validity of the proposed model and the hypotheses. The arguments against the use of PLS include the fact that it is not considered a factor-based variable method, it does not entail goodness-of-fit measures and it develops biased parameter estimates (Rönkkö *et al.*, 2016). However, other research (Henseler *et al.*, 2014) argues that PLS should be used as an important statistical tool and these arguments ignore the PLS technique fundamentals i.e. the philosophy of this technique is different from factor-based methods and it is a prediction-oriented approach (Rigdon *et al.*, 2017). PLS was chosen as the most appropriate technique and it has been applied in many studies in the field of supply chain management (Zhu *et al.*, 2018; Gualandris *et al.*, 2018).

PLS can accommodate small sample sizes (Hair *et al.*, 2014). A minimum sample size of 200 is suggested for SEM whereas the minimum sample size for PLS is 30 data sets (Hair *et al.*, 2014). This feature is crucial to the present research as there are 183 respondents for the model testing. Increasing the sample of respondents further was not possible due to time constraints and the difficulty of reaching a greater percent of the total population. PLS is also preferred when the emphasis is on prediction and theory development particularly for examining exploratory research models as in the present study (Henseler *et al.*, 2009).

5. Data analysis and results

This model includes seven first order factors namely product and process (re-) design, supply chain (re-) design, transactional mechanisms, relational mechanisms, hierarchy mechanism, resource efficiency and competitive advantage. The measurement model results such as composite reliability and convergent validity were measured and are presented in the sub-sections below.

5.1 Construct and indicator reliability

The items loaded (see Appendix 1) more than the recommended thresholds (i.e. 0.70 and 0.5) (Hair *et al.* 2014; Tenenhaus *et al.* 2005). The data also indicated that the measures are robust (see Table VI) in terms of their internal consistency reliability as indexed by the composite reliability (CR) and the value of Cronbach's α; the values of these indicators are more than 0.7 exhibiting acceptable construct reliability. Results revealed that the Average Variance (AVE) for all constructs exceeded the minimum threshold value of 0.5, thus the convergent validity is also adequate. Discriminant validity was evaluated by using the Fornell-Larcker criterion (see Table VII) and it was found that each construct is strongly correlated with their own items; thus, the overall model fulfilled the requirements for adequate discriminant validity (Barclay *et al.*, 1995).

Table VI . Measurement model results

Constructs	**AVE**	**CR**	**Cronbach's α**
PP_design	0.666	0.908	0.874
SC_design	0.528	0.815	0.715
Transactional	0.609	0.886	0.847
Relational	0.728	0.930	0.906
Hierarchy	0.867	0.970	0.962
REF	0.518	0.842	0.771
CAD	0.906	0.873	0.870

Table VII . Correlation between the latent variables

Construct	PP_design	SC_ design	Transactional	Relational	Hierarchy	REF	CAD
PP_design	0.816						
SC_ design	0.483	0.726					
Transactional	0.619	0.387	0.781				
Relational	0.379	0.266	0.302	0.853			
Hierarchy	0.271	0.263	0.187	0.294	0.931		
REF	0.459	0.479	0.369	0.412	0.294	0.720	
CAD	0.460	0.395	0.415	0.522	0.463	0.451	0.812

Moreover, the value of SRMR is 0.082 a value of less than 0.201, the d_{ULS} value is 4.210 which is less than 13.127, and d_G value is 1.259 which is less than 6.602 indicating that the proposed model represents a good fit (Benitez *et al.*, 2018). Multicollinearity of the measures was also checked; Variance Inflation Factor (VIF) (see Table VIII) is less than the suggested threshold of 10 (e.g. Hair *et al.*, 2011; Tamayo-Torres *et al.*, 2018), and within the more stringent cut-off point of 3 (Petter *et al.*, 2007), thus there is no issue of multicollinearity problem across the indicators. The effect size is considered small for H1a, H1b, H1c, H1d, H2c, H2e ($f2 \geq 0.02$), as medium-sized ($f2 \geq 0.15$) for H2a, H2f, H3 and as large ($f2 \geq 0.35$) for H2b, H2d (Cohen, 1988).

Table VIII . Effect size analysis and multi-collinearity

Hypotheses	**VIF**	**f^2**
PP_design→ REF	1.951	0.023
PP_ design → CAD	1.995	0.074
SC_ design→ REF	1.460	0.084
SC_ design→ CAD	1.583	0.025
Transactional→ REF	1.664	0.272
Transactional→ CAD	1.671	0.362
Relational → REF	1.241	0.061
Relational→ CAD	1.317	0.391
Hierarchy→ REF	1.182	0.095
Hierarchy→ CAD	1.192	0.168
REF → CAD	1.549	0.165

5.2 Structural model evaluation and hypotheses testing

All hypothesised relationships for the structural model are provided in Figure 4. The structural equation model is evaluated based on the variance explanation (R^2) of the endogenous (dependent) constructs and the goodness-of-fit (GoF) (Chin, 1998). The values of R^2 for the REF and CAD are 0.360 and 0.466 respectively which shows that the endogenous constructs (PP_design, SC_ design, Transactional, Relational, and Hierarchy) explain 36% and 47% of the REF and CAD variance. The R^2 values exceed the recommended minimum value of 0.1, thus the model has an adequate predictive power. Additionally, the goodness of fit (GoF) of 0.53 was calculated for the complete (main effects) model indicating that it has substantial explanatory power.

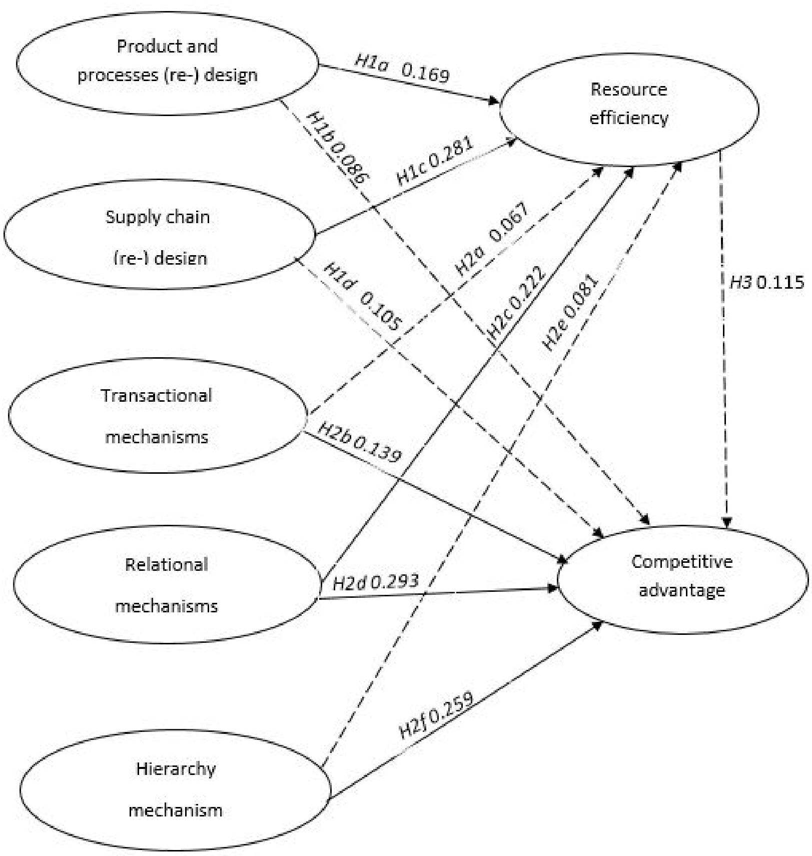

Figure 4. Results of the structural model with path coefficients (—— : accepted hypothesis - - - - : rejected hypothesis).

The significance of all paths of the structural model was also tested. Standardised path coefficients were used to analyse the degree of support for the research hypotheses with values greater than 0.1. Bootstrapping was used to generate standard errors and t-statistics; thus, it was used to assess the statistical significance of the path coefficients. The bootstrapping confidence intervals of standardised regression coefficients were used to accept or reject the hypotheses. Since the hypotheses are one-directional, one tailed t-tests were used to identify the significance level. Table IX illustrates the path coefficients, T-statistics, and significance (p-value).

Table IX. Results of hypothesis testing

Hypotheses	Path	Path Coefficient	T-statistics	P-value	Decision (effect)
H1a	PP_design→ REF	0.169	1.751	0.081***	**Accepted**
H1b	PP_ design → CAD	0.086	1.041	0.298	Rejected
H1c	SC_ design→ REF	0.281	3.515	0.000**	**Accepted**
H1d	SC_ design→ CAD	0.105	1.223	0.222	Rejected
H2a	Transactional→ REF	0.067	0.681	0.496	Rejected
H2b	Transactional→ CAD	0.139	1.740	0.082***	**Accepted**
H2c	Relational → REF	0.224	2.983	0.003*	**Accepted**
H2d	Relational→ CAD	0.296	4.539	0.000**	**Accepted**
H2e	Hierarchy→ REF	0.081	1.099	0.272	Rejected
H2f	Hierarchy→ CAD	0.259	4.073	0.000**	**Accepted**
H3	REF → CAD	0.115	1.362	0.174	Rejected

*p <0.01, ** p < 0.001, ***p < 0.1

Besides the examination of direct effects, the size of organisations was considered as a moderator in these relationships to understand these complex relationships (Henseler and Fassott, 2010). It is found that a powerful buyer (large companies) enforces and monitors sustainability requirements (i.e. minimisation of waste and CO_2 emissions) over its smaller suppliers (Touboulic *et al.*, 2014). The path coefficients show the direction and strength of the relationship (Chin, 1998) which should be greater than 0.1 (Sellin and Keeves, 1994). The model is further analysed in order to compare the role of the company's size namely small, medium and large (see Table X). Multi-group partial least squares analysis was then run to compare the differences among large, medium sized and small companies. From this analysis there were no statistically significant differences among these groups. In section 6, the findings of the path analysis are discussed and the justification for the rejected hypotheses is also provided.

Table X. Results of hypothesis testing based on the size of the companies

Hypotheses	Small companies			Medium companies			Large companies		
	T-statistics	P-value	Decision (effect)	T-statistics	P-value	Decision (effect)	T-statistics	P-value	Decision (effect)
H1a	0.987	0.324	Rejected	0.282	0.778	Rejected	1.821	0.069***	**Accepted**
H1b	0.671	0.503	Rejected	1.074	0.283	Rejected	0.621	0.535	Rejected
H1c	0.080	0.936	Rejected	2.297	0.022****	**Accepted**	4.479	0.000**	**Accepted**
H1d	1.307	0.192	Rejected	0.787	0.432	Rejected	0.340	0.734	Rejected
H2a	0.821	0.412	Rejected	0.812	0.417	Rejected	1.220	0.233	Rejected
H2b	1.468	0.143	Rejected	0.478	0.633	Rejected	1.941	0.053***	**Accepted**
H2c	0.607	0.544	Rejected	2.426	0.016 ****	**Accepted**	1.706	0.089***	**Accepted**
H2d	0.087	0.931	Rejected	1.834	0.067***	**Accepted**	3.692	0.000**	**Accepted**
H2e	0.473	0.636	Rejected	2.252	0.025****	**Accepted**	1.916	0.056***	**Accepted**
H2f	1.662	0.097***	**Accepted**	4.141	0.000**	**Accepted**	1.919	0.056***	**Accepted**
H3	0.468	0.640	Rejected	1.700	0.090***	**Accepted**	2.551	0.011****	**Accepted**

*p <0.01, ** p < 0.001, ***p < 0.1, **** p < 0.05

5.3 Summary of Results

The results show that product and process (re-) design and supply chain (re-) design strategies used to overcome or minimise the risk of natural resource scarcity do not lead to competitive advantage. The reason is likely that there is a high innovation cost and the non-compatibility of strategies applied (Doran and Ryan, 2012). Also, supply chain (re-) design initiatives (e.g. plant relocations) carry cost that may lead to a competitive disadvantage particularly for SMEs (Johansson and Olhager, 2018).

The results provide sufficient evidence that transactional mechanisms have a positive impact on competitive advantage (H2b), but these mechanisms do not have an impact on resource efficiency (H2a). The emphasis on these relationships is on short-term payback periods in terms of efficiency; thus, companies are not willing to adopt strategies that do not have a direct and immediate impact on their results (Dahlmann *et al.*, 2008). The respondents have identified water (27%) and energy (32%) as scarce natural resources used in their companies; these are considered resources with low purchase importance and with a low supply market complexity. For such resources companies employ mainly transactional mechanisms are they are reluctant to investing in R&D e.g. to develop more resource efficient products and processes (APSRG, 2016; Kalaitzi *et al.*, 2018).

Moreover, some companies do not have well-developed supply chain strategies to achieve resource efficiency through all of their different units (Delmas and Pekovic, 2013). The relationship between hierarchy mechanism and resource efficiency was negative (H2e). It appears that the choice to vertically integrate upstream, in the face of natural resource scarcity, is due to reasons other than that of increasing efficiency e.g. advantage of having a steady supply of raw material at a competitive price.

There is also no relationship between resource efficiency and competitive advantage. Previous studies in the field of green supply chain management found that, in some cases, companies can gain competitive advantages through resource efficiency (Dalhammar *et al.*, 2014). This research focused on natural resource scarcity; thus, the explanation could be based on the value of the particular natural resource. Resources such as aluminium and steel do not decrease in quality and can be recycled and used endlessly by offering a competitive advantage (i.e. differentiation from rivals and leveraged access to resource) whereas other resources (such as water) suffer from quality loss and relevant low cost and even if they are recycled, they will not offer an advantage over competitors. Moreover, some companies do not have the infrastructure and expertise to collect used products so they remanufacture and lose the competitive advantage of accessing recycled resources (Ferguson, 2010).

5.4 Buffering and Bridging interaction: A post-hoc testing

Buffering and bridging strategies are second-order constructs and consist of the following first order constructs: product and process (re-) design, supply chain (re-) design, transactional mechanisms, relational mechanisms, and hierarchy mechanism). The two stage approach was considered appropriate. The latent variable scores for lower order constructs are computed in the first stage to obtain the estimates for the lower order construct variables and then being used as indicators for higher order construct in the second stage. As the buffering and bridging strategies are formative second order constructs, the formative measures assessment guidelines recommended by Petter *et al.* (2007) were followed to evaluate construct validity and reliability. Regarding buffering strategies, the PLS analysis shows that the first-order constructs have significant weights namely 0.720 and 0.421. The first order constructs for bridging strategies have the following weights 0.391, 0.470 and 0.543 providing evidence for construct validity (Diamantopoulos and Winklhofer, 2001). Multicollinearity was assessed by computing the latent variable scores for each first-order. The VIFs for the first order constructs product and process (re-) design, supply chain (re-) design, transactional mechanisms, relational mechanisms, and hierarchy mechanism are 1.633, 1.407, 1.104, 1.173 and 1.105 respectively. These values do not exceed 3.3 which suggest that the formative measure is reliable (Diamantopoulos and Siguaw, 2006).

Hypothesis testing was carried out assessing the direction, strength and level of significance of the path coefficients for the two models (see Table XI and Table XIII). The results suggest that buffering strategies are positively related to bridging strategy and vice versa with a path coefficient of 0.595 and 0.549, thus supporting H4a and H4b. To further examine the mediating effect of buffering and bridging strategies, the significance of the indirect effects was estimated. Table XII and Table XIV show that the corresponding indirect effects are significant. Thus, mediation is present and therefore, H5a, H5b, H6a and H6b are supported.

Table XI. Results of hypothesis testing (buffering to bridging)

Hypotheses	Path	Path Coefficient	T-statistics	P-value	Decision (effect)
H4a	BUFFER → BRIDGE	0.595	9.128	0.000*	**Accepted**
H4b	BRIDGE→ BUFFER	0.549	2.738	0.006**	**Accepted**

* p < 0.001, ** p < 0.1

Table XII. Specific indirect effects

Hypotheses	Path	Path Coefficient	T-statistics	P-value	Decision (effect)
H5a	BUFFER →BRIDGE→ REF	0.296	4.853	0.000*	**Accepted**
H5b	BUFFER →BRIDGE →CAD	0.335	5.620	0.000*	**Accepted**

* p < 0.001

Table XIII. Specific indirect effects

Hypotheses	Path	Path Coefficient	T-statistics	P-value	Decision (effect)

H6a	BRIDGE→ BUFFER→REF	0.319	5.767	0.000*	**Accepted**
H6b	BRIDGE→ BUFFER→ CAD	0.221	3.604	0.000*	**Accepted**

* $p < 0.001$

6. Discussion

This research set out to fill some existing gaps in the literature and provide empirical validations of the links among supply chain strategies, resource efficiency and competitive advantage. Previous studies e.g. Bell *et al.* (2012), Kalaitzi *et al.* (2018) have mainly investigated the antecedents and relevant strategies to minimise the risk of natural resource scarcity. The present research contributes to the literature by providing empirical evidence into the implications of those strategies (buffering strategies and bridging strategies) on organisational performance, namely resource efficiency and competitive advantage. Specifically, buffering strategies were found to have a positive impact on resource efficiency but these strategies do not lead to competitive advantage. However, Bell *et al.* (2013) supported that closed-loop supply chains will be utilised when natural resources are scarce leading to a competitive advantage; nevertheless, this argument was not empirically tested.

This research examined bridging strategies along with buffering strategies and an original contribution is that only relational mechanisms were found to have a positive impact on both resource efficiency and competitive advantage in times of natural resource scarcity. Regarding relational mechanisms, this is line with previous studies (He *et al.*, 2013; Tarafdar and Qrunfleh, 2017) found that through relational mechanisms knowledge sharing (i.e. supplier co-design, develop better knowledge of raw materials for their production and co-location) is enabled that enhances supply chain performance i.e. reduction of development costs and accessibility to the technological knowledge of suppliers (Kalaitzi et *al.*, 2019). This research also supports that transactional mechanisms can achieve price reductions and enable companies to access scarce resources despite the fact that they are not able to develop resource efficient supply chains; this finding contradicts results from previous studies (see Kalaitzi *et al.*, 2018). This is also supported by Selviaridis *et al.* (2016) who found that contracting improves performance in the context of logistics service supply chains; however, direct relationships among those variables have been not tested.

Previous research (Kalaitzi *et al.*, 2018) also showed that vertically integrated companies adopt resource efficient practices and achieve resource efficiency. Drees and Heugens (2013) also found that bridging strategies such as interlocks, alliances, joint ventures, and mergers and acquisitions can improve organisational performance. In this research, however, the relationship between hierarchy mechanism and resource efficiency was found to be negative (H2e). Prior research by Van Leeuwen (2007) found that companies on recovered-resource dependencies in the paper and board, aluminium, and plastic industries use vertical integration by acquiring firms that own the recovered resources they need, or firms that control the access to recovered resources; however, they have not statistically tested the relationship. Surprisingly, the relationship between resource efficiency and competitive advantage was not supported. This was a tested hypothesis aiming to give empirical proof to the arguments proposed by Matopoulos et *al.* (2015) concerning the link between resource efficiency and competitive advantage.

In addition, this study contributes to RDT by investigating the interaction of buffering and bridging strategies in times of natural resource scarcity. Overall the results are in line with previous studies that suggested that these strategies "are generic, yet distinct, coping strategies to supply chain disruptions" (Bode *et al.*, 2011) and interact with each other whilst other studies have only focused on bridging strategies (Lai *et al.*, 2013).

7. Conclusions and future research

This research shows that, in the presence of natural resource scarcity, the implementation of certain supply chain strategies helps achieve resource efficiency and competitive advantage. More specifically, our research shows that both buffering and bridging strategies have a positive impact on resource efficiency; however, the analysis indicates that only bridging strategies have a positive impact on competitive advantage.

7.1 Implication to theory

This study extends previous theoretical research, it provides empirical evidence and adds new and novel insights into the risk of natural resource scarcity within the field of supply chain management by exploring its implications on organisational performance. From an RDT perspective, one implication is that this research looked at the interaction of buffering and bridging strategies and the influence that they have on each another; research on this area is limited (Hillman *et al.*, 2009). There was an investigation of the interplay of these two strategies that explored how these two strategies interact with each other and impact resource efficiency and competitive advantage. Research on the antecedents and relevant strategies that can be used to overcome or minimise the risk of natural resource scarcity has previously been performed. However, studies of the implications of these strategies on resource efficiency and competitive advantage have been limited.

Research (Bode *et al.*, 2011; Bell *et al.*, 2013; Kalaitzi *et al.*, 2018) has identified several strategies to minimise or overcome natural resource scarcity, but this research has either treated the strategies in isolation or does not explore the implications of these strategies on organisational performance. Based on survey findings, resource efficiency was linked with the implementation of the following buffering and bridging strategies: product and process (re-) design, supply chain (re-) design and relational mechanisms. For example, companies in the automotive and aluminium industries formed relational mechanisms with their material suppliers to revert back waste.

Apart from resource efficiency, companies that build relational mechanisms with both suppliers and customers can achieve a competitive advantage. For example, partnerships and alliances lead manufacturers to keep in house the natural resources and make them unavailable to competitors (Pagell *et al.*, 2007). Much of the supply chain literature focuses on collaborative relationships as a means for competitive advantage, but it is clear that for certain resources such as water and energy there is no need for collaboration and investments in times of natural resource scarcity. It is supported that transactional mechanisms provide less immediate or visible competitive advantage (Nyaga and Whipple, 2011) and, in certain cases, an incentive misalignment and a lack of a holistic view make relational mechanisms an inappropriate strategy for achieving a competitive advantage (Lapko *et al.*, 2016). In the presence of natural resource scarcity, companies are considering utilising the hierarchy mechanism of vertical integration to achieve an advantage over their competitors. Companies through vertical integration can control scarce natural resources, differentiate and thus increase the entry barrier (Grant, 2010). Another contribution of this study is the development and validation of new constructs such as competitive advantage and resource efficiency; these scales could be useful for future studies.

7.2 Implication to practice and policy

First, by developing and validating a multi-dimensional construct of supply chain strategies and by unveiling its value in improving performance in terms of resource efficiency and competitive advantage, this research provides managers with a useful tool for evaluating the applicability and effectiveness of buffering and bridging strategies that can be used to overcome and/or minimise the implications of resource scarcity. It also provides insights on how managers can plan and adapt their supply chain activities and processes (e.g. return management, product development and manufacturing flow management, supplier relationship management) to achieve better performance (e.g. by accessing scarce natural resources at a lower price than other competitors, and by minimising the usage, waste, and cost of these resources).

From a policy perspective, government policy has to provide incentives for SMEs in order to improve their performance by a better utilisation of technology and by minimising the usage of resources. In addition, policy makers should have a proactive role in formulating relevant standards and legislation (e.g. more complete and stricter Waste Electrical and Electronic Equipment legislative measures to encourage manufacturing firms to adopt supply chain strategies under proper guidelines and regulations). Extending this argument, the greatest obstacle in today's hybrid vehicle market is the production and supply of batteries as they demand rare earth elements such as lanthanum and dysprosium (Humphries, 2013). Companies try to reduce the usage of these resources, but there is a lack of cost-effective recycling and reusing options and policies to control this emerging market (Mukherjee, 2018).

7.3 Limitations and further research

This research is a first attempt to empirically test the association between supply chain strategies and organisational performance in times of natural resource scarcity, but it is not without limitations. First, there is a statistical power from the regression results, but the relatively small sample size suggests that the results should be considered with some caution. Future research can contain a set of large companies versus sets of smaller companies as firms with different sizes may respond with different supply chain strategies, thus achieve different levels of resource efficiency and competitive advantage. Moreover, the survey focuses on focal firms' strategies and performance thus we could not identify the implications on the whole supply chain performance. Future studies could find the implications of individual firm decisions/supply chain strategies on the performance of the entire supply chain by developing parallel surveys with other supply chain members. Moreover, this study cannot show the changes of the hypothesized relationships over time (as natural resource scarcity is also changing over time); thus, future research could take a longitudinal approach to extend our findings.

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Appendix 1

Table AI. Items used to measure each construct and loadings

Constructs	Items	Loadings
Product and Process (re-) design (PP_design) adapted from Singhal (2012) and Eltayeb and Zailani (2009)	We work closely with suppliers of resource X in product (re-) design to minimise or avoid the use of resource X.	0.771
	We work closely with suppliers of resource X in developing innovative practices (e.g. new technologies) to minimise use of resource X.	0.867
	We work closely with suppliers of resource X in process (re-) design in order to minimise or avoid the use of resource X.	0.832
	We work closely with suppliers of resource X in order to produce products or design production processes that include recycled resource X.	0.836
	Our company returns the waste generated by the use of resource X to suppliers for reuse.	0.769
Supply chain (re-) design (SC_design) adapted from Umar *et al.* (2013) and Park (2011)	Our facilities are close to where suppliers of resource X are located.	0.657
	We have designed a closed-loop supply chain (e.g. collection/acquisition centres, inspection/sorting centres and disposal facilities) to be able to recycle resource X.	0.837
	Our facilities are in a place where competition cannot act as a barrier to obtaining resource X.	0.762
	Our facilities are located in a place where political pressures cannot act as a barrier to acquiring resource X.	0.632

Transactional mechanisms (Transactional) adapted from Liu *et al.* (2009) and Blome *et al.* (2013)	We have formal agreements with the suppliers of resource X that detail the obligations and rights of both parties.	0.675
	We have formal agreements that explicitly state the legal remedies for failure to perform.	0.763
	We spend much time and effort in developing processes to meet the practices of the suppliers of resource X.	0.813
	We have programs to help improve performance of the resource X (i.e. training).	0.799
	Our formal agreements outline warranty policies.	0.842
Relational mechanisms (Relational) adapted from Liu *et al.* (2009)	In the relationship with the suppliers of resource X, information is shared bi-directionally.	0.860
	In the relationship with the suppliers of resource X, ideas or initiatives are widely shared and welcomed via open communication.	0.890
	In the relationship with the suppliers of resource X, problems or conflicts are remedied through joint consultations and discussions.	0.871
	The suppliers of resource X will be ready and willing to offer assistance and support in case of unexpected events.	0.797
	When making important decisions, the interests of the suppliers of resource X are taken into consideration	0.845
Hierarchy mechanism (Hierarchy) adapted from Guldbrandsen and Haugland (2000)	We are considering vertical integration with the supplier of resource X because there are few options available.	0.923
	We are considering vertical integration with the supplier of resource X because of fluctuations in price.	0.944
	We are considering vertical integration with the supplier of resource X because of government regulations.	0.914

	We are considering vertical integration with the supplier of resource X to reduce the cost.	0.934
	We are considering vertical integration with the supplier of resource X to increase the control and secure supply of resource X. (e.g. supplier may not be able to deliver more than the fixed amount agreed previously).	0.941
Resource Efficiency (REF) adapted from Kumar *et al.* (2012) and Zhu and Sarkis (2004)	My company has achieved reduction of the usage of resource X.	0.565
	My company has reduced the waste of resource X.	0.733
	My company has decreased the purchasing cost of resource X.	0.721
	My company has decreased the cost of processing of resource X.	0.807
	My company has increased the recycling rate of resource X.	0.750
Competitive Advantage (CAD) adapted from Bell *et al.* (2013)	My company has leveraged access to resource X to which competitors may be restricted.	0.802
	My company has secured resource X at a lower price than my competitors.	0.811
	My company has enhanced the intangible internal resources (technical skills, knowledge etc.) making replication difficult.	0.848
	My company has leveraged access to resource X when other competitors face shortages or spiking prices.	0.863
	My company is able to provide new or/and improved products to markets as a result of the efficient use of resource X (e.g. recycled resource X).	0.731