# SUPPLY CHAIN NATURAL RESOURCE SCARCITY STRATEGIES AND THEIR IMPLICATIONS FOR ORGANISATIONAL PERFORMANCE: AN EMPIRICAL STUDY OF MANUFACTURING COMPANIES

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**Supply chain natural resource scarcity strategies and their implications for organisational performance: an empirical study of manufacturing companies**

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## Thesis Summary

Concerns about natural resource scarcity are growing as some of these resources are critical for the successful functioning of firms. Research into the appropriate strategies for minimising dependencies caused by the scarcity of natural resources is still insufficient in the field of supply chain management. Whilst there is a growing recognition of the need to handle the issue of natural resource scarcity, there is limited empirical work on investigating what supply chain strategies should be utilised. This research provides insights from manufacturing companies and explores the conditions under which a specific natural resource will lead to buffering and/or bridging strategies and the implications for organisational performance.

The research attempts to contribute to theory development by developing a Resource Dependence Theory based framework. The framework identifies the contingency factors that determine companies' dependence that leads to specific supply chain strategies. This study contributes further into the identification of the impacts of these strategies on organisational performance. The proposed conceptual framework is validated through the means of exploratory research.

The empirical research included the collection of qualitative data from thirteen companies that use different natural resources. In order to manage and analyse the 31 semi-structured interviews content analysis was conducted using the qualitative analysis software NVivo. After the qualitative first stage, quantitative research followed to validate the findings. Responses from 183 logistics, purchasing and supply chain managers were collected and analysed by using the partial least squares (PLS) method to verify the relationships between the constructs in the framework. The study reveals that there are three main contingent factors, namely; the importance of the scarce natural resource (e.g. the price of the natural resources), the supplier substitutability of the scarce natural resource (e.g. number of suppliers) and the discretion over the scarce natural resource (e.g. legislation and geopolitical risk). This is leading companies to natural resource dependencies thus to specific supply chain NRS strategies (i.e. buffering strategies and bridging strategies). The research has shown that the two strategies can improve both resource efficiency and a company's competitive advantage.

Keywords: Natural Resource Scarcity, Resource Dependence Theory, Supply Chain Strategies, Manufacturing Companies, Mixed Methods

## DEDICATION

Dedicated to my family, especially I would like to thank my mother Maria and my grandparents Ioannis and Ourania who have provided me with the strength and motivation to work hard and finish my Ph.D.

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## List of Abbreviations

| | |
|---|---|
| NRS | Natural Resource Scarcity |
| PLS | Partial Least Squares |
| REEs | Rare Earth Elements |
| RDT | Resource Dependence Theory |
| SCRM | Supply Chain Risk Management |

# Chapter 1 : INTRODUCTION

## 1.1 Overview

This chapter introduces the research background, the literature and the gaps identified. It highlights the research aim, objectives and question, the research methodology and presents the empirical context. Finally, the structure of this thesis is provided at the end of this chapter.

## 1.2 Research Background

In recent years, there has been a growing concern over the environmental impacts caused by industrialisation and the advent of new technology. These concerns have mainly to do with the over depletion of the ozone layer, natural resources, and other negative environmental effects (Hussain, 2011). In this context, questions have been raised about the responses or the strategies that firms need to follow in order to assure business continuity particularly for the depletion or scarcity of natural resources.

Over the past 200 years, resource scarcity has been considered as a challenging topic among scientists, engineers and economists because it is a complex issue and there is a dependence of economies on a finite number of natural resources to produce consumer goods (Alonso, 2010). The view of natural scarcity dates back to the work of Malthus in 1798 that considered scarcity as a constraint on economic growth (Neumayer, 2000). Malthus highlighted that land scarcity puts constraints on food consumption growth. Later, others tried to explore the scarcity in other resources such as coal (Neumayer, 2000). For many years land was the only economic resource with a few minor exceptions, particularly metals (Ayres, 2001).

Until now the issues of scarcity were overcome by the support of technology that can create substitutes or it can exploit new sources of natural resources (Krautkraemer, 2005). Despite the fact that to date there has never been a documented case of a depleted material (i.e. physical depletion) there are growing concerns that in the near future past solutions (e.g. technology-based substitutes or exploitation of new natural resources) alone will not be able to prevent a resource crisis (Neill, 2005), because the causes may not be related to economic or physical scarcity, but to political issues.

The availability of certain resources can be affected by restricted access or price volatility, which could lead to severe impact and high uncertainty (Department for Environment, Food and Rural Affairs, 2010). Even when global deposits for certain natural resources are sufficient to meet demand these natural resources tend to be located in a few countries which creates a number of implications (e.g. increased dependency on imports and on certain suppliers, price volatility).

These implications often extend well beyond purchasing/supply chain to even manufacturing operations. For example, Coca Cola's plant in Plachimada was shut down due to water scarcity (Autry et *al.*, 2012) and Pepsi had to shut down its soft drink plant for a month due to water scarcity in Addis Ababa (Ooskanews, 2013). China's dominance of the rare earth elements (REEs) market and also the implementation of tax and export quotas, affected the availability, continuous supply and the prices of these resources (Humphries, 2013). Thus, the focus should not be on the physical scarcity of the natural resources only, but also on the issues that perceived scarcity can bring such as *"supply disruptions, volatile prices, accelerated environmental degradation and rising political tensions over resource access"* (Lee et *al.*, 2012).

Based on these arguments Natural Resource Scarcity (NRS) can put supply chains at risk if managers fail to address the issues posed by scarcity (Bell et *al.*, 2013). As with any risk, effective forecasting and management can mitigate the problem for businesses (Chopra and Sodhi, 2004). Companies need to understand, manage and implement specific strategies to address the risks and the uncertainty posed by the scarcity of natural resources in order to achieve a competitive advantage (Brown, 2012).

At the policy level the issue of resource scarcity is also gaining importance. Governments planned and implemented some actions to address the above issues, however not successfully in most of the cases (Lee et *al.*, 2012; United Nations Environment Program, 2009). The European Union for example is setting the rules in order to secure rare earth metals by boosting resource efficiency and promoting recycling. These concerns are also reflected in the EU's Raw Materials Initiative, as well as in a number of legislative efforts to address the rare earths supply in the US (e.g. in the House, H.R. 761, the National Strategic and Critical Minerals Production Act of 2013 or in the Senate, the Critical Minerals Policy Act of 2013-S. 1600).

Thus, as natural resources become scarcer, companies need to shift their concentration towards resource efficiency and develop a more systematic approach to mitigate the risk of NRS and to identify the dependencies and the regulatory risks of these resources. Supply chains have to adapt and respond proactively. However, research into appropriate responses is still insufficient (Bell et *al.*, 2012).

Several studies (e.g. PricewaterhouseCoopers (PwC), 2011; KPMG, 2012) have shown that companies are considering the issue of natural resource scarcity (NRS), but lack sufficient awareness of the implications of NRS on their business performance. Also, companies have not implemented any comprehensive strategies to address this issue. Companies have to develop strategies to mitigate the implications of NRS (Bell et *al.*, 2012; Bell et *al.*, 2013; Matopoulos et *al.*, 2015).

The present research contributes in filling this gap, by developing a conceptual framework which aims to improve the understanding of how NRS affects companies' supply chain strategies and the implications for organisational performance. The following sections provide a rationale for such an investigation, set out the research aims and objectives, and state the significance of the research.

## 1.3 Research Problems and Gaps

The trends of rising prices and increasing scarcity constitute a major risk for companies. Organisations are highly dependent on natural resources, but these resources are becoming increasingly scarce and expensive (Cetinkaya, 2011). Manufacturing firms are becoming increasingly cognisant of the issue of scarcity in renewable and non-renewable natural resources such as water, land, minerals, energy and metals. Particularly companies that make use of REEs will find it difficult to maintain a competitive position in the markets as they need to plan how to extract these raw materials without affecting other resources such as land.

By 2015 the world demand for REEs is forecast to rise to at least 185,000 tons annually (Humphries, 2013). For this reason, companies are starting to collaborate or vertically integrate through mergers and acquisitions with their suppliers to have access to scarce and critical resources for their survival. For instance, Molycorp Inc. a world class rare earth resource company acquired Neo Material Technologies Inc. a world-class rare earth processor. This acquisition helped Molycorp Inc. to expand its production (magnetic powders, and rare metals including gallium, indium and rhenium) (Mining.com, 2012). Strategic alliances with suppliers and supplier diversification are seen as fundamental in responding to the risks posed by scarcity (PwC, 2011).

Another issue is the material efficiency and the minimisation of waste. In order to comply with these actions companies are redesigning processes or products to improve material efficiency and reduce waste e.g. Tesla Roadster, an electric car that does not entail any rare-earth metal in its production. Scarcity is also an important driver of resource efficiency (PwC, 2011). In considering the redesign of products and processes, companies need to involve supply chain managers in this process to reduce the probability of occurrence or its negative consequences of a risk (McCormack et *al.*, 2008), namely NRS.

Papageorgiou (2009) called for more research in the areas of design and planning as new types of supply chains emerge which are associated with sustainability and resource efficiency (e.g. bioenergy supply chains, water provision/distribution, utilisation of scarce resources across the supply chain). Similarly, Sheu and Talley (2011) highlight that green logistics network configurations and resource allocation strategies are topics that need further investigation.

Organisations can achieve a sustainable future, if they design networks based on the fluctuation of scarcity and take into account the environmental uncertainty e.g. population growth and geopolitical conflicts (Autry et *al.*, 2012). The scarcity of natural resources was not being considered until now as a critical issue, which could change the supply chain configuration to guarantee business continuity and survival.

Specifically, how companies choose and develop their strategies to handle the issue of NRS and the dependence that derives from it, what strategies are usually used by companies, and the outcomes stemming from these strategies have not been investigated. For instance, water scarcity may lead companies or farmers to avoid water stressed areas in order to be able to produce their food products. Organisations will come under greater pressure to use less water and increase efficiency. But when companies suffer from absolute water shortages, and better water management cannot be achieved, they have to close or relocate their operations due to environmental rather than purely financial constraints (Orr et *al.*, 2009).

It can be seen that most of the studies in the field of supply chain management (SCM) focus on green strategies and sustainability (e.g. Seuring and Müller, 2008; Pagell and Shevchenko, 2014) but do not touch upon issues of natural NRS or dependence on specific natural resources.

This study identifies some significant research gaps (Table 1.1) that are explained below.

Table 1-1 Summary of literature gaps

| Research gaps | Addressed in study |
|---|---|
| The issue of NRS has not been adequately addressed in the field of supply chain management until now. Research into appropriate strategies that can manage that issue is also insufficient. | The main focus of this study is on the implications of NRS on buffering and bridging strategies that can be used to overcome or minimise the dependence on scarce natural resources. |
| Lack of theories in research development and a framework was not provided within which to conduct the analysis. | Develop a conceptual framework based on Resource Dependency Theory (RDT). |
| Empirical research is needed. | Focus on empirical (case studies and survey questionnaire) rather than anecdotal research. |
| Previous studies did not highlight any potential impacts on organisational performance. | The effects of buffering and bridging strategies on organisational performance are examined. |
| Previous research does not consider the contingency factors that change the level of dependence and shape supply chain strategies. | RDT provides the contingency factors that lead to buffering and/or bridging strategies. |

There is a limited number of studies that refer to the issue of NRS on manufacturing supply chains and there is no empirical work (Alonso et *al.*, 2008; Alonso et *al.*, 2009; Alonso et *al.*, 2010; Alonso et *al.*, 2012; Autry et *al.*, 2012; Bell et *al.*, 2012, Bell et *al.*, 2013; de Winter, 2014; George et *al.*, 2015). Most of these studies focus on NRS and its implications for the platinum, cobalt, rare earth metals markets (e.g. Alonso et *al.*, 2008; Alonso et *al.*, 2009; Alonso et *al.*, 2010; Alonso et *al.*, 2012) thus they do not compare whether different natural resources might lead to different strategies.

All of these studies focus merely on recycling as a mitigation strategy. Bell et *al.* (2012) provided a typology with comprehensive mitigation strategies based on approaches such as logistics, resource recovery and resource protection to handle the issue of scarcity and highlighted the need for industry case studies to recognise and implement creative supply chain strategies to alter natural resource availabilities. This research is conceptual and also did not imply any potential implications for resource efficiency and/or competitive advantage.

According to Carter and Rogers (2008, p. 362), *"calls for more theory development in supply chain management research"* result in little theory-building research in the field to date. Carter and Easton (2011) conducted a literature review and found that about 55 percent of papers have failed to employ any sort of theory. However, there is a strong trend towards integrating theory, with just over 33 percent of papers in the 2001-2010 timeframe not making use of any theoretical lenses (Carter and Easton, 2011).

There is a call for supply chain management academics to use current resource theories (Bell et *al.*, 2012; Esper and Crook, 2014). With the exception of one (Bell et *al.*, 2013), there is no other theoretically grounded conceptual framework. Bell et *al.* (2013) proposed a model based on the Resource Advantage theory that explores how closed loop supply chains enable competitive advantage. However, their work is not empirically tested and verified, and their framework focuses just on the role of recycling strategy to achieve competitive advantage. The forces that can also change the scarcity level are discussed but they are not explored in great detail in their framework.

Most of the previous research does not consider the contingency factors that can change the level of dependence of one firm to another for a specific natural resource. Thus, they do not take into account how the right mitigation strategy will be chosen and triggered and the studies are not empirically tested. It is also suggested that future studies in the supply chain field must include contingency factors that shape supply chain strategies (Esper and Crook, 2014). Dependence on scarce natural resources has a number of causes and may take a number of forms. For richer understanding and validation, empirical research is needed (Bell et *al.*, 2012).

Thus, while there are already some efforts to identify the implications of NRS on supply chain management, and to explore what mitigation strategies can be implemented and their impacts on organisational performance, there is still need for further work. As this is a new area of study, this research is essentially exploratory in nature and tries to understand whether companies acknowledge the relevance and the importance of NRS for their companies and specifically the impact that this may have on their supply chain strategies and on organisational performance.

## 1.4 Research Aim, Objectives and Questions

The overall objective of this thesis is to explore how manufacturing companies respond to the dependence that stems from NRS by utilising different strategies in their supply chain with the ultimate goal of achieving better organisational performance. The aim of this research is the following:

**Aim:** To develop and validate a conceptual framework for understanding the implications of NRS for supply chain strategies and performance.

In particular, the following three research objectives will be achieved:

**Objective 1:** To identify the factors that determine the dependence level of companies on specific scarce natural resources, the strategies implemented to minimise or overcome dependence and the implications for organisational performance.

**Objective 2:** To develop a conceptual framework for understanding how manufacturing companies can respond to the issue of NRS.

**Objective 3:** To validate the proposed framework by applying it to the case study companies and by constructing a survey questionnaire.

Thus, this research aims to answer the following main question:

***Why and how do manufacturing companies respond to the growing competition for ever more scarce natural resources and what is the effect on their performance?***

## 1.5 Research design and chosen methodology

In order to achieve the above objectives, a review is conducted regarding the theoretical basis of NRS and resource dependence responses specifically in the field of supply chain management. To serve the research objectives, an exploratory conceptual framework developed and proposed which is statistically tested. The framework developed explores the relationship between the natural resource dependence level, supply chain NRS strategies and performance. This conceptual framework is supported by the RDT.

Concerning the research design, a qualitative (case studies) and quantitative (survey) approach is taken. More specifically, in this study, a two stage research methodology was followed. An exploratory study was conducted in the first stage. When little or no information is available about certain phenomenon exploratory study is employed (Sekaran, 2003).

Exploratory research is conducted through certain research techniques such as secondary data analysis and case studies (Zikmund, 2000). Qualitative methods applied that tend to be more open using a range of evidence and discovering new issues (Neuman, 2006). A literature review was conducted which also provides the theoretical bases for the framework development. Thus, a conceptual framework is proposed as well as a series of corresponding propositions. The case studies are used to help the researcher to collect extensive data on each case study firm through face-to-face interviews and examine/confirm the framework.

This approach is appropriate because of the limited research (a key gap identified above) and the exploratory nature of the research. In the second stage, the use of survey allowed quantifying and testing the relationships between the variables in the conceptual framework developed in the first stage. By applying mixed methods, the research can lead to *“novel findings into contingency relationships, and also the development of richer theory about supply chain functioning and management”* (Esper and Crook, 2014, p. 97).

## 1.6 Scope: Natural Resources and Manufacturing Companies

Resources help a company to operate and do business. The location, quantity, and quality of these resources play a crucial role in the supply chain's capabilities and logistics costs (Bell, 2012). The concept of resources is really crucial and it is the foundation of a growing body of research in the field of supply chain management (Esper and Crook, 2014). Resources have to be taken into account for long-term planning as they offer direction to a firm's strategy and are the main source of a firm's economic success (Grant, 1991). There are two kinds of resources: tangible resources (assets) that can be seen or quantified such as financial resources, plant, production machinery, natural resources and intangible resources such as brand image, knowledge and organisational culture (Tabares et *al.*, 2015).

The focus of this study will be on natural resource amenities. Natural resources or natural capital involve land, water, air, mineral, plants and animal elements (POST, 2011). For the purposes of this research the definition of the World Trade Report is adapted (2010, p. 46) which states that natural resources are *"stocks of materials that exist in the natural environment that are both scarce and economically useful in production or consumption, either in their raw state or after a minimal amount of processing"*. The terms resource(s) and natural resource(s) are used interchangeably. Natural resources can be measured in physical units (e.g. tons), and in monetary terms (i.e. economic value) (United Nations Environment Program, 2011a).

Resources can be renewable (e.g. water, land, crops, timber, and fisheries) which can be reproduced and non-renewable natural resources (e.g. minerals, metals, organic resources) that cannot be generated (or cannot be generated in short periods) and once they are depleted (exhaustion of natural resource) no more of these will be available for future use. Renewable resources can also be distinguished from those that are depleted (soil, groundwater, land, and biofuels) and those that are infinite (solar, tidal, wind) (Mildner et *al.*, 2011). Water, energy (e.g. oil, gas), rare earth metals and metals (i.e. aluminium) are of particular interest for this study as these natural resources are gaining considerable attention and are considered a challenge to the manufacturing industry as they become scarcer (United Nations Environment Program, 2011b). On the other hand, land use is mainly an agriculture issue rather than industrial production problem (United Nations Environment Program, 2011b).

The research takes into consideration the upstream product-based supplier-manufacturers context and thus, is not relevant to a manufacturer-distributor context that is based on service. Services are mainly people intensive rather than materials intensive (Brouthers et *al.*, 2002; Campbell and Verbeke, 1994). Thus, service firms are less likely to be affected by materials uncertainty than manufacturing firms. In this study the focus will be on how an individual company (i.e. either buyer or supplier) situated in a supply chain should act and behave in times of uncertainty that derives from NRS. This research focuses on the focal company whose success depends on its ability to operate under changing conditions, effective use of natural resources that are finite. The strategies that focal companies can apply are discussed and the antecedents and outcomes of those strategies. Supply chain strategies refer to the focal firm's behavioural orientation towards collaborative partners in the network (Jüttner et *al.*, 2010) and when the research focuses on supply chain strategies supply chain management studies utilise and suggest the focal company as the appropriate unit of analysis (e.g. Harland et *al.*, 2004; Jüttner et *al.*, 2010).

For this study, the unit of analysis is the upstream part of the supply chain and more specifically the manufacturing focal company. Even though important, the investigation into the link between manufacturing firms and their key suppliers is not taken in this study, only partially in the quantitative study. Thus, the supply chain questions will be considered from the company's perspective. This means that despite the fact that supply chain practices such as resource efficiency strategies or collaboration always involve at least two actors, the whole picture of these practices are, in this thesis, based upon one side's description. The impact of NRS will be evaluated from the company's logistics/supply chain manager or purchasing manager viewpoint.

The case study companies were selected on the basis of their ability to provide information on the subject. There is a growing demand for REE that it is estimated to rise about 160,000 tons annually by 2016 (Humphries, 2013) due to growing populations and income especially in developing countries (KNVC, 2012). The automotive and electronic industries are experiencing already rising prices (Humphries, 2013). Water is also an important natural resource for nearly all industries such as automotive, beverage, chemical, electronics and metal mining (Chernock, 2013). Water scarcity is a higher risk to businesses than oil (Morrison et *al.*, 2009) and is expected in the future to increase in many regions, because of reasons such as population growth, climate change, urbanisation and changing lifestyles (Jefferies et *al.*, 2012).

In many regions, industrial demands (e.g. painting, cooling, and heating) for water cannot be satisfied (Jefferies et *al.*, 2012) which puts water use in direct competition with local populations (Morrison et al., 2009). For example, a Coca Cola plant in Plachimada was shut down due to water scarcity (Tercek and Adams, 2013). There is also competition over energy resources (Sovacool, 2009) that impacts aluminium, chemicals and food sectors that are energy intensive (Zero Waste Scotland, 2011). Thus, the selected manufacturing companies make use of that kind of natural resources and try to manage their dependencies and take them into account during the formulation of their supply chain strategies to be able to minimise the negative effects. This research examined how specific practices such as collaboration can reduce or neutralise the dependence for key scarce natural resources from other parties in the supply chain. Apart from the above criteria, the selection of the case studies was also influenced by the practical feasibility of access to the case study companies i.e. willingness to participate in the research, and availability for the interview.

## 1.7 Structure of the thesis

A schematic overview of the structure of the thesis is provided in Figure 1.1, whilst the description follows.

Chapter 1: This chapter introduces the background of the research, identifies the main issue and further explores and outlines the aim and objectives of the project.

Chapter 2: A brief literature review about studies that investigate the issue of NRS is given to highlight the research gaps. The research questions are provided with the summary of research gaps that will be addressed in this project. This chapter also presents the theoretical lenses in order to develop the conceptual framework and propositions.

Chapter 3: A conceptual framework is developed that explicitly recognises the emerging role of resource scarcity by assessing its consequences and the effects of various mitigation strategies.

Chapter 4: The fourth chapter presents and justifies the selected methodology. A mixed method of approach (Quantitative and Qualitative) is proposed, namely interviews and survey methods, to achieve the research objectives.

Chapter 5: This chapter presents the findings of the first phase of the exploratory research by applying the multiple-case studies. Each case is explored in order to examine the proposed conceptual framework and its propositions.

Chapter 6: A cross-case analysis is performed to explain the associations between the key themes.

Chapter 7: This chapter discusses the analysis and results of the second phase (quantitative study).

Chapter 8: The last chapter presents the conclusions of this research as well as the research limitations and suggestions for future research.

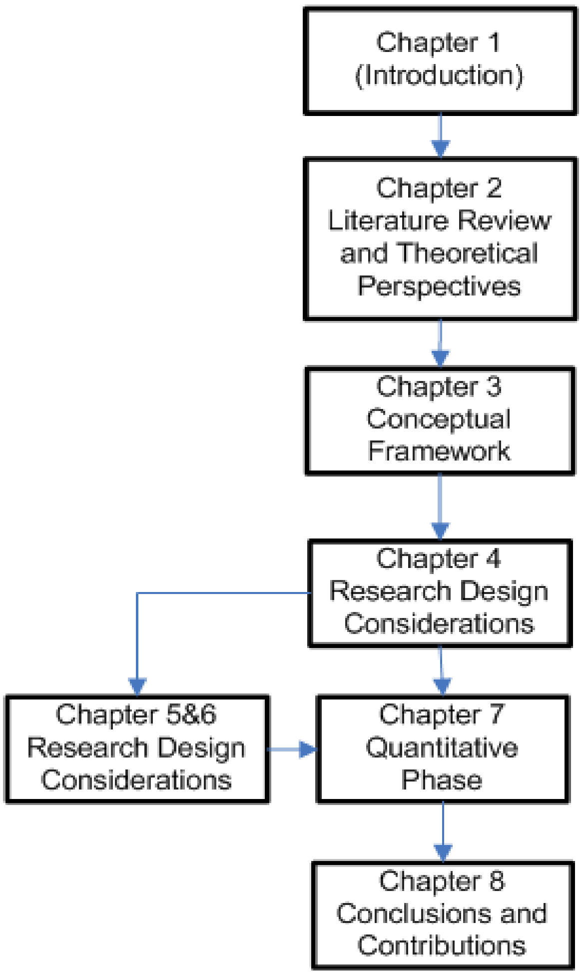


Figure 1.1Thesis structure Source

# Chapter 2 : LITERATURE REVIEW AND THEORETICAL PERSPECTIVE

## 2.1 Introduction

This chapter provides an overview of the literature with respect to NRS which is considered a risk in the field of supply chain management. The definition and basic concepts of Supply Chain Risk Management (SCRM) are provided in section 2.2. The review then focuses on three basic concepts of SCRM namely consequences, dimensions (i.e. drivers) and SCRM strategies. Sections 2.3 provide a broad review of the risk of NRS as a risk in the field of supply chain management and its consequences. Then in sections 2.4 to 2.5 there is a review of the dimensions of NRS and the possible strategies that can be used to minimise its consequences. In section 2.6 a justification is provided regarding the choice of the theoretical lenses in this research. The chapter concludes with the gaps and a set of research questions developed after the review of the literature.

## 2.2 SCRM and NRS

Nowadays the marketplace is characterised by shorter product lifecycles, volatility in demand and turbulence (Christopher, 2011). Complex networks and interdependencies among different organisations increase disruption and lead inter-organisational coordination of risks to be a major element in the supply chain. Supply chain risks are any risks that derive from the variation of information, material and product flows from supplier to customer (Jüttner et *al.*, 2003) and its scope for understanding varies across industries (Jüttner et *al.*, 2003; Zsidisin, 2003). The larger the organisation, the greater the number of nodes in the network that can contribute to a number of potential risks (Kildow, 2011).

Risk and uncertainty are terms that are often used interchangeably, however they have different meaning. Supply chain risk is the exposure of a supply chain to the impact of disruptions and it is defined by the likelihood and the outcomes of the disruption (Zsidisin et *al.*, 2005). Thus, a supply chain risk is the possibility and effect of a mismatch between supply and demand. Thus, it is crucial to managing and mitigating supply chain risks. SCRM is defined (Jüttner et *al.*, 2003, p.9) as "*the identification and management of risks for the supply chain, through a co-ordinated approach amongst supply chain members, to reduce supply chain vulnerability as a whole".* SCRM is a strategic management activity as it influences the operational, market and financial performance of firms (Narasimhan and Talluri, 2009). The concept of SCRM has received a lot of attention in the SCM literature. Particularly the focus is on the risk implications such as disruptions in the firm's business continuity that involves disruptions in the inbound flows of materials and services as scheduled, where in many cases the whole supply chain had to shut down (Jüttner and Maklan, 2011).

Several authors have provided a systematic literature review of the topic of risk and uncertainty (Behdani et *al.*, 2012; Ghadge et *al.*, 2012; Rao and Goldsby, 2009; Simangunsong et *al.*, 2011). There are a large number of papers in the literature that tried to categorise supply chain risk (Chopra and Sodhi, 2004; Simchi-Levi et *al.*, 2010; Wagner and Bode, 2009). Pujawan and Geraldin (2009) developed a framework to proactively manage SC risks and support that they can be faced in the stages of planning (demand forecasting, production planning and inventory control for materials), source (procurement process), make (supplier evaluation and development, production execution and control), deliver (packaging process, selection of shipping companies , warehousing of finished products , delivery of products to customers) and returns stage (returning rejected items to supplier, handling return from customers).

Jüttner et *al.* (2003) state that there are three risk sources: environmental, network-related and organisational. In addition to these risks, Ghadge et *al.* (2012) identify two other sources of risk, that of exchange rates and political/ social. Christopher and Peck (2004) considered three categories of risk sources: 1) internal or organisational risk (process risks and control risks), 2) external to the firm but internal to the supply chain network (demand and supply) and 3) external or environmental.

Others, classify risks into internal and external (Bogataj and Bogataj, 2007; Cucchiella and Gastaldi, 2006; Goh et *al.*, 2007; Simangunsong et *al.*, 2011; Vlajic et *al.*, 2012). A source of external risk is that of environmental risk (Faisal et *al.*, 2006; Halldórsson and Kovács, 2010). It is used to describe risks that can be man-made (accidents, socio-political actions, policy risks, exchange rate risks, competitive risks, network risks, resource risks) and natural disasters (acts of God) (Bogataj and Bogataj, 2007; Ghadge et *al.*, 2012; Jüttner et *al.*, 2003; Manuj and Mentzer, 2008; Sawik, 2013; Oke and Gopalakrishnan, 2012; Simangunsong et *al.*, 2011).

There has been much research into specific sources of supply-chain risk; however, there are many other distinct sources that have not received sufficient attention (Simangunsong et *al.*, 2011). For example, the risk of shortage is widely used in the field of supply chain due to the loss of key suppliers, import restrictions etc. (Diabat et *al.*, 2012; Oke and Gopalakrishnan, 2012), however the risk of NRS has recently started to be considered as a crucial risk in the supply chain (Alonso et *al.*, 2009; Bell et *al.*, 2012; Bell et *al.*, 2013).

## 2.3 NRS as a Supply Chain Risk and its Consequences

Globalisation of the market, outsourcing, reduction on supplier base, shorter product and technology life cycles, capacity limitation of key components, fewer and larger production and distribution sites, volatility of trading environment, are some events that increase the vulnerability of supply chains to disruption (Christopher and Lee, 2004; Diabat et *al.*, 2011; Goh et *al.*, 2007; Jüttner et *al.*, 2003; Narasimhan and Talluri, 2009; Norrman and Jansson, 2004; Simangunsong et *al.*, 2011).

Scarcity and shortage are widely used as interchangeable terms. However, scarcity defines a resource that is finite or limited (e.g. clean air, copper); while shortage is when the demand for a product exceeds the available supply, for example due to miscalculation of demand and the weather. Natural resources are elements that are supplied by the natural environment. A scarce resource implies that there are only a few raw materials to manufacture a product. NRS has been defined as *"the reduction in economic well-being that results from a decline in the quality, availability, or productivity of natural resources"* (Cleveland and Stern, 1998, p.1).

Another definition from Wagner (2002, p.14) is "*the lack of adequate supply to meet demand"*. In this research we will adopt the following definition, NRS is defined as *"the inability of the supply of natural resources to meet the demand for natural resources at a particular location"* (Bell et *al.*, 2013, p. 7).

The debate over the implications of population pressure on natural resources dates back at least to Malthus in 1798 (Neumayer, 2000). Malthus highlighted the land scarcity and he supported that duties on imported corn can minimise the dependency on foreign nations. Jevons (1865) focuses on coal scarcity as an energy resource that may lead to rising costs of extraction and detrimental effects on the competiveness of British industry (Neumayer, 2000). However, both of them were wrong as Malthus did not take into account the progress of technology that mitigated the challenges posed by resource constraints and Jevons underestimated the exploration of new reserves and the substitution of coal to produce energy (Neumayer, 2000).

NRS concerns began in the mid-1980s under the concept of sustainability or sustainable development (Krautkraemer, 2005). NRS is recognised as a threat in supply chains. For instance, in 2011 a survey conducted by PwC found that 77% and 75% of the respondents were concerned about the scarcity in energy and minerals and metals respectively. Another 57% and 35% of respondents point out the scarcity of water and land respectively. In the same survey, it can be seen that different regions are facing different scarcity issues. In the Americas, 73% of respondents found energy scarcity as an issue in comparison to 53% of respondents in Asia Pacific. However, minerals scarcity was identified as an issue in America and Asia Pacific. Europeans highlight the issue of energy scarcity (96%) and material scarcity (92%) as issues relevant to their company. The Department for Business, Innovation and Skills (BIS) and the Department for Environment, Food and Rural Affairs (DEFRA) (2012) focus on resource security rather than scarcity in their report and identify the scarce resources for each sector (see Figure 2.1).

Aston University

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Figure 2.1 Examples of scarce resources by sector (Source: BIS and Defra, 2012)

Figure 2.2 below shows the trends in worldwide extraction of resources until 2030 by the Sustainable Europe Research Institute (SERI) Global Material Flow Database. The results suggest that there will be a high growth in resource demand if no strategies are implemented to increase resource efficiency (Lutz and Giljum, 2009).

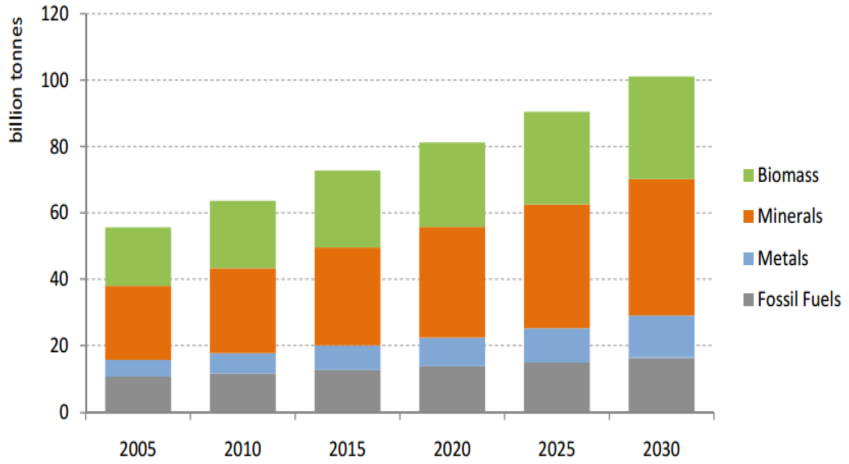


Figure 2.2 Scenario on worldwide resource extraction, 2005 to 2030 (Source: SERI, 2009).

Concerning the risk of NRS, it can lead to high impact disruptions in the supply chain that in turn may increase public scrutiny and regulations. Consequences will also include barriers to access to the resources and decline of the quality or purity of a resource. The consequences of a disruption in the supply chain have different magnitudes, based on the strategic position inside the chain. Hendricks and Singhal (2003) state that the impacts of disruptions lead to the following consequences: 107% decrease in operating income, 7% lower sales growth, and 11% higher costs. A recent research in the UK found that the main consequences when disruption occurs were loss of orders and sales (60%), reputational damage and increased operating costs (43% respectively) (Zurich Insurance Report, 2012).

Other consequences that were found in the literature review are physical costs (e.g., damage to facilities, inventory, electronic networks, and infrastructure), inventory costs due to product obsolescence, markdowns or stock-outs, inability to react to competitor moves, shifting customer demand (Jüttner et *al.*, 2003). As resource constraints tighten, companies that depend on the (external) natural resources can experience huge economic impacts as resources become costly and its price unpredictable (increasingly volatile prices). The impact of scarcity, apart from affecting companies by increasing costs of these scarce natural resources, can also lead to a disruption of supply, thus an inability to meet customer needs. These implications will motivate organisations to apply some mitigating strategies to minimise their exposure to NRS or the level of dependence on natural resources.

An Ernst and Young (2012) survey found that 76% of the survey respondents believe that natural resource shortages will impact on their company's core business objectives in the next 3 to 5 years. Firms and supply chain managers need to adapt and understand the crucial implications of resource scarcity and transform their organisation's context, to sustain future success (Autry et *al.*, 2012). CEOs (76% of Energy and Power & Utility and 62% Mining) are already feeling the pressures of NRS (e.g. increased costs, competition for new sites, regulation and government intervention) (PwC, 2014).

Despite the wide recognition of NRS, organisations are responding slowly (KPMG, 2012). While some companies have already implemented comprehensive strategies, most companies have neither developed nor implemented any responses (see Figure 2.3).

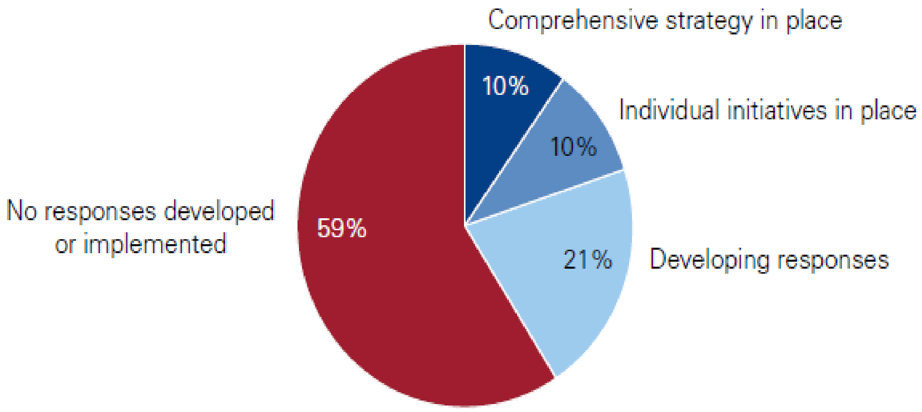


Figure 2.3 Response to NRS (Source: KPMG, 2012)

Companies that do not have an SCRM in place may neglect this risk as the frequency of occurrence is low or because the nature of the risk is unique (e.g. in the case of Ericsson, the mobile phone manufacturer, who experienced a major supply disruption due to a fire in its supplier plant). Below, the dimensions of the NRS and its mitigation strategies that can be used to minimise the consequences are discussed in sections 2.4 and 2.5.

## 2.4 NRS Dimensions

There are three dimensions to the risk of NRS (see Figure 2.4) that include the psychical, geopolitical and economic (Bennett and Estall, 1991; de Winter, 2014; PwC, 2012).

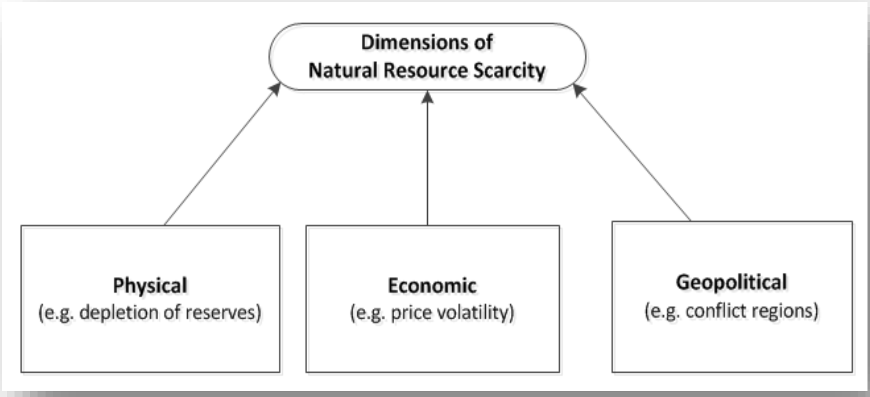


Figure 2.4 Dimensions of NRS

The physical dimension refers to the amount of natural resources that are available in the earth (i.e. depletion of reserves, insufficient renewable stocks). This dimension of scarcity takes into consideration the total quantity and quality of reserves of non-renewable natural resources in the earth's crust. For instance, mines are depleted; the rate of discovery of new supplies of natural resources such as coal is low as it exists in finite amounts. Copper is also close the technical limits of mining and is becoming harder to extract (Circular Economy Task Force, 2013). In the past the psychical dimension of NRS was attracting the most attention. However, there is a shift towards securing access to resources thus focusing more on the economic and geopolitical dimensions.

The word population will reach 9.1 billion by 2050 (United Nations Department of Economic and Social Affairs (UNDESA), 2009). There is a growing demand for critical resources such as fossil fuels and steel by developing economies, primarily China and India. For instance, China and India have the largest coal reserves but they are consuming them faster than they can develop them. This demand induced scarcity of natural resources. The demand for food is projected to rise by 50% by 2030 (World Bank, 2008). However, the rates of productivity growth dropped from 2% for the period 1970-1990 to 1.1% for 1990-2007, and it is expected to decrease further due to land shortage (Trostle, 2008).

According to United States Department of Agriculture (USDA) (2008) the growth will decline to 0.8% per year for the period 2009-2017. If the land productivity does not change, 6 million hectares of land may need to be converted to agricultural production every year until at least 2030 to satisfy the growing demand (United Nations Convention to Combat Desertification, 2014). The global demand for water is expected to rise by 35 - 60% between 2000 and 2025 (United Nations Convention to Combat Desertification, 2014). There is an increasing scarcity of water and land resources that will constrain food production growth (Rosegrant et *al.*, 2014).

The growing demands for rare earth elements (REEs) stems as well from the increasing world population and the welfare that exceeds the supply (KNVC, 2012). All the above lead to price fluctuations and we can see in Figure 2.5 that since the beginning of 20th century, the prices for critical natural resources such as food, water etc. have been on the rise again (McKinsey & Company, 2011).



Figure 2.5 Fluctuation of prices (Source: McKinsey & Company, 2011, p. 5).

Another dimension of NRS is the increased geopolitical activity. Geopolitical activity increases as a result of the heterogeneous distribution of natural resources across the planet (British Geological Survey, 2012; European Commission, 2010). Governments try to ensure access to scarce natural resources and in most cases to intervene in the marketplace activities to assure safety or security of their nation’s interests (Autry et *al.*, 2012). Securing those natural resources is challenging, especially for countries that are dependent on imported resources (Garrett and Piccinni, 2012). Political tensions can be raised as countries such as China may not be willing to share their natural resources with other countries (i.e. export restrictions) (Garrett and Piccinni, 2012; KPMG, 2012).

China's monopoly on REEs (it produces around 95% of the materials used in high-tech applications) plans a full export ban in 2015. Thus, critical scarce natural resources will not be accessed easily. This policy encouraged not only companies such as Molycorp and Lynas to have their deposits and expand the supply of REEs but also leads companies (especially automotive) to find alternatives or substitutes (U.S. Department of Energy, 2010). For instance, General Electric develops wind turbine generators that use less permanent-magnet machines and W.R. (William Russell) Grace a chemical manufacturer in Columbia implemented fluid catalytic cracking catalysts that entail less lanthanum (U.S. Department of Energy, 2010).

Another example is in the agri-food supply chain when farmers faced the difficulty of fulfilling the demand for grain in 2007. The impact was prices of grain and soybean started to climb, tripling by mid-2008. As a response, many countries such as Russia, Argentina and Vietnam restricted their exports to control the rise of domestic food prices. Importing countries started to be concerned about how they will meet the needs of customers, which in turn led to a high increase of world market prices (Trostle, 2008). In the fear of not fulfilling their demand for grain, Saudi Arabia, South Korea, China, and India started to buy or lease land abroad, either through government or through domestically based agribusiness entities. This led to hundreds of lands acquisitions (land, water and energy usage) which may increase conflicts in the future, as some of these acquisitions are not legal and the residents of these countries (e.g. in Africa where "land grabs" have been made) suffer from poverty (Trostle, 2008). Thus, the dimensions of resource scarcity, NRS can be from natural or manmade (Pereira et *al.*, 2009).

Companies have to identify the dimensions of NRS and through them find strategies to ensure business and operational continuity and quick recovery from disruptions. There are natural resources that are scarce at a local or global level (Bell et *al.*, 2012). When a resource is locally scarce, supplies can be shifted to other places to meet local demands (Bell et *al.*, 2012). Globally scarce resources have a significant role as it is hard for companies to meet the demand for them (Bell, 2012). In this case the supply chain has to explore alternative materials or methods to meet customer needs (Bell, 2012). The next sections outline the research gaps in the field of supply chain management regarding the risk of NRS and the strategies that are explored further to develop the conceptual framework.

## 2.5 SCRM strategies and NRS

A supply chain strategy is part of the overall business strategy and must be aligned with customers' needs, the power position of the firm and needs to be adaptive (e.g. supply uncertainty) (Cohen and Rousell, 2005). Christopher et *al.* (2006) stated that *"one size does not fit all"* as there are a wide range of products with different characteristics and thus different strategies are needed. Environmental uncertainty leads to specific supply chain strategies in order for a firm to cope with this uncertainty, for instance by building larger stocks or expanding capacity.

Lee (2002) suggested a framework (Figure 2.6) to align supply strategies with the different levels of demand and supply uncertainty. Low demand patterns and low supply uncertainties demand an efficient supply chain. When the demand is highly unpredictable and there are high supply uncertainties there is a need of an agile supply chain. A risk-hedging supply chain employed when there is a low demand uncertainty and high supply uncertainty. High demand uncertainty and low supply uncertainty requires a responsive supply chain.

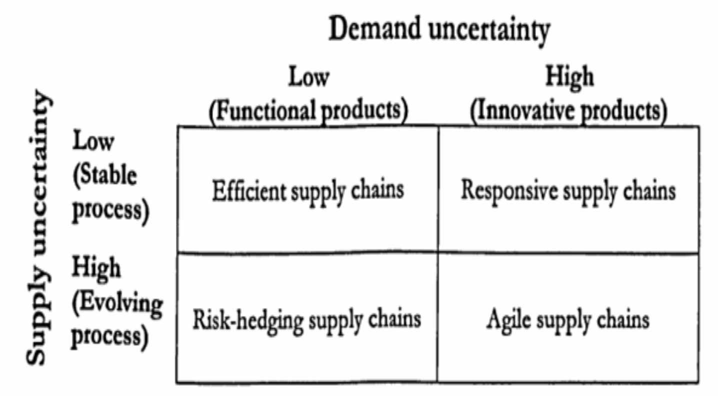


Figure 2.6 Uncertainty and supply chain strategies (Source:  Lee, 2002).

Although it is impossible to avoid risks in a supply chain, it can be minimised by adopting some enablers such as information sharing, collaboration, information security (Faisal et *al.*, 2006). Several authors provide different mitigation strategies (potential ways of approaching the risks and disruptions) such as increasing the inventory capacity by using internal and external safety stocks (Goetschalckx et *al.*, 2013; Harland et *al.*, 2003; Vlajic et *al.*, 2012).

Rice and Caniato (2003) identified ways of increasing resilience by changing inventory levels, using a spot market and multiple production facilities. Ritchie and Brindley (2007), argue that it is not a good practice to use buffer stocks and slack lead times nowadays. Christopher and Lee (2004) believe that the lack of confidence leads to built-up inventory buffers. Zsidisin et *al.* (2000) and Zsidisin (2003) illustrate various strategies to minimise risk from the supply perspective and the use of multiple sourcing has been supported widely (Deep and Dari, 2009; Diabat et *al.*, 2012; Kleindorfer and Saad, 2005; Oke and Gopalakrishnan, 2012; Sheffi, 2002; Thun and Hoenig, 2011) as a way to minimise certain supply chain risks.

Other researchers use the terms of avoidance, control, cooperation, flexibility as mitigation strategies (Singhal et *al.*, 2011; Tang and Tomlin, 2008; Manuj and Mentzer, 2008). Jüttner et *al.* (2003) provide the following description for each strategy:

- Avoidance: drop specific products, suppliers or geographical markets and/or customer organisations.

- Control: vertical integration increased stockpiling or maintaining excess capacity in all stages and imposing contractual requirements on suppliers.
- Cooperation: joint agreements, improve supply chain visibility
- Flexibility: postponement, multiple sourcing, localised sourcing

Thus, there is *“no one single silver bullet response”* (Rice and Caniato, 2003). Each supply chain is unique, thus mitigation strategies (hereafter strategies) should be tailored to match a specific chain. Each strategy can handle specific risks; managers need to understand the advantages and disadvantages of strategies and which the appropriate one to be implemented is.

Most of the studies take a closer look at the social impacts such as conflicts as they try to help in policy development or they focus on individual-level responses such as social/community activism or consumer recycling (Bell et *al.*, 2012). Some studies focused on dependence on resources for population growth and economic development (Brown et *al.*, 2012). These studies however, do not consider any ways of mitigating the risk of NRS.

Allwood et *al.* (2011) propose some strategies for minimising the demand for natural resources: longer-lasting products, modularisation and remanufacturing, component re-use and designing services with less material. Hart (1995) took a natural resource based perspective to environmental strategy that assumes that possession of capability will impact on the corporate strategy and competitive advantage. He proposed three strategies: pollution prevention, product stewardship and sustainable-development. The Technology Strategy Board (2012) suggested three approaches: substitution: using materials that are more secure, closing the lifecycle loop, and dematerialisation: using less material and reducing energy intensity. One question that needs to be asked, however, is when the above strategies are applied but also what are the implications on the organisational performance of these strategies.

Concerning the implications of mitigation strategies some papers explore the impacts of specific mitigation strategies. Bretschger (2005) supports that technological change and innovation can compensate NRS but are limited by various restrictions such as rising research costs. Technology is also proposed by Prior et *al.* (2012) that tried to explore the economic and productivity implications of peak minerals. They concluded that technology can lead to negative and positive impacts as it depends on how it is used (e.g. intensively) in exploitation and extraction. Rimos et *al.* (2013) proposed a methodology to measure the implications of fossil fuel substitution as a result of scarcity. There are various negative effects that tried to be identified in this study such as emissions to air and water, solid waste generation and water depletion.

Other studies focus on the implications of resource scarcity. Evans (2010) explores the concept of resource scarcity by focussing on resources of food, land and water; not to high-value commodities such as diamonds and coltan. This issue brings a conflict over access to or control of scarce resources and some actions must be made such as anticipating and finding ways of reducing vulnerability issues. Evan's (2010) study is conceptual and does not propose specific mitigation strategies to handle this issue. Jones et *al.* (2013) examine the influence of markets and governments responding to the resource challenge. They had a broad look at the resources of oil, coal, natural gas, uranium, land, food, water and metals from the actuaries' perspective.

WRAP (2010) examined the resources of iron ore ,steel, wood, pulp products, plastics, fertilizers, aggregates, aluminium, gypsum and plaster products, copper, cobalt, lithium and rare earths.  They have implemented two main resource efficiency strategies: production strategies (e.g. lean production, material substitution, waste reduction) and consumption strategies (e.g. reducing food waste, dietary changes, restorative economy) to minimise resource usage. However, these strategies were not chosen to find the best way to reduce the use of water or the specific materials chosen. These strategies were implemented to show the relationship between climate change and resource efficiency. Thus, this research does not take into account particular sectors and products.

Corporations that are using scarce resources (the prices of these resources went up), try not only to redesign their products, but they also follow other strategies such as return and recycling. The strategies will be developed for a given resource status. The European Commission (2011) developed a project by using recycling and waste prevention in product design to explore the implications for overall material use and material productivity. The scenarios of material savings based on current policies, policies with targets reached, feasible potential and theoretical 100% recycling rates. Three strategies are used: reducing material intensity and light weighting, design for recycling, and, design for longevity. However, the data for waste prevention and product design was limited and estimates were based on case studies. Thus, the implications in material use can be flawed. In Table 2.1 the responses that governments follow to address the issue of NRS are presented.

Table 2-1 Examples of government responses (Source: Lee et *al.*, 2012)

| **Goals** | **Policy objectives** | **Examples of tools** |
|---|---|---|
| Ensuring access to affordable supplies | Protect domestic supply | Export restrictions – quotas investment restrictions; import tariffs |
| | Increase domestic production | Subsidies/tax incentives, technological support, concessionary loans and import restrictions. |
| | Ensure access to foreign resources | Foreign direct investment long-term contracts. |
| Reducing demand | Resource efficiency | Recycling, reusability, recovery of products |
| | Promote substitution for scarce resources | Renewable energy; new product designs |

Oakdene (2011) identifies the benefits from resource efficiency by focusing on four key resources: materials, waste, water and energy. It also explores the relationship between the size of an organisation and resource efficiency. However, Oakdene's (2011) research does not look at the strategies but mainly takes into account government policies and solutions further up the waste hierarchy to mitigate the risk, however other strategies could be further explored.

### 2.5.1 Supply Chain NRS strategies

In this research the focus is mainly on the implications of NRS in the strategic decision making in the field of supply chain management. As mentioned in the above section a crucial issue that supply chains face is the NRS that is a significant supply chain risk (Bell et *al.*, 2012). For instance, in the 1970s it was cobalt supply which had an impact on costs to private firms and led them to follow some strategies such as reducing material usage, recycling, stockpiling and substitution (Alonso, 2010). However, not much work has been done in terms of mitigation strategies.

A study conducted by Alonso (2009) explored the dynamics of platinum markets in the presence of material scarcity risks by implementing the strategy of recycling. The higher price motivates companies to recycle but it is limited due to the low number of products collected after reaching end-of-life. Recycling decreases the primary metal consumption. Another paper by Alonso et *al.* (2009) focussed on platinum group metals scarcity risks that electronics firms may face by building a simulation model. Two other strategies were proposed: materials substitution and reduced materials usage; but they were not investigated.

Dewulf et *al.* (2010) developed two scenarios in order to compare the resource savings by recovering and reusing cobalt and nickel into the production chain and using virgin natural resources. Lithium security for use in electric vehicles was also explored by implementing scenarios by Kushnir and Sanden (2012) who concluded that there is a need for policy support for recycling practices. In the automotive industry Alonso et *al.* (2012) created various future scenarios on platinum availability. Their research showed that there is a decline in ore grades and the platinum supply is concentrated in a specific geographic area.

Alonso et *al.* (2007) stated that manufacturing companies that face shortage will follow the approaches below:

- Technological: Redesign their products by using less or substitute materials.
- Geographic: Reconfigure to tap into new sources
- Operational: Alter inventory practices

Bell et *al.* (2012) provided a typology (see Figure 2.7) with comprehensive mitigation strategies based on approaches such as logistics, resource recovery and resource protection to handle the issue of scarcity.

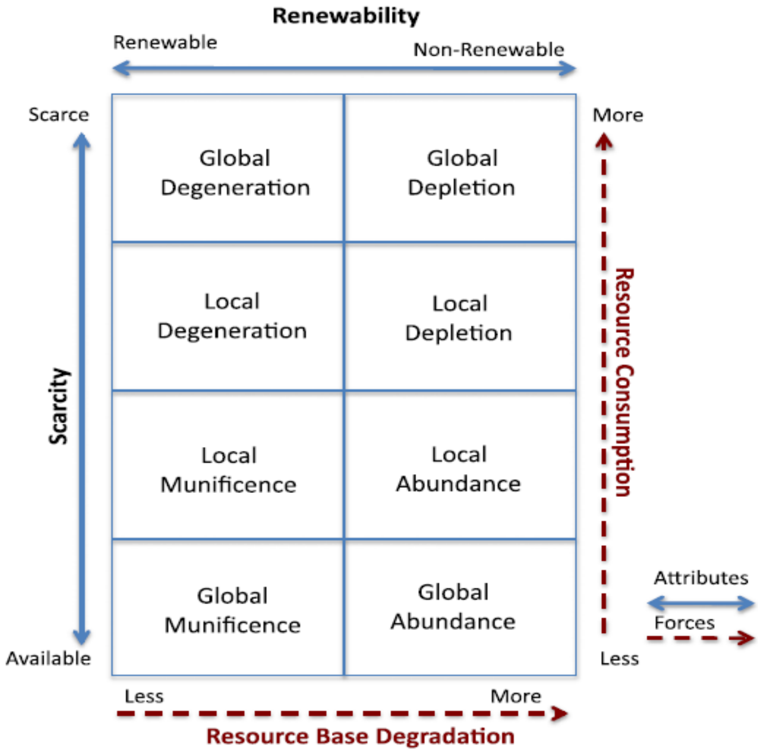


Figure 2.7 NRS typology (Source: Bell et *al.*, 2012)

There are eight mitigation strategies which are based on resource employment and conversation approaches (Bell et *al.*, 2012):

**Fortification:** In this case companies face global degeneration, which means that there is a scarcity of a resource at a global level, but this resource can be regenerated in the long term. This strategy can be illustrated by taking into account the corn resources that are scarce. In this situation food companies need to find substitutes for a short to medium term and are taking actions for the renewal of this resource. Substitution is also supported by BIS and Defra

(2012) stating that there are two ways of doing this: direct substitution where a material is replaced by another and indirect substitution where an alternate technology is developed which does not require the use of the critical element. For example, Ford announced that its nickel-metal-hydride batteries will be replaced with lithium-ion.

**Mobilisation:** This strategy may be implemented in the case of local degeneration, which means that a resource is scarce in a certain area but in the long term will be regenerated. Thus, the company can import this resource or to use the logistics approach that called for postponement to balance demand and supply. Also, it is important to participate in local initiatives to renew this resource.

**Discretion:** In this case the company faces global depletion of a rare resource, thus trying not to use this resource unnecessarily and employing returns management practices. In the agri-food industry supply chain phosphorus is a good example as it is estimated that 90% of it has already been used, thus certain practices must be implemented to use and reuse phosphorus efficiently. Another strategy that farmers use is substitution; for example, manure.

**Compilation:** This strategy stems from local depletion and is implemented when a rare source is locally depleted, companies use a logistics approach such as leverage transportation and postponement; and also use recovery methods such as recycling.

**Cultivation:** The resources in this case are renewable at a local level (local munificence).

**Perpetuation:** This is the case that the resource is renewable at a global level (global munificence).

**Utilisation:** This strategy can be taken in the case of a non-renewable resource (local abundance) that is more than enough at the local level. An example is land that is a finite resource, however abundant in some regions (e.g. in South Africa) but a judicious allocation and resource recovery must be followed in order not to deplete this resource.

**Preservation:** Global abundance can lead to strategies such as sustainment and recovery practices.

Bell et *al.* (2013) proposed a model based on the Resource Advantage (R-A) theory that explores how closed loop supply chain management enables competitive advantage. However, this work is not empirically tested and verified and the framework focuses just on the role of recycling strategy to achieve competitive advantage. The forces also that can change the scarcity level are discussed but they are not explored in great detail in this framework.

De Winter (2014) also proposed the circular economy (reuse, repair, refurbishment, remanufacturing, component harvesting / cannibalization, recycling) as a response to NRS and explored the roles and information needs of relevant actors across the supply chain. Cordell et *al.* (2015) by focusing on the scarcity of phosphorus presented various contingency factors such as geopolitical risk, physical etc. and potential risk mitigation strategies (e.g. recycling) to minimise/overcome this issue. However, it does not focus on manufacturing companies and their relationships with suppliers. This work does not include any empirical data and the framework is not based on theory.

There is also a lack of research and empirical evidence of the impact of scarce natural resources on strategic decision making. Supply chain studies focus on specific mitigation strategies without taking into account any contingency factors (i.e. antecedents or factors shaping patterns of specific practices) that can change the balance between supply and demand for a specific resource and do not explore the impacts on supply chain configuration as a whole. A systematic literature review by Matopoulos et *al.* (2015) highlighted that there is a need for further research to understand the implications of resource scarcity on the supply chain relationships and supply chain configurations in order to enhance resource-efficiency.

According to PwC (2011) resource efficiency is more likely to be implemented as a response to scarcity and the role of suppliers is also considered important (i.e. identifying strategic alliances with suppliers and diversification of suppliers) in minimising the dependency on these sources. However, relocating the production facilities and resource extraction (see Figure 2.8) are seen as the least relevant strategies for mitigating the NRS that indicates the low importance of physical scarcity in comparison with the other dimensions of NRS (PwC, 2011).

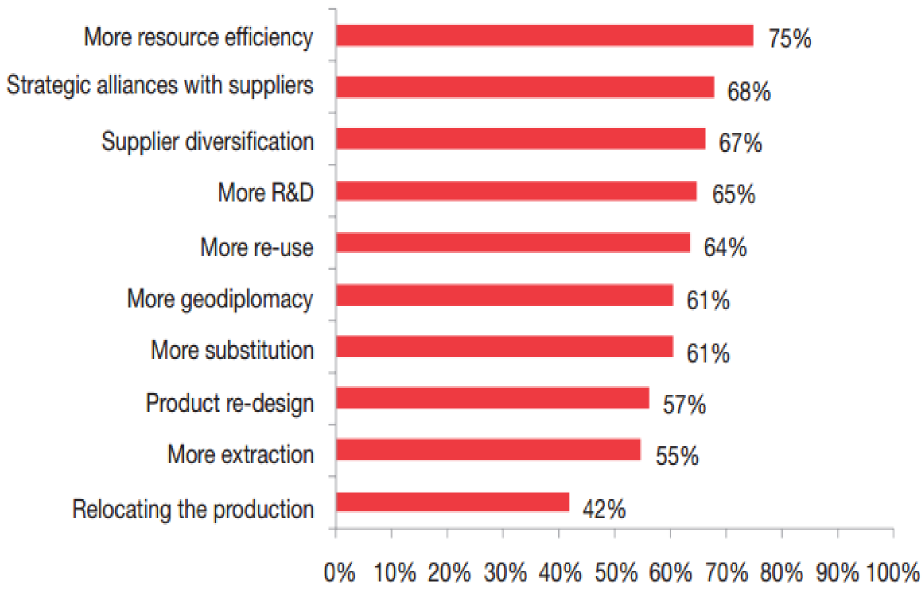


Figure 2.8 Response to NRS (Source: PwC, 2011).

Several strategies can be utilised to achieve resource efficiency (e.g. efficient usage of resources, reduction of consumption of natural resources). The efficient use of natural resources brings to the surface emission mitigation strategies and other design criteria (structures and strategies) for competitive supply chains (Halldorsson and Kovacs, 2010). The strategy of changing the location has been supported widely in the food supply chain (Vlajic et *al.*, 2012; van der Vorst, 2000). However, there is a lack of research into supply chain configuration as a strategy to avoid the NRS risk.

Disruptions in the supply chain can lead to shortage of resources and pre-defined plans for supply chain operation should be revised according to the new situation and result in the efficient use of available resources (Adhitya et *al.*, 2007; Dani and Deep, 2010; Huang et *al.*, 2006; Xiao et *al.*, 2005). Matopoulos et *al.* (2015) also concluded that efficient usage of natural resources can be achieved by adapting product designs and production processes. Thus, this study will take into account the redesigning of supply chains and the rethinking of the product design. Finally, there is evidence that there is a need for research regarding the impact of NRS on the supply chain relationships (Matopoulos et *al.*, 2015). In the sub-sections below a review is provided on the product and process (re) configuration, supply chain (re-)configuration and specific business relationships and vertical integration.

### 2.5.2 Product and process (re-) configuration

Product design is *"the configuration of elements, material and components that give a product its attributes of function"*, appearance, durability and safety (Potter et *al.*, 1991, p.11). Involving environmental concerns into products and relevant processes design are the most crucial solutions to enhance environmental performance (Ehrenfeld and Lenox, 1997). Eco-design and Design for Environment focuses on incorporating environmental concerns in product development, which involves both product design and manufacturing process designs (Pujari et *al.*, 2004). Also, environmental design leads a company to a superior environmental performance thus to a competitive advantage (Lenox and Ehrenfeld, 1997). Through eco-design firms can minimise resources. In this study, eco-design refers to the effort of firms to systematically design products and related manufacturing processes in an environmentally conscious way (Pujari et *al.*, 2004).

The study conducted by Walsh et *al.* (1988) reached the conclusion that product design is more significant than price alone to define the competitiveness of firms. Design is a crucial process in the supply chain as it determines which products can be made to the desired specifications and with the right materials. By determining the product design, suppliers know what is needed and designers know what can be done based on the capabilities of suppliers. Designing products with suppliers can minimise the risk of material shortages (McCormack et *al.*, 2008). Mughal and Osborne (1995) believe that early decision making at the design stage is needed in order to design with the maximum flexibility in changing markets. Zsidisin et *al.* (2005) investigated supplier involvement in the supply chain as co-designers to minimise supply chain risk by enhancing product design. Khan et *al.* (2008) emphasised that most companies did not consider the phase of design in the strategic decision making, but there are a few exceptions such as Toyota, Rolls Royce and Boeing.

Despite the fact that design can be a source of risk, it can play a crucial role in risk mitigation (Khan et *al.*, 2008). Based on a case study of Marks and Spencer, Khan et *al.* (2008) investigated product and process design and propose a framework for design-led supply chain risk management. The research concluded that a well-designed product and process flow helps organisations to mitigate risks. In this study the researcher will try to find the link between scarce natural resources and product and process (re-)configuration. As an alternative to the current resource intensive production system where the influence over resources is lost, this thesis explores the introduction of strategies that change the design of a product in order to minimise resource demand. These strategies will also minimise the dependency to purchase resources thereby mitigating the risk of natural resource scarcity.

### 2.5.3 Supply Chain (re-)configuration

A promising area of research in supply chain management is about supply chain (re-) configuration (Harland et *al.*, 2001). Fine (1998) observed that supply chain design is a critical dimension of strategic performance. However, changing supply chain configuration is a major undertaking due to time and resource constraints. Thus, it is a strategic decision that should be examined carefully.

*“The traditional focus of the supply chain looking at operational risks shifted towards more tactical and strategic risks”* because global outsourcing activities are on the rise (Ghadge et *al.*, 2012, p. 318). The issue of risk in supply chain networks has attracted significant attention (Carvalho et *al.*, 2012 Goetschalckx et *al.*, 2013; Schmidt and Raman, 2012). Carvalho et *al.* (2012) explore alternative scenarios based on supply delay for enhancing resilience and also tried to identify how mitigation strategies have an impact on performance.

Tsiakis et *al.* (2001) explore the supply chain network design under demand uncertainty based on a two-stage stochastic programming model. Scaparra and Church (2008) introduced a problem to determine the optimal allocation of a limited amount of protective resources to minimise the impact on accessibility reduction. Jüttner et *al.* (2003) proposes that risks in networks stem from three sources: lack of ownership, chaos and inertia.  Lack of ownership risk of sources in supply chains stems from blurring boundaries between buyer and supplier organisations, chaos (unnecessary interventions, mistrust) that lead to consequences of the bullwhip effect and inertia that includes lack of responsiveness to environmental and market changes.

Network-related risks also stem from interactions between organisations within the network (Jüttner et *al.*, 2003) and supply risk, supplier default and demand risk are the most studied network-related in SCRM (Ghadge et *al.*, 2012). Klibi et *al.* (2010) conducted a comprehensive critical review and identified three broad categories of sources that lead to supply network uncertainty: endogenous assets, SC partners and exogenous and geographical factors. The first deals with equipment, vehicles, human resources and inventories of production. The second one, SC partners, has to do with customers, raw material, energy suppliers and 3PLs. Geographical factors include public infrastructures, natural disasters, major accidents (e.g. nuclear spills.) and socio-economic, political factors.

Global supply chain networks entail hundreds of companies that have several tiers of suppliers and customers, thus it means that there are several risks that organisations need to consider and tackle (Goh et *al.*, 2007). Risks arising within the supply chain network must be reduced across the network and not only to a single location in order to strength the overall supply chain. The decision on where to produce, assemble and store can make a huge difference between profit and loss (Christopher, 2011).

Network structure entails the partners and the links between these firms. The level of management of this supply chain depends on the complexity of products, number of available suppliers and the availability of raw materials (Brewer et *al.*, 2001). Decisions regarding the role and location of facilities can have an important influence on the supply chain's performance (Chopra and Meindl, 2010; Hugos, 2006). Thus, it is significant to have an explicit understanding of how the supply chain network structure is configured. Firms should invest and act proactively to assess the risk in order to have a plan to react in the case of disruption and minimise the risk impact.

Network planning involves strategic decisions and deals with supply chain infrastructure which often needs to be reconfigured due to changes in supply/demand patterns, cost of running facilities etc. (Simchi-Levi et *al.*, 2010). The main reason behind the reconfiguration of the networks is cost reduction (production, inventory holding cost, storage cost, handling cost, transportation cost etc.). Simchi-Levi et *al.* (2010) portray the three stages of network planning: 1) Network design: decisions on the number, locations, size of plants, warehouses, 2) Inventory positioning: facilities that will keep inventory and others that they will produce to order and 3) Resource allocation: whether production and packaging is done at the right facility.

Until now the logistics structure was based on the desired market, product characteristics and customer service (Stock and Lambert, 2001). However, different objectives can be considered when designing supply chains (e.g. reduce emissions). When planning a network, multiple criteria and objectives must be taken into account (Nagurney, 2009). Considering sustainability, the design of distribution networks relates to the distance that products have to travel to reach customers. Sustainable SC design has emerged and its focus is on integration of economic, environmental and societal decisions into the supply chain design (Chaabane et *al.*, 2012). However, the economic dimension will be the dominant one when designing a network (Carter and Rogers, 2008; Wognum et *al.*, 2011).

As far as NRS is concerned, it may force companies to design their networks based on the proximity to the scarce resources, which will have to be allocated efficiently and effectively.

Network position has a great impact on access to the resources of other members in the supply chain, reputation and expectations (Burt, 1997; Lenz, 1980), thus it is crucial this is taken into account when assessing and managing risk (Harland et *al.*, 2003). It is a crucial element in the supply chain as there is a commitment of resources for a long term (Santoso et *al.*, 2004). Through this stage organisations structure their supply chain and make a decision about their supply chain configuration (e.g. facility location, safety stock); how resources will be allocated and what processes will be performed at each stage (Chopra and Meindl, 2010).

As stated above, a company needs other companies to achieve its aims (manufacture, transport). Thus, dependencies are created in a network. Svensson (2004) support that structural choices, such as locations of factories and warehouses, decisions on supply chain partners lead to dependencies which in turn leads to vulnerability of supply chains and interdependencies provide the ground for collaboration to fulfil mutual or individual goals. According to Svensson, (2004), dependencies can be technical, time, social, economic, IT or knowledge, while Sheffi (2005) also highlights the infrastructure dependencies, such as electricity, gas, water, telecommunications that can result in significant vulnerabilities in the supply chain.

### 2.5.4 Dependence in Buyer-Supplier relationships

Croom et *al.* (2000) highlight ten variables that determine the nature of relationships between actors in a network such as the degree of power and influence of each company. Power refers to the influence of companies over other organisations that they do business with (Emerson, 1962) which is also related to the level of dependence in a dyadic relationship. The organisation that is the most dependent on the other party has the least amount of power (Caniels et *al.*, 2005).

Spekman et *al.* (1998) conclude that there are three main buyer-supplier relationships: 1) co-operation between companies that have longer-term contracts, 2) co-ordination that can be used as a strategy where companies exchange information and 3) collaboration strategy in which the supplier becomes a supply chain partner and there is a certain level of trust and commitment. Companies through joint venture have some interdependence as the manufacturing company and the supplier share their resources and expertise to achieve a particular goal that is to access the scarce natural resources.

If no company is superior the relationship is symmetrically interdependent as both parties are equally dependent on each other. When there is an imbalance in the level of dependence the relationship is an asymmetrically dependent relationship. For example, companies in order to determine the level of power or dependence can take a close look at the resources, if the company needs those resources then the company need to closely collaborate or vertically integrate or create a joint venture with the supplier to secure the accessibility to scarce resources.

There are several strategies that companies can follow to have access to resources. Williamson (1986) has categorised the strategies ranging from market transactions (no interdependence) through "relational exchanges or long term contracts" (some interdependence) to hierarchy (ownership or vertical integration). Vertically integration is a strategy that a company follows in order to retain ownership and/or control over the resources.

The following section provides a justification of utilising the RDT for the purpose of providing theory-based explanations.

## 2.6 Justification for the Theoretical Perspective

Fawcett and Waller (2011) propose that good theory is needed to face pressing challenges and to take advantage of opportunities that emerge in the field of supply chain management. Organisational theory is in the early phases in operations management and the SCM literature (Ketchen and Hult, 2007). The lack of theoretical development in logistics research has been highlighted numerous times (Carter and Ellram, 2003; Chicksand, et *al.*, 2012; Defee, et *al.*, 2010; Flint et *al.*, 2005; Glock and Hochrein, 2011; Kovács and Spens, 2005; Mentzer and

Khan, 1995; Mollenkopf et *al.*, 2010; Skjoett-Larsen, 1999; London, 2007) and identified as a key gap also in this study. Several theories (see Table 2.2) can be used in this research for supporting the development of a conceptual framework and propositions.

Table 2-2 Summary of theoretical perspectives

| **Dimensions for Comparison** | **Unit of analysis (Key themes)** | **Description** | **Originating Authors** |
|---|---|---|---|
| Resource Dependence Theory | Firm (transaction and structural relationship) | Resources are important in determining firms' behaviour (dependence and consequences). | Pfeffer and Salancik (1978) |
| Resource Based View | Firm (internal resources, capabilities) | Core competencies of a firm are key to strategic success. | Barney (1991) |
| Natural Resource Based view | Firm (natural environment, competitive advantage) | Strategic advantage is restrained by dependence on the natural environment. | Hart (1995) |
| Relational View | Networks and dyads of firms (collaboration) | Companies have to cooperate with other firms to establish relational networks for mobilising external resources. | Dyer & Singh, 1998 |
| Resource Advantage Theory | Firm (Competition is the struggle for advantages amongst rival firms) | Competitive advantage which yields superior financial performance. | Hunt (2000) |
| Population Ecology Theory | Population of organisations (longitudinal analysis ,examine the birth and mortality of firms) | The environment selects the organisational forms. | Aldrich and Pfeffer (1976) |
| Institutional Theory | Firm (cultural-cognitive, normative, and regulative elements) | The behaviour of an organisation is influenced by its institutional environment. | Powell and DiMaggio (1991) |
| Contingency Theory | Firm (organisational form, open systems) | Contextual factors are significant in firm performance | Woodward (1970) |
| Transaction Cost Economics | Transactions (Information costs, enforcement costs, bargaining costs) | Costs influence strategic decisions (governance structure for a specific transaction). | Williamson (1975) |

The Resource-Based View (RBV) is one of the most widely used approaches/theories in the strategic management field (Powell, 2001; Rouse and Daellenbach, 2002); it has its roots in economics. This theory can be applied in this study to develop the theoretical understanding of scarce resources in the supply chain and competitive performance. It is a theory that has been applied to determine the strategic resources available to an organisation and it is one of the most accepted theories in strategic management (Newbert, 2007). However, RBV has an internal focus whereas RDT has an external focus (Nemati et *al.*, 2010). This study considers scarce natural resources. RDT will be used to show how companies acquire new firms, create co-operations and merge with other firms in order to acquire these external scarce natural resources.

Hart (1995) proposed the Natural Resource Based View (NRBV) theory of the firm that takes into account the environment and attempts to reconcile the RBV. RBV does not take into account the constraints associated with the natural environment (Hart, 1995). As the earth's natural capital is depleted, organisations in the supply chain have to re-examine the processes, networks, products to use natural resources more efficiently for their own continued viability. NRBV is a theory of competitive advantage and it entails three strategies that are well connected with each other, pollution prevention, product stewardship and sustainable development. However, the focus of this research is on achieving interdependence. In the case of scarce natural resources the natural environment is not the only factor that must be taken into account. For example, government regulations can affect the accessibility to natural resources. The strategies RDT provides are more relevant in order to minimise the dependencies that arise due to scarcity of critical resources e.g. vertical integration and also these strategies are well connected with some contingency factors.

Resource advantage theory also is a theory that argues that organisations strive for comparative resource advantages; a resource to a firm is seen in terms of its potential to yield competitive advantage. However, companies will try to secure scarce natural resources to survive (business continuity) and gain competitive advantage by utilising these resources.

On the one hand Relational View (RV) supports fair investment of relation-specific assets and implementation of routines for collaboration (Waters, 2010). On the other hand, RDT focuses on asymmetric resource distribution in a social and political setting and how a powerful firm can use the dependency of others to fulfil its goals (Waters, 2010). Thus, the Relational View is trust-based and RDT is power based (Waters, 2010).

In this study RDT will be chosen because the topic is about scarce and strategic natural resources that are usually owned by countries, and companies try to control those resources by *"using power, position and role differences"* (Waters, 2010, p. 218). Competition for those critical resources may increase *"the risk of a downward spiral towards more competition and less trust"* (Lee et *al.*, 2012, p. 8).

Another theory that could be relevant in this study is the Population Ecology Theory (PET) that shows the effects of the environment on firm's forms and behaviour. PET shares the same concerns as RDT namely both recognise the significant role of environmental characteristics and changes in terms of scarcity or/and abundance of resources (Pfeffer and Salancik, 2003; Patti, 2000). By using the PET the level of analysis will be the population of organisations (a set of firms engaged in similar activities that use and compete for the same resources) and it requires longitudinal analysis as its purpose is to examine the birth and mortality of firms (Daft, 2010; Patti, 2000). This theory supports that environments change faster than firms, thus the performance of organisations is determined by the environment and not managers (Donaldson, 1995). PET takes the stance that the environment can determine whether or not a firm will survive that gives a reactive strategic behaviour to the organisation (Patti, 2000). Thus, this theory ignores power, conflict and the powerful impacts that firms have on their environments (Farazmand, 2002).

The Institutional theory also focuses on the impacts of the social environment on firms. This theory highlights social rules, norms and values as the cause of a firm's conformation rather than transactions and exchanges that RDT considers (Pfeffer and Salancik, 1978). RDT does not consider the issue of social and cultural mood in the organisational environment but it focuses on the technical (task) environment represented by resources, suppliers, and customers (Shehada, 2010).

RDT stems from the strategic contingency theory (Hatch, 2013). RDT takes environmental uncertainty and dependence as key antecedents for engaging in inter-organisational relationships (Nienhüser, 2008). The Contingency theory explains how managers adjust the organisational structure to minimise environmental uncertainty. Structure depends on certain characteristics called contingency factors such as strategy and size, and firms respond by increasing their organisational units, following business models of best practice companies etc. (Bevir, 2007). RDT is a contingency-based theory but emphasises how a company tries to minimise the dependence on the environment in the supply of rare resources by using different strategies such as mergers and co-optation (Nienhueser, 2008).

Contingency theory puts the emphasis on the internal organisation whereas RDT goes beyond and includes relationships between organisations such as mergers and co-optation (Kessler, 2013). RDT, due to the political aspect of this theory, entails the notion that firms respond upon their contexts not only in response to and try to affect other organisations which they are dependent for critical scarce natural resources (Clegg and Bailey, 2008). RDT takes the firms as an open system that has to manage external contingencies within a constantly shifting environment (Hillman et *al.*, 2009; Smith and Graetz, 2011). RDT advocates also that firms have to respond to uncertain external demands and expectations which show the importance of contingency models. Thus, organisations choice will be formed by external and internal pressures (Pfeffer and Salancik, 1978).

Lastly, transaction cost economics theory supports that organisational decisions are based on the cost of make or buy decisions. This theory maintains that *"if it's cheaper to obtain a resource by buying it, you do so instead of making it internally"* (Peters, 2009, p. 4). Thus the focus lies on the examinations of efficiency and cost structure whereas RDT highlights the need for firms to gain control over necessary external resources (Weber, 2002).

As it was stated in the above section the main objective of this study is to develop a framework for the conditions under which firms will emphasise specific strategies in order to minimise the dependency caused by the scarcity of natural resources. Also, the implications of the above strategies on organisational performance are investigated. RDT provides us with the sources and implications of the power of organisations embedded in networks of interdependencies that revolve around the control and dependence on critical external resources in the environment (Pfeffer and Salancik, 1978).

RDT provides a foundation to develop the conceptual model and examine the research questions and it is reviewed below. Thus, this study aims to explore how firms are interrelated with their external environment in order to have access to scarce natural resources and applies the RDT to build a model to explore the implications of the dependence that derives from NRS on the supply chain strategies of manufacturing firms and on their performance. In the following sections RDT will be discussed in depth and its applications to supply chain management will be presented in one of the sections.

### 2.6.1 RDT

RDT was developed by Pfeffer and Salancik's seminal publication in 1978 and it considers resource as a crucial element to implement corporate strategy and generate competitive advantages and explore the company from an external perspective. Despite the fact that RDT is a leading theory for understanding organisation-environmental relationships, it is not explored and tested as it could have been (Drees and Heugens, 2013; Casciaro and Piskorski, 2005; Pfeffer and Salancik, 2003; Stock, 2006).

*"The organization does not control the resources it needs"*, and resource acquisition will be *"problematic and uncertain"* (Pfeffer and Salancik, 2003, p.258). Companies need resources that are often owned by other companies and/or governmental authorities. Organisations are not self-sufficient and embeddedness in a network of relationships is a response to the uncertainty involved in a relationship and the resource dependence. The degree of dependency results from: 1) the importance of the resource 2) supplier substitutability and 3) discretion over the resource.

Dependency should be handled through the implementation of safeguarding mechanisms (Heide and John, 1990). Thus, organisations will try to minimise instability and uncertainty in their supply of resources, but also firms will try to stay independent by their environment (Holm, 2008). Firms make economically rational decisions without taking into account any cultural, ideological, and institutional forces (Eiriz and Wilson, 2006). More specifically, a firm will follow buffering strategies (dependency reduction) and/or bridging strategies (dependency restructuring) (Green and Welsh, 1988).

Considering buffering practices, it entails inventories or altering the structure and goals of the firm in order this resource will no longer be required (Pfeffer and Salancik, 1978). Thus, in this strategy companies try to find alternatives or other sources of supply (Brockhaus et *al.*, 2013). According to Pfeffer and Salancik (1978, p. 108) *"Generally, the more unstable the source of supply, the larger the inventory must be"*. In the supply chain management field there are two main types of inventories: the base stock and the safety stock. The former is the inventory that is replenished after it is sold to customers. The latter is the inventory that firms hold to protect against the impact of uncertainty. Thus, this study will refer to the safety stock.

Another way to minimise the resource importance is to alter the structure and purposes of the organisation. The practice of substitution can be used where firms are trying to find alternative materials that are more abundant. Another practice is recycling of these materials at the end of life. NRS will lead companies to (re)-design their process and product in order not to use or to use less of the scarce resources. When a firm does not directly own, or even control scarce natural resources they would like to alter the shape of the network. This involves reconfiguring the network in order to change the scope of the activities performed such as relocate the facility plant in order to have access to scarce resources.

On the other hand, bridging strategies are used when a firm uses approaches such as vertical integrations, joint ventures to move from one type of dependence to another (Hillman et *al.*, 2009; Brockhaus et *al.*, 2013). Thus, the company is dependent on external resources and this dependency can lead to acquisitions, mergers, co-operations and strategic alliances. Bridging entails long-term contracts that establish supply and price over an extended period, and/or partnerships and joint ventures (Jaffee, 2001).

Thus, this theory is useful as it will provide the managerial supply chain NRS strategies (buffering strategies and/or bridging strategies) to minimise the dependence that derives from strategic scarce natural resources.

### 2.6.2 Applications of RDT to Supply Chain Management

Several authors discuss implications of this theory for crucial aspects of supply chain management (Crook and Combs, 2007; Ireland and Webb, 2007). The table in appendix 1 classifies and summarises these previous studies that have applied the lenses of RDT in the field of supply chain management. Most specifically this theory has already been used to investigate collaboration, bargaining power in times of uncertainty in the field of supply chain.

Handfield (1993) relies on RDT in order to develop a framework and to explain the relationship between just–in-time, purchasing systems and the transaction uncertainty. He proposed that environmental and transaction uncertainties determine the type of the buyer-supplier relationships. Ireland and Webb (2007) have drawn on social capital theory, RDT and transaction cost theory (TCT) to find the relationship between trust and power in supply chains. Paulraj and Chen (2007) based on the RDT study the relationship between environmental uncertainties (demand, supply and technology) and strategic supply management. Supply management tries to cope with strategic weakness through collaboration. RDT supports cooperation among partners to produce mutual benefits. This collaboration leads to accessing unique resources and environmental uncertainties are positive related to integration.

RDT is supported in the SCM field as supply chain members that collaborate often become more dependent on each other (Ketchen and Hult, 2007). RDT is applied to find which factors increase the power over the buyer and what mitigation strategies can be followed (Petersen et *al.*, 2008). According to Petersen et *al.* (2008) both buyer dependency (on a supplier) and socialisation are crucial in shaping relational capital. Lately, Carter and Rogers (2008) developed some propositions based on RDT, transaction cost economics, population ecology, and the resource-based view in the field of sustainable supply chain management. In this study they found a positive relationship between resource dependency and vertical integration in the supply chain.

Based on the work that has already been done in the field of supply chain, uncertainty that arises from NRS has not been studied until now. Scarcity of resources results in power relations between the company and its external environment. Firms can gain control over resources through vertical integration or long-term contracts and minimise external dependency. Within RDT, uncertainty is a major concern. Another limitation of previous studies in supply chain management is the focus on bridging strategies such as vertical integration. Bode et *al.* (2011) referred to both strategies but did not empirically test and operationalise the context of buffering and bridging strategies. This study proposes the adaptation of both buffering strategies and/or bridging strategies.

Thus, RDT is particularly relevant for this study as it will help in understanding how supply chains adapt to uncertainty that rises from NRS and manage resource flows and interdependencies by using buffering or bridging strategies. By using these strategies this study will also try to find the implications for organisational performance.  RDT supports that managers are vital in making decisions about resource acquisition and responses of the firm to the environmental pressures (Farazmand, 2002). RDT also focuses primarily on specific firms settings (Baum and Oliver, 1991). According to RDT, environments change and reflect the practices taken by the firms to handle the issue of interdependence (Pfeffer, 1982). Thus, the ability of a firm to survive depends on appropriate proactive strategic choices that will lead the firm to adapt and ensure its survival (Patti, 2000).

## 2.7 Summary of research gaps

Several motivations to this research have been identified in practice and are supported by the review of the literature. The overarching research question can be articulated around three research questions that fill in research gaps as shown in Table 2.3.

Table 2-3 Research gaps and questions

| ***Overarching Research Question:***<br>What the impact of NRS on manufacturing supply chains? | ***Overall Research gaps filled:***<br>• Lack of conceptual framework and empirical work regarding the NRS in the field of supply chain management<br>• Limited applications of RDT to supply chain management. |
|---|---|
| **Research questions** | **Research gaps filled** |
| Natural Resource Dependence Level<br>R1: What are the factors that determine the dependence on scarce natural resources? | • Lack of contingency factors that change the level of dependence and shape supply chain strategies. |
| Supply Chain NRS strategies<br>R2: What are the supply chain strategies that organisations apply to overcome or minimise dependence? | • Lack of a coherent set of strategies and focus just on recycling as a mitigation strategy. |
| Organisational Performance<br>R3: What are the implications for organisational performance of these strategies? | • Lack of understanding of the impacts of strategies on resource efficiency and competitive advantage. |

# Chapter 3 CONCEPTUAL FRAMEWORK

## 3.1 Introduction

Having identified the gaps in the literature, this study now develops and proposes a framework in order to address these gaps as well as, the research questions identified in Chapter One. Given the current state of research on NRS in the field of supply chain management, a theory building perspective is taken, which is crucial at this stage of the discipline development (Bell et *al.*, 2012).

RDT provides a useful foundation to develop the conceptual framework. A firm needs natural resources to operate and the lack of self-sufficiency of these natural resources will lead to dependence on other firms. Accordingly, firms will apply specific strategies in order to minimise or overcome dependency and to improve their performance. As shown in Figure 3.1, the framework, analyses the causal relationships among the three main constructs: Natural Resource Dependence Level, Supply Chain NRS Strategies and Organisational Performance.


Figure 3.1 Overall Conceptual Framework

The first part considers the natural resource dependence level, which is the degree of dependence of a company on the scarce natural resource and it represents the independent variable of the study. The second part is concerned with the supply chain NRS strategies, which are the strategies that companies use to manage the issue of NRS and to influence the relationship between the natural resource dependence level and the organisational performance, which is the third part of the framework. The instrument development stage is described in chapter 4. Detailed conceptualisation of each part of the developed framework and measurement scales are provided in the following sections.

## 3.2 Natural Resource Dependence Level

Based on Pfeffer and Salancik (1978) there are three factors that determine the resource dependence level: 1) the importance of the resource 2) supplier substitutability and 3) discretion over the resource.

Whilst most of the studies highlight mainly the first two factors (e.g. Bourantas, 1989; Caniels and Gelderman, 2005), in this research all three factors will be taken into account. The third factor is important in this research as companies can face issues regarding the discretion over the natural resource. For instance concerning government regulations, if China bans the exports of rare earth metals in 2015, manufacturing firms may have a low degree of discretion over the rare earth metals. Thus, discretion over the scarce natural resource can alter the level of natural resource dependence.

### 3.2.1 Importance of the scarce natural resource

Pfeffer and Salancik (1978) define the importance of the resource as the criticality of the resource and the relative magnitude of the exchange. Bourantas (1989) measures the importance of the resource based on relative magnitude, the functional cruciality of a resource and the strategic cruciality of a particular resource. The relative magnitude of the exchanged resources can be measured by the proportion of total resources accounted for by the exchange and the financial magnitude (Caniels and Gelderman, 2005; Pfeffer and Salancik, 1978). The criticality refers to the ability of an organisation to continue functioning without the resource (Caniels and Gelderman, 2005).

In this research, some natural resource attributes may determine the importance of a given natural resource. Resource is critical when it cannot be substituted (PwC, 2011). Silva et *al.* (2013) highlight the need of replacing non-renewable resources (exhaustible resources) by renewable ones. For instance, non-renewable energy sources such as fossil fuels can be replaced by renewable energy sources such as wind and solar energy, and biomass fuels. However, water, which is a renewable resource, has no substitute, which means that strategies such as recycling would be more appropriate. Thus, substitutability (i.e. the ability to substitute one resource with another) can make a natural resource more critical than other natural resources, but it can also differentiate the strategy chosen by firms to manage the issue of NRS.

Concerning renewability, renewable resources are replenished regularly, such as water if properly managed. Non-renewable resources are fixed in supply and cannot be regenerated quickly enough or at all such as metals. However, there are some renewable natural resources (e.g. water) that, in specific regions for example, are consumed at a rate that exceeds the rate of replacement. Recycling can extend the life of a depletable natural resource. Recycling potential refers to the recycling rate of a certain material. Thus, apart from substitutability, the higher recycling rate makes a natural resource less critical (Cullbrand and Magnusson, 2011).

### 3.2.2 Supplier Substitutability of the scarce natural resource

The second dimension is the supplier substitutability, the extent to which the natural resource that is provided by one supplier can be provided by others (Pfeffer and Salancik, 1978). It refers to *"the availability issue as well as the cost incurred when replacing a trading partner (switching cost)"* (Gelderman and van Weele, 2003, p. 5). When supplier markets are highly competitive, firms can acquire resources from different suppliers. In contrast, oligopolistic markets lead to a higher degree of uncertainty. Thus, the availability of alternative suppliers plays a significant role in the level of dependence (Pfeffer and Salancik, 1978) and this can directly influence how industrial buying is pursued: for example, what type of relationship is formed (Cannon and Perreault, 1999).

Besides the availability of alternative suppliers, switching costs can also make the replacement of a supplier difficult (Heide and John, 1990). Switching costs occur when having to terminate the relationship with the current supplier and secure an alternative for purchasing the same resources (Porter, 1980). For example, the time and effort for selecting a new supplier and the uncertainty related to its performance are obstacles for switching (Whitten and Wakefield, 2006). Richardson (1993, p. 344) supports that *“when no alternative supplier can be found or developed, the switching cost is essentially infinitely high”*.

Academics refer to supplier substitutability from two perspectives: the availability of alternative suppliers and the switching costs between suppliers (e.g. Caniels and Gelderman, 2005). Geyskens et *al.* (1996) also referred to the availability of alternative suppliers, whilst Kim (2001) highlighted the difficulties in finding alternatives suppliers and to compensate for the loss when switching supplier for a specific product line.

### 3.2.3 Discretion over the scarce natural resource

Concerning the discretion over the natural resource, discretion over the resource X can be determined by 1) the ownership of resource X, the ability 2) to access and 3) use resource X. Discretion can be hindered by government regulations (e.g. Chinese government banned rare earth metals exports to Japan), competition for scarce natural resources etc. (Pfeffer and Salancik, 2003). Resource ownership is related to the fact that whoever possesses the resource has power over how that scarce natural resource will be utilised and thus, it is an absolute discretion of a resource (Pfeffer and Salancik, 2003).

Competition can decrease resource access that means there is a difference between access to resources, and the presence of resources (Carter and Stanley, 2007). However, a firm can have access (i.e. to have the ability to obtain and use) to scarce natural resources without owning them. According to RDT, access to a resource can compensate for the absence of possession in some cases. Thus, accessibility to the natural resource gives a firm the opportunity to use the resources (Lavie, 2006).

Government regulations also determine the allocation and usage of the resources. Concerning natural resources, the usage can be hindered by government regulations regarding the scarce natural resource. Natural resources can be found in specific regions and they may be controlled by the government who in turn may ban exports to other countries, for instance China banned exports to Japan for rare earth metals (Blakely et *al.*, 2012), or even legislation can be made in the production country that the focal firm exists that allows a specific amount of natural resources to be used. For instance, the CRC Energy Efficiency Scheme (CRC) is a mandatory government scheme in the UK that leads large private sector organisations to become more energy efficient in order to reduce their $CO_2$ emissions (Department of Energy and Climate Change, 2014).

Based on the above in this research the discretion over the scarce natural resource can be defined as the ***ownership of the scarce natural resource,*** the level of ***accessibility*** of the manufacturing company ***to the scarce natural resource,*** and the ***usage of the scarce natural resource.***

According to RDT, organisations could minimise and/or overcome their resource dependence by using ***buffering and/or bridging strategies*** (Leonardi, 2013; Scott, 2003). Buffering and bridging activities are not mutually exclusive (Fennell and Alexander, 1987). For instance, an organisation may increase its safety stock (buffering) of strategic natural resource, while simultaneously establishing collaboration (establishing better information exchange) with a supplier of this scarce natural resource (bridging) (Bode et *al.*, 2011).

In the following section the buffering strategies and bridging strategies are discussed in depth.

## 3.3 Supply Chain NRS Strategies

Appropriate supply chain strategies are contextual and structured based on the characteristics of a specific environment. Firms adapt to changing circumstances and there is a discretion regarding the strategies that organisations adopt, *"although the degree of choice is often severely constrained by resources or circumstances"* (Kitching *et al.,* 2009, p. 12). RDT suggests that the above factors that determine the level of the natural resource dependence lead to either buffering and/or bridging strategies. Concerning the importance of the scarce natural resource, it is supported that ***buffering strategies*** are appropriate (Van Leeuwen, 2007, p. 68). For instance, when availability of critical resources is uncertain, firms often stockpile them. Considering the second and the third factors that determine the natural resource dependence level, ***bridging strategies*** that entail long-term contracts are proposed (Van Leeuwen, 2007, p. 69).

In the following section the buffering strategies and bridging constructs are developed.

### 3.3.1 Buffering strategies

Buffering strategies are used to minimise the importance of the valued resource and thus the level of resource dependence by altering or minimising the resources used for production (Bode et *al.*, 2011, Leonardi, 2013; Scott, 2003; Tang, 2006). The goal of the buffering strategy is also to "*gain stability by establishing safeguards that protect a firm from disturbances that an exchange relationship confers"* (Bode *et al.,* 2011, p. 834). Buffering strategies entail the use of flexible production processes, product designs and safety stocks or a higher level of inventory (Bode et *al.*, 2011) and they are often employed when a firm face uncertainties that hinder the production processes (Carlile et *al.*, 2013).

Product and processes (re-)configuration is followed by companies in order to reduce the natural resource usage (Delmas and Pekovic, 2013; WRAP, 2010). For instance, companies are recycling a natural resource, which is converted into new materials and products. Firms need to understand the benefits they would gain if they concentrate on their product and processes (re-) configuration simultaneously with the supply chain configuration decisions (Fine, 1998).

Concerning ***supply chain configuration***, safety stock is a common buffering strategy that is followed in order to minimise the dependence on resources (Bode et *al.*, 2011; Leonardi, 2013; Su et *al.*, 2014). Apart from the inventory decisions (tactical decisions) regarding the supply chain configuration, facility location decisions (strategic decisions) need to be considered. As far as NRS is concerned, it may force companies to design their networks based on the proximity of the scarce natural resources or to relocate factories in other regions in order to access scarce natural resources.

In the following section the product and processes (re-) configuration and supply chain configuration are analysed as the main sub-constructs of the buffering strategies.

#### 3.3.1.1 Product and process (re-) configuration

There has been of growing interest in the natural environment in the last decade, which leads to (re-) configuration of existing products, to develop new ones, which are more energy efficient and use less raw materials (Huang et *al.*, 2009; Shrivastava, 1995). In the supply chain, the efficient use of natural resources is widely used and achieved by implementing several strategies in order to reduce the footprint of industrial activities (Kounetas and Tsekouras, 2008).

This strategy is concerned with the configuration of products and process in order to reduce the use of non-renewable natural materials and to use renewable resources in accordance with their rate of replenishment (Lenox and Ehrenfeld, 1997). Eco-design (Knight and Jenkins, 2009) has to do with the systematic incorporation of environmental considerations into product and relevant manufacturing process design to enhance the environmental and economic performance of an organisation and leads to a competitive advantage (Lenox and Ehrenfeld, 1997).

Companies apply these strategies as a solution to resource scarcity (Kling, 2013; PwC, 2011) as they can conserve natural resources (Gungor and Gupta, 1999; Sundarakani *et al.,* 2010). Thus, organisations need to configure their products by using materials with a high recycling rate and substitutes should be used and the abuse of products should be actively avoided (Tsoulfas and Pappis, 2006). The strategies that companies can employee in the phase of product and process (re-) configuration are (Singhal, 2012; Eltayeb and Zailani, 2009):

- reducing the amount used
- substitution (e.g. the use of renewable sources of energy)
- adding reused or recycled resource in the products

- making easier the disassembly of the waste product, separation of parts according to material, and reprocessing of the material.
- recycling (e.g. water, metals)
- returning back to suppliers
- collecting back used products from customers
- remanufacturing (the use of parts “as-is” or after minor repairs or overhauls)
- energy recovery: the conversion of non-recyclable waste materials into useable heat, electricity, or fuel

#### 3.3.1.2 Supply Chain (re-)configuration

Another important aspect of the supply chain strategy is the supply chain configuration (Delfmann and Thorsten, 2007). Supply chain configuration has to do with the network design and inventory decisions and deals with supply chain infrastructure which often needs to be reconfigured due to changes in supply/demand patterns, cost of running facilities etc. (Simchi-Levi et *al.*, 2010). Supply chain configuration can be defined as the decisions regarding the facility location and the safety stock in order to secure and to access the scarce natural resource that a manufacturing firm needs to operate.

With facility location decisions, the main rationale behind the configuration of the networks is to reduce costs (production, inventory holding cost, storage cost, handling cost, transportation cost etc). One of the main issues in supply chain configuration is supply chain structuring in accordance with a given supply chain strategy and uncertainty (Ivanov, 2009). Network position has a great impact on access to the resources of other members in the supply chain, reputation and expectations (Burt, 1997; Henders, 1992; Lenz, 1980),and therefore it is crucial to be taken into account when assessing and managing risk (Harland et *al.*, 2003).

Concerning inventory decisions, organisations keep an inventory of strategic parts that is called safety stock (Gilbert and Gips, 2000). Safety stock protects a firm against uncertainty such as unreliable supplier lead times or shortage of a specific resource. Many researchers have argued that safety stock can mitigate the negative impact of supply chain disruptions (Christopher and Peck, 2004; Tomlin, 2006; Tang and Tomlin, 2008; Sheffi, 2006). Thus, by increasing the inventory of scarce natural resources the continuity of the production can be assured.

In the next section, the bridging strategies are discussed.

### 3.3.2 Bridging strategies

Whilst in the case of buffering strategies an organisation keeps suppliers at a distance, bridging strategies *“involves developing relationships and formal connections with other organisations”* (Jaffee, 2001, p.220). In order for companies to acquire critical scarce natural resources, they need to interact with other actors that control those resources.

There are various types of business relationships. Some authors are using qualitative variables such as poor relationship, bilateral relationships (Humphries et *al.*, 2007, Tangpong et *al.*, 2008,) while others classify the relationships in terms of content variables such as contractual, administered (Rinehart et *al.*, 2004), coordination (Duffy, 2008) and Type I (Lambert et *al.*, 1996). Content-based typology is more objective and the practical interpretation will be easily measureable.

Buyer-supplier relationships are often conceptualized as existing on a continuum ranging from market transactions or arm’s length transactions and ending at vertical integration (Cousins, 2002; Cox, 1996; Cox and Lamming, 1997, Lambert *et al.*, 1996; Spekman *al.*, 1998). Figure 3.2 illustrates the most common typology used based on Lambert et *al.* (1996).

Figure 3.2 Vertical integration and Buyer-supplier Relationships (Lambert et *al.*, 1996; Spekman et *al.*, 1998; Mena et *al.*, 2009)

| | | | | | |
|---|---|---|---|---|---|
| Spot market/Arms' length | Type I (Cooperation) | Type II (Coordination) | Type III (Collaboration) | Joint Venture | Vertical Integration |

According to Spekman *et al.* (1998), spot market does not entail any integration between the companies and the negotiation based on price rather than improvement discussion. Arm’s length relationships involve single or multiple transactions in an environment where trust and commitment have no place but are based on price-based negotiations (Lambert et *al.*, 1996). Partnership is a relationship that tries to build interdependence, achieve shared goals which involves sharing benefits and burdens over some agreed time horizon (Cooper and Gardner, 1993). In partnerships buyers and sellers agree to share information, benefits and risks. Lambert et *al.* (1996) argued that partnerships lead firms to trust each other and share risks and benefits and thus to gain competitive advantage and to enhance financial performance. Combining the above definitions a partnership can be defined as a short or long-term and stable relationship to share resource (e.g. natural resources) risks and benefits. Partnerships can differ in duration, strength and closeness.

Lambert *et al.* (1996) categorise partnerships in three types, Type I – operational partnership or cooperation (fewer suppliers than the arm's length relationship) entails short-term approach and some degree of coordination besides negotiating price and quantity. Type II – coordination partnership has long term approach and some integration of activities is involved, Type III – strategic partnership or collaboration which emphasises a high level of operational integration as each firm perceive the other as an extension of their own organisation.

Joint ventures are relationships with some degree of shared ownership while there is no shared ownership in partnerships (Cooper and Gardner, 1993; Lambert et *al.*, 1996). The final part of the continuum is vertical integration or hierarchy which entails *"two or more parties involved in a transaction becoming one, either through a merger of the organisations, the acquisition of one organisation by the other, or through one organisation deciding to perform a function in-house that has traditionally been outsourced"* ( Patterson, 2005, p.24).

The above typology can also be classified as market-hierarchy continuum (Williamson, 1975) where market is the arm's length relationships and hierarchy is the vertical integration. Humphries (2003) also categorise Lambert's typology to transactional mechanisms (arm's length relationships, cooperation and coordination) and relational relationships (collaboration and joint ventures). Liu et *al.* (2009) define the transactional mechanism as a formal contract for safeguarding transaction-specific assets whereas a relational mechanism entails the aspects of trust and relational norms.

Bridging entails long-term contracts that establish supply and price over an extended period ***(transactional mechanisms)***, or/and partnerships and joint ventures ***(relational mechanisms)*** that *“brings together the managerial personnel from different firms and contributes to a perception of common interests between the interdependent entities”* (Jaffee, 2013, p.11). Arm’s length relationships will not be considered in this research as it is a purely transactional relationship for simple products, a great deal of suppliers, discrete transactions and one time transactions (Wagner and Boutellier, 2002).

Another bridging strategy is vertical integration ***(hierarchy)*** *“in which, for example, a producer buys out a supplier and gains control of the critical resource”* (Jaffee, 2013, p.11). In this research the third bridging strategy will be referred to as hierarchy mechanism. Vertical integration can be backward and forward. Backward integration refers to the manufacturing companies’ acquisition of inputs or raw materials from their suppliers, so the acquisition by a car manufacturer of a component manufacturer can be achieved by backward integration (Johnson and Scholes, 2002). Forward integration refers to the development of activities which are concerned with a company’s output such as transport, distribution (Johnson and Scholes, 2002). Thus, the first form, the manufacturer/supplier integration is under exploration as due to NRS the emphasis will be to ensure that the required raw materials or components for manufacturing are made available on time and in the right quantities.

## 3.4 Organisational Performance

In the literature, organisational performance refers mainly to the financial aspect as a final economic goal for firms (Li et *al.*, 2006). Past studies have been centred around financial metrics such as return on investment (ROI), market share, profit margin on sales, the growth of ROI and/or sales, the growth of market share (Li et *al.*, 2006; Sanchez and Perez, 2005).

However, other researchers proposed that there are limitations in looking just at the financial performance (Li et *al.*, 2006).

Researchers have advocated the dimensions of both effectiveness and efficiency for measuring organisational performance. Effectiveness is about meeting customer requirements, while efficiency measures how economically a firm's resources are used. Long-term objectives focus on the improvement of efficiency and effectiveness and many researchers use these measurements (e.g. Lee et *al.*, 2007; Tan et *al.*, 1999).

Performance measurement can be defined as the process that can be used in order to quantify the efficiency and effectiveness of action (Neely et *al.*, 1995). Performance measures can be used to quantify the efficiency and effectiveness of an action (Neely et *al.*, 1995). Thus, a performance measurement system is a set of metrics that a company can use to quantify the efficiency and effectiveness of their actions (Neely et *al.*, 1995). The measurement can show the implications of strategies and potential opportunities in supply chain management. It reflects the need for enhancement in areas with unsatisfactory performance (Bhagwat and Sharma, 2007).

Beamon (1999) emphasised on three types of performance measures for manufacturing supply chains: output measures (customer responsiveness, quality, and the quantity of final product produced), flexibility measures (ability to respond to fluctuations from suppliers, manufacturers, and customers) and resource measures (total cost, distribution cost, manufacturing cost, inventory cost (e.g. waste or scrap), and return on investment, energy usage) (Kurien and Qureshi, 2011; Tjader et *al.*, 2014). A few researchers apply this three-part framework to their studies (e.g. Angerhofer and Angelides, 2006; Persson and Olhager, 2002).

Efficiency addresses the relationship between the output of goods and the resources used to produce them (Lysons and Farrington, 2006). Efficiency is concerned with the present state and adding or eliminating any resources can change the current state of efficiency.

Effectiveness measures the relationship between the intended and actual results of projects (Lysons and Farrington, 2006). Effectiveness tries to meet the end goal. It mainly focuses on customer satisfaction such as delivery time and right quantity and focuses on the long term strategy. Cost-related advantage is achieved through efficiency whereas effectiveness is an advantage of customer responsiveness (Borgström, 2005). Effectiveness will therefore not be discussed as the focus of this research is on the minimisation or avoidance of the scarce natural resources, which are the inputs, to reduce the cost of resources in the manufacturing plants.

Flexibility refers to the ability of a system to change in order to fulfil customer orders. However, once again this will not be measured as flexibility, i.e. the adaptability of the company for future changes, as it is more difficult to be measured as managers do not usually have a comprehensive view of flexibility (Dhiaf et *al.*, 2012). One reason for the above issues is that flexibility measures potential behaviour whereas efficiency (and effectiveness) measures operational objectives *"that are actually demonstrated by the system's operating behaviour"* (Beamon and Balcik, 2008, p.18).

In this research the measures that are more relevant focus on the efficiency as companies try to minimise or avoid the use of specific scarce natural resources by applying specific strategies. Efficiency refers to the proper utilisation of resources such as waste minimisation (Bourlakis et *al.,* 2014). The indicators that measure the efficient use of resources are important for firms in order to be profitable and are focused on resource minimisation (Beamon, 1999). Resource measures assess the efficient level of resources used to meet the goals such as the costs of using resources, manufacturing cost, inventory levels in the supply chain, and the return on investments (ROI). Output measures are concerned with customer responsiveness. Flexibility is the ability to respond to uncertainty and the measurement is related to volume changes, distribution (delivery changes), responsiveness, product and/or new product introduction.

Thus, the focus in this study will be on resource efficiency that entails resource measures and can be defined as producing the desired quantity of products with the minimum amount of scarce natural resources and waste. By using natural resources more efficiently companies can also gain a competitive advantage (The Scottish Government, 2013). Many authors support that effective supply chain practices can lead firms to competitive advantages (Li et *al.*, 2006; Tracey et *al.*, 2005).

Thus, this research takes a closer look at the implication of supply chain NRS strategies not only for ***resource efficiency,*** but also for the ***competitive advantage***.

### 3.4.1 Resource Efficiency

Resource efficiency focuses on the use of resources and apart from reducing environmental impacts it also tries to minimise the risk of scarcity and the security of supply of resources (BIO Intelligence Service, 2012). Resource efficiency include measures such as minimising energy consumption, reducing the amount or quantity of material and natural resources required to produce a unit of economic output or services (Delmas and Pekovic, 2013).

Matopoulos et *al.* (1015) conclude that supply chain resource efficiency consists of resource awareness, resource sparing, resource sensitivity and resource responsiveness. There is no agreed definition for resource efficiency among academics (e.g. Huysman et *al.*, 2015), but it refers *"to the economic efficiency and the environmental effectiveness with which an economy or a production process is using natural resources"* (OECD, 2008, p.155). Thus, resource efficiency will be measured in this research with the dimensions of the environmental performance and economic performance (see Table 3.14).

Environmental performance is the impact of a company's operation and products on the natural milieu (Sharma and Vredenburg, 1998). By using resource efficiency strategies companies can produce less waste for example by using the strategy of recycling and thus energy, water and by-products can be used in a more efficient way (Tsoulfas and Pappis, 2006). Zhu et *al.* (2007) found that enterprises implementing green supply chain management practices in China have only slightly improved environmental and economic performance. However, Klassen and Mclaughlin (1996) supported that environmental performance positively affects financial performance. These studies differ from each other which may be due to the heterogeneity of the practices adopted by companies and industries (Elsayed and Paton, 2005).

### 3.4.2 Competitive Advantage

According to Bell et *al.* (2013), apart from the advantages in short-term efficiency goals (i.e. resource efficiency and transactional cost savings), companies can gain operational competencies by securing scarce resources (i.e. competitive advantages in the market). Operational competencies *"include the purchase of scarce natural resources, the transformation of those resources, and the delivery of the resulting products and services"* and can secure needed external natural resources which will lead to future competitive advantages (Bell et *al.*, 2013, p. 15). Competitive advantage is the ability of a firm to *"create a defensible position over its competitors"* (Li et *al.*, 2006). The evaluation of one's industry and resources is crucial in order for a firm to gain a competitive advantage. *"A firm is said to have a competitive advantage when it is implementing a value creating strategy not simultaneously being implemented by any current or potential competitors"* (Barney, 1991, p. 102).

Also, RDT focuses on changes to achieve accessibility or ownership of strategic scarce resources which will provide a firm a distinctive edge over competitors. Resource efficiency strategies, like product configuration which entails product *innovation "works through a redefinition of what is required to achieve a competitive advantage"* (Abernathy and Clark, 1985, p. 6). The main aspects of enhancing supply chain competitive advantage entail the minimisation of customer service cost (e.g. Jones and Riley, 1985), improving customer service through minimising order cycle time and increasing the availability of stock (e.g. Cooper and Ellram, 1993), developing innovative solutions (Ross, 1998), cost reduction.

## 3.5 Propositions Development

In this section the propositions are presented (see Figure 3.3 and Figure 3.4). Based on RDT theory a conceptual model that is divided into three parts and its propositions are developed. The first part identifies the natural resource dependence level. Based on Pfeffer and Salancik (2003) the resource dependence level is determined by three dimensions namely the importance of the scarce natural resource, supplier substitutability and discretion over the scarce natural resource.

The second part deals with the supply chain related strategies that companies may adopt to minimise the resource dependence level. RDT suggests that the above factors that determine the level of the natural resource dependence lead to either buffering and/or bridging strategies. The third part of the framework addresses how organisational performance can be affected by the adoption of supply chain strategies. The conceptual framework (Framework 1) was initially derived from the literature and in the sections below is further refined with the findings of the cross-analysis. This exploratory phase (Chapter 5 and Chapter 6) validate the framework that shows the links between natural resource dependence level, supply chain NRS strategies and organisational performance and propose an updated conceptual framework (Framework 2) at the end of Chapter 6 that is used in the second phase where a survey method was conducted.

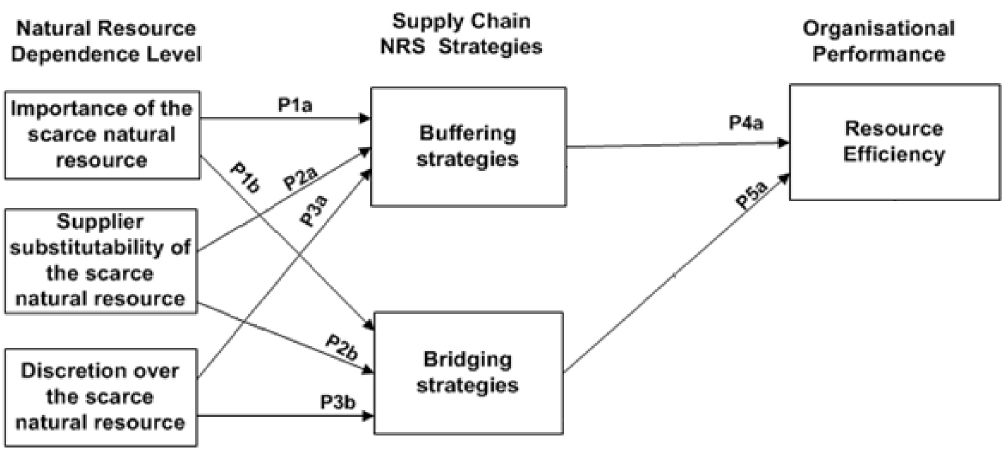


Figure 3.3 Research Framework 1

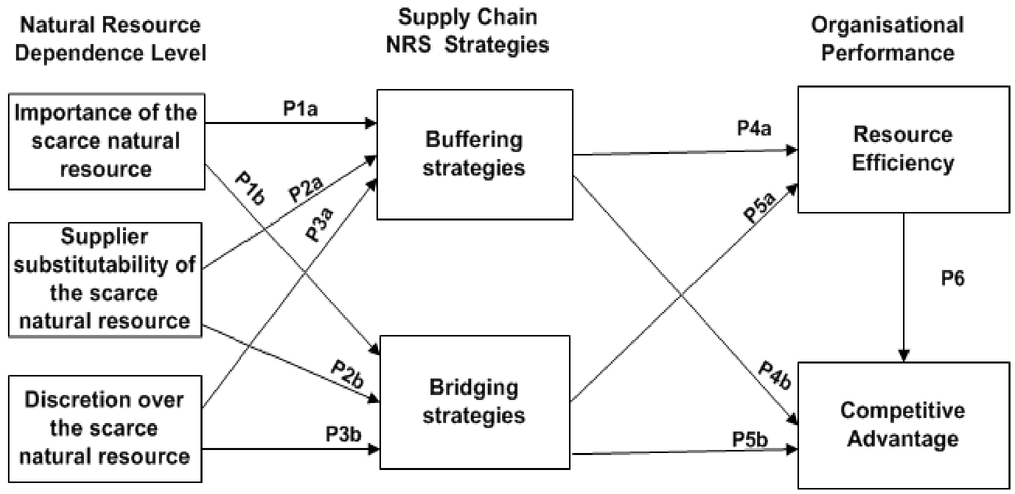


Figure 3.4 Research Framework 2 after the empirical data

## 3.5.1 Natural Resource Dependence Level and Supply Chain NRS strategies

### 3.5.1.1 Importance of the scarce natural resource

When prices for a certain material increase, firms search for substitutes. Substitutability of materials is a key factor of market prices of raw materials (Ecorys, 2012). According to Pfeffer and Salancik (1978), an organisation that owns scarce valuable resources, that cannot be easily replaced, is in a powerful position. Companies that cannot find substitutes may alter the structure or inputs. This can be achieved by using buffering strategies, such as recycling, safety stocks and by minimising the resource use.

For instance, there is no alternative for water. For, AnheuserBusch InBev, a beer producer based in the USA, water is a critical element in their production process and the company is trying to reduce water usage in its plants. In a similar vein, SABMiller aims to reduce the water used per litre of beer by 25% by 2015 (Kissinger, 2013). Thus, organisations may adopt resource efficiency strategies as they are related to a cost-saving process and product innovation. Organisations need to design their products by using materials with a high recycling rate (Tsoulfas and Pappis, 2006) especially for material that are non-renewable.

Non-renewable are the resources that are renewed at a really low rate if they are replenished at all (Wenzel et *al.,* 1997). Developed nations and firms are dependent on non-renewable energy sources such as fossil fuels (coal and oil). Renewability is really crucial when it comes to resource scarcity (Lin and Lin, 2003). Product designers may be motivated to minimise the use of such resources by substituting them with other natural resources or by using recycled materials (Lin and Lin, 2003). For instance, alternative sources of energy like solar and wind energy can be used on a large scale to substitute for fossil fuels. Recycling plays a crucial role for the competitiveness and security of supply for several resources (Ecorys, 2012).

**Proposition 1a:** The importance of the scarce natural resource has an impact on the adoption of buffering strategies.

**Proposition 1b:** The importance of the scarce natural resource has an impact on the adoption of bridging strategies.

#### 3.5.1.2 Supplier substitutability of the scarce natural resource

Competition decreases access to resources meaning that there is a difference between the access to resources, and the presence of resources (Carter and Stanley, 2007). If a resource is important, but there are many suppliers that offer this resource the focal firm will not be dependent on any of them. In other words, the extent to which input transactions of the manufacturing company are made by many or few suppliers is a significant factor.

When only a limited number of suppliers sell a resource, concentration and uncertainty increases because the dependence on a smaller number of suppliers that control most of the resources is increased (Pfeffer and Salancik, 2003). Pfeffer (1972) supports that the relationship between concentration and uncertainty is curvilinear. When there is not so much concentration, less uncertainty is faced by firms as individual firms are inconsequential to the other firms. When concentration increases (e.g. in oligopolistic market structures) there is high uncertainty. A firm is less dependent on a resource if it is readily available in different or multiple suppliers. Firms who compete for input materials that are not sufficient to satisfy everybody’s needs are in a situation of competition for these resources.

Competition has been identified as one of the important drivers of NRS (Bell et *al.,* 2013). For instance, the competition for water can be faced between the agricultural and the automotive industry due to scarcity of this resource. Bell et *al.* (2013, p. 34) asserts that: *"The resource-factor market is a growing competitive arena in which firms seek to gain advantage over rivals by securing scarce resources and by attacking their competitors' factor markets to prevent access to valuable resources"*. López-Gamero et *al.* (2011) supports that when the resources are scarce firms compete with their rivals for the acquisition of these resources and this is more obvious in the food, agriculture and industrial management sectors. The environment of scarce resources is generally characterised by severe competition (Samairat, 2008).

Collaboration has become a new mantra to address the issue of volatility that derives from scarcity of natural resources. Johnson et *al.* (2011) argues that scarcity results in individuals and communities being willing to participate in alliances in order to escape resource imbalances. For example, most companies in the automotive industry collaborate with Novelis Inc. which is a global leader in aluminium rolled products and the world's largest recycler of aluminium. Novelis material is used in more than ninety vehicle platforms (Novelis, 2012). However, Novelis and Jaguar Land Rover (JLR) have a long-time partnership in order to minimise the use of aluminium and closing the loop for this natural resource. Deudney (1991) also concludes that resource scarcity encourages joint efforts and helps in the creation of a network of common interests. Companies integrate and collaborate with suppliers as critical resources are becoming scarce, expensive and commodity prices are increasingly volatile (Deloitte, 2012). Hence, it is proposed:

**Proposition 2a:** Supplier substitutability has an impact on the adoption of buffering strategies.

**Proposition 2b:** Supplier substitutability has an impact on the adoption of bridging strategies.

#### 3.5.1.3 Discretion over the scarce natural resource

The accelerated economic growth in emerging markets (e.g. BRIC countries) has provided the European Union with tangible competition for access to natural resources (Garrett and

Piccinni, 2012). The supply for specific resources such as rare earth metals becomes less available and governments try to protect domestic resources by imposing export restrictions. China that has the most rare earth reserves, restricted exports of REEs to Japan in September 2010.

China reduced rare earth shipments by 9% in 2010 over 2009 and some heavy rare earths such as dysprosium and erbium will be prohibited from exporting after 2015 (Humphries, 2013). Philips developed a technology to reduce its reliance on rare earths in the production of LEDs (Reddall and Gordon, 2012). The greatest obstacle in today's hybrid vehicle market is the production of batteries that demand REEs such as lanthanum and dysprosium (Humphries, 2013). Thus, many companies try to minimise the use of these resources. For instance, Nissan tries to reduce the usage of catalytic metals (Cullbrand and Magnusson, 2011).

Another way of handling these uncertainties is by using substitution. The Japanese automaker Nissan is building its Nissan Leaf by cutting its use of rare-earth minerals, 40% less dysprosium, in its electric motor (Rousseau, 2012). Another practice of resource efficiency strategies is recycling. An example can be the regulation of End-of-Life vehicles issued by the European Commission in 2000 and enforced that by 2015 the reuse and recovery shall be increased to a minimum of 95 % (Lucas, 2001). Honda also focuses on recycling of nickel metal batteries (Honda, 2013).

RDT also takes partnerships as a means of gaining access to resources from the environment and manage environmental uncertainty and it is a high control strategy (Sherman, 2007). Firms will try to find partners to capture crucial resources. This point can be further illustrated by taking into account Toyota that has secured lithium supply for battery packs through a joint venture with lithium Australian mining company Orocobre. Volkswagen is also looking into mining projects in Australia and Vietnam (Cullbrand and Magnusson, 2011)). Based on the above, it is proposed:

**Proposition 3a:** Discretion over the scarce natural resource has an impact on the adoption of buffering strategies.

**Proposition 3b:** Discretion over the scarce natural resource has an impact on the adoption of bridging strategies.

### 3.5.2 Supply chain NRS Strategies and Organisational Performance

#### 3.5.2.1 Buffering strategies

According to Hart (1995) resource efficiency strategies (product stewardship) can contribute to a firm's business performance. For instance, Ford will replace its nickel-metal-hydride batteries with lithium-ion alternatives and the firm will cut 500,000 pounds of REEs from its manufacturing process annually (Currie, 2013). By avoiding the use of natural resource there will be minimisation of the consumption of nickel-metal-hydride batteries and there will be a reduction on purchasing cost.

MillerCoors also (a joint venture of SABMiller PLC) have installed a camera inside one of the process vessels in their brewery in California (Wales, 2013). These vessels need to be cleaned by using a set amount of water. By doing this innovation, they cut off the water supply and achieved significant savings both financially and in terms of water resources (Wales, 2013). Honda Motor Company and Japan Metals and Chemicals Company will implement a world-first process to extract rare-earth metals from used parts and through this process Honda will gain a competitive advantage as it would be the first Japanese car manufacturer that will sell recycled parts (Cullbrand and Magnusson, 2012).

Firms have to find where a lack of safety stock will influence normal operations and thereby organisational slack in this case is an effective practice. For instance, Southwest Airlines bought future fuel and oil quantities to avoid price volatility (Autry et *al.*, 2012). Thus, Southwest achieved competitive advantage and operational performance when other airlines faced volatile oil markets (Autry et *al.*, 2012). Safety stock can cut production cost and purchasing cost of natural resources. Although this strategy may protect a company from supply chain disruptions for a certain time, if the disruption continues then the stock levels will not be enough to assure business continuity. Companies also have to find ways to minimise this and the extra amount of inventory has to be carefully calculated and the benefits need to be justified (Chopra and Sodhi, 2004).

As far as NRS is concerned, it may also force companies to design their networks based on the proximity of the scarce resources. Supply chain reconfiguration can also be applied (Bell et *al.*, 2012). For instance, Coca Cola and Nestlé have moved from regions that faced local fresh water scarcity. Another practice that will change the supply chain configuration is the reverse logistics in which a company must determine the collection/acquisition centres, inspection/sorting centres, disposal facilities etc. (Ene and Ozturk, 2014). However, the indirect losses such as temporary relocation and/or rerouting of material are significant (Klibi et *al.*, 2010).

It is expensive to shut down a facility or to relocate it to a different location (Truong and Azadivar, 2003). The configuration of a supply network has become complex as elements of a supply network configuration can be changed to support the business model and achieve a competitive advantage (Institute for Manufacturing, 2007). Thus, it is significant for companies to have an explicit understanding of how the supply chain has to be configured in order to access scarce natural resources. Based on the above:

**Proposition 4a:** The adoption of buffering strategies has an impact on resource efficiency.

**Proposition 4b:** The adoption of buffering strategies will lead companies to obtain a distinct competitive advantage.

#### 3.5.2.2 Bridging strategies

A number of researchers also support that higher levels of integration lead to better performance (Gimenez and Ventura, 2005; Stock *et al.,* 1998). Resource sharing between supply chain partners can improve utilisation of the resources and reduce risk in their business environment (Barney, 2012). Supply chain collaboration enhances the organisational and operational performance (Bowersox, 1990) and it leads to profits, cost reductions (Fisher, 1997; Lee *et al.,* 1997). Resource focused collaboration may give the opportunity for firms to achieve cost savings, involvement in innovation and create win-win outcomes for stakeholders along the value chain (Deloitte, 2012). Aldrich and Pfeffer (1976) support that in an environment of limited resources, in order to survive firms must obtain those scarce resources from other firms.

SABMiller faced a challenge in Colombia as they paid more to get good quality water. Recognising the need to find a solution to escalating costs that lay in the water catchment, Bavaria, SABMiller's Colombian subsidiary, formed a partnership with World Wildlife Fund (WWF) Colombia, The Nature Conservancy, Colombia's National Parks administration, and the Aqueduct and Sewage Company of Bogotá (Kissinger, 2013). This partnership prevented 2 million tonnes of sediment from entering the water catchment which in terms of monetary value is about *"$458,000 per year in treatment costs in the supply area and US$3.5 million per year across the entire water supply system"* (Kissinger, 2013, p. 9). Thus, these cost reductions have been passed to Bavaria which improved the organisational performance. Specifically a decrease of cost for energy consumption, decrease of greenhouse gas emissions, reduction of waste water, reduction of waste of natural resources, minimisation of the consumption of natural resources, minimisation of energy usage, and the cut of production cost and purchasing cost of natural resources achieved.

Firms also are aware that in order to improve competitiveness they need to integrate within a network of organisations or supply chain partners (Christopher, 2011). According to RDT companies in order to reduce the uncertainty in the environment acquire resources, which is a competence. The lack of control of scarce resources would generate competitive disadvantage. By following practices such as vertical integration or collaboration companies access critical resources. Resource sharing between supply chain partners can improve utilisation of the resources and reduce risk in their business environment, which will lead to a competitive advantage of the firms (Barney, 2012). Better communication, information sharing etc. was found to increase responsiveness of the supply chain, thus the competitive advantage of an organisation (Chen et *al.*, 2004).

Therefore,

**Proposition 5a:** The adoption of bridging strategies has an impact on resource efficiency.

**Proposition 5b:** The adoption of bridging strategies will lead companies to obtain a distinct competitive advantage.

### 3.5.3 Resource efficiency and Competitive advantage

As was stated above Matopoulos et *al.* (2015) supported the need for finding the links between resource efficiency and competitive advantage. Deloitte (2015) study showed that energy efficiency creates competitive advantage from a financial perspective (77%) and image perspective (79%). Inefficient resource use results in competitive disadvantage.

Efficient management of a supply chain is a key factor in differentiating product and service offerings thus companies can gain a competitive advantage through it (Christopher, 1998). The costs of enhancing environmental performance can be offset by increased revenues and cost reductions (Atkin et *al.*, 2012). Thus, companies will achieve competitive advantage through greater resource efficiency (Ecorys, 2012).

Competitive advantage can be achieved through resource efficiency; companies have greater perceived benefits for the same cost (differentiation) or same perceived benefits for a lower cost (Brahma and Chakraborty, 2011). This issue has already been recognised by several countries for example the Minister of State for Energy and Climate Change (2014) in the UK stated that *"a resource-efficient business has a distinct competitive advantage over those who are not"*. Thus, competitive advantage arises from the efficiency of the critical scarce natural resources.

**Proposition 6:** Resource efficiency will lead companies to achieve a distinct competitive advantage.

## 3.6 Scale Development

Based on the discussion above, the importance of the scarce natural resource can be defined as the degree to which a purchased scarce natural resource is critical for a manufacturing firm (Cannon and Perreault, 1999, Krause, 1999) and the magnitude of the exchange. Thus, the criticality of the scarce natural resource and the purchase importance of the scarce natural resource are the sub-constructs of the construct Importance of the scarce natural resource (see Table 3.1 and Table 3.2). The criticality of the scarce natural resource was measured by referring to measurement scales in the previous work of Ellis et al. (2010) and Ainuddin (2000), whereas the purchase importance of the scarce natural resource will be based on the measurement items developed by Hunter et *al.* (2006).

Specifically, Ellis et *al.* (2010) measured the item importance based on three items. The reversed item has not been used in this research as it can be problematic averaging nearly 20% of mis-response (Swain et *al.*, 2008). The answers to those reverse items have to also be reversed for analysis and this requires the researcher to be more careful of processing such results. For example, these items frequently produce unexpected factor structures (Netemeyer et *al.*, 2003). Thus, no reverse items are included in this research. All the remaining items are adapted in order to refer to a scarce natural resource of a firm namely Resource X (i.e. water, energy, metals, rare earth metals, minerals or other). The first item covers the criticality of natural resource characteristics that was discussed above such as importance, essentiality, priority (e.g. large proportion or a particularly critical element in a firm's end-products).

The other items were modified due to the need to refer to specific natural resource attributes such as the ability to recycle a particular natural resource and its renewability. These attributes will make natural resources more critical for the firms. For example, for aluminium and copper there are high recycling rates of 50%, but for REEs such as indium, tellurium recycling rates are low, below 1% (United Nations Environment Program, 2011c). The attribute of substitutability will be measured based on the items developed by Ainuddin (2000); the second item- “This resource cannot be substituted with other kinds of resources.” - was adapted as it referred specifically to substitutes but resources such as water do not have substitutes thus this item will not be valid.

Concerning the purchase importance of the scarce natural resource, of the four items Hunter et *al.* (2006) used for measuring it this research will be using three of them as the fourth item is reversed (R). The first item focuses on the financial magnitude. Thus, the focus of this study is both on financial magnitude and the quantities of the scarce natural resources used by the companies. A critical resource does not necessarily imply that this resource represents the largest proportion of the total input of natural resources used in the organisation. (Pfeffer and Salancik, 1978). For instance, only a small quantity of rare earths is needed in the production of digital technology, but there is not currently a substitute, which makes REEs very critical. The second item was adapted from Hunter et al. (2006). It measures the requirements/criteria that must be fulfilled in order to purchase this natural resource.

Table 3-1 Criticality of the scarce natural resource sub-construct

| Original measures | Source | Adopted measures |
|---|---|---|
| 1. If our company ranked all purchased items in order of importance, Item X would be near the top of the list.<br>2. Compared to other items our company purchases, Item X are a high priority with our company's purchasing managers.<br>3. Most other items that our company purchases are more important than Item (R). | Ellis et *al.* (2010) | 1. Compared to other natural resources, resource X is really critical (i.e. the ability of an organisation to continue functioning without the resource) for our company.<br>2. Compared to other natural resources, the recycling potential of resource X is low.<br>3. Compared to other natural resources, resource X is not easily replenished or is used at a greater rate than it can be renewed. |
| 1. This resource is not easy to replace.<br>2. This resource cannot be substituted with other kinds of resources. | Ainuddin (2000) | 4. Compared to other natural resources, resource X is not easy to replace.<br>5. We do not have (a good) alternative for resource X. |

Table 3-2 Purchase importance of the scarce natural resource sub-construct

| Measurement items | Source | Adopted measures |
|---|---|---|
| 1. This purchase was a major financial commitment for our organization. | Hunter et *al.* (2006) | 1. The purchase of resource X is really important for our business continuity. |

| | | |
|---|---|---|
| 2. Compared to other purchases, high level approval was required.<br>3. This purchase influenced many aspects of our organization.<br>4. Considering all of the purchases that I am involved in, this one was not very important (R). | | 2. Resource X is a significant financial commitment for our company.<br>3. Compared to other purchases, the purchased quantities of resource X influences many aspects of our company.<br>4. Resource X influences many aspects of our company even though its cost is not significant at the moment.<br>5. Compared to other purchases, a set of requirements/criteria must be fulfilled in order to purchase resource X. |

Based on the above, supplier substitutability for scarce natural resources can be defined as ***the availability of alternative suppliers*** (e.g. number of the suppliers) and ***the switching costs*** (e.g. the level of relation specific investments) for a given supplier that provides the manufacturing with the resource. Thus, the construct supplier substitutability (see Table 3.3 and Table 3.4) is measured based on two sub-constructs: 1) The availability of alternative suppliers and 2) the switching costs. The measurement items of Chen et *al.* (2004) were used to measure the availability of alternative suppliers and switching costs were measured with items adapted from Ganesan (1994).

The availability of alternative suppliers refers mainly to the number of suppliers. Chen et *al.* (2004) measure the limited number of suppliers with five items. In this research the first two are used as the other three were deleted in their research after exploratory factor analysis and also do not fit within this study (e.g. hedging contracts). One item is used from the research of Ainuddin (2000) that focuses on a few vendors for selecting the specific product. Finally, an item is used from the research conducted by Cannon and Perreault (1999).

Ganesan (1994) measured transaction-specific investments of retailers on vendors based on four items. These measures were adapted; one was not used as it was not appropriate within the manufacturing context. These measures refer to the supplier (-s) of resource X which is the supplier of the particular scarce natural resource used by the firm. Two items were added to highlight the changes in the operating processes of the suppliers and in the production systems (e.g. tooling, equipment).

Table 3-3 Availability of alternative suppliers sub-construct

| **Measurement items** | **Source** | **Adopted measures** |
|---|---|---|
| 1. We rely on a small number of high quality suppliers.<br>2. We maintain close relationship with al limited pool of suppliers.<br>3. We get multiple price quotes from suppliers before ordering.<br>4. We drop suppliers for price reasons.<br>5. We use hedging contracts in selecting our suppliers. | Chen et *al.* (2004) | 1. We rely on a small number of suppliers that can provide us with the resource X.<br>2. We can purchase resource X from a limited pool of suppliers because only a few are capable of supplying us the volume and the specifications we need (e.g. technical expertise).<br>3. When it comes to selecting suppliers for resource X, there are not many options available.<br>4. Due to geographical proximity, we rely only on a few suppliers of resource X.<br>5. The supplier (-s) of resource X almost have monopoly power. |
| 1. When it came to selecting the specific product, there were not many options.<br>2. There were many vendors who could have supplied what we need.<br>3. Many vendors would have been suitable for this product.<br>4. We were able to choose from among many vendors for this purchase. | Ainuddin (2000) | |
| 1. This supply market is very competitive<br>2. Other vendors could provide what we get from this firm<br>3. This supplier almost has a monopoly for what it sells<br>4. This is really the only supplier we could use for this product<br>5. No other vendor has this supplier's capabilities | Cannon and Perreault (1999) | |

Table 3-4 Switching costs sub-construct

| Measurement items | Source | Adopted measures |
|---|---|---|
| 1. We have made significant investments in displays, trained salespeople, etc. dedicated to our relationships with this vendor.<br>2. If we switched to a competing resource, we would lose a lot of the investment we have made in this resource.<br>3. If we decided to stop working with this resource, we would be wasting a lot of knowledge regarding their method of operation.<br>4. We have invested substantially in personnel dedicated to this resource. | Ganesan (1994) | 1. We have made significant investments dedicated to our relationship with the supplier (-s) of resource X.<br>2. If we switched to another supplier (for resource X), we would lose a lot of the investments made already in our relationship with the supplier (-s) of resource X.<br>3. If we decided to stop working with the supplier (-s) of resource X, we would be losing a lot of knowledge regarding their method of operation.<br>4. It would be difficult for us to replace the supplier (-s) of resource X as their operating processes have been tailored to meet our company's needs.<br>5. We have adjusted our production systems (e.g. tooling, equipment) in order to meet the practices of the supplier(-s) of resource X. |

In Tables 3.5, 3.6 and 3.7 the items adapted from Wittkowski et *al.* (2013), Çavus (2008) and Golicic et *al.* (2014) are presented.

As can be seen all measurement items of Wittkowski et *al.* (2013) have been adopted and adapted that measure the control over assets. These items were modified to focus on the advantages stemming from the ownership of the scarce natural resource. First, some companies own resources solely to increase competitive advantages from gaining access to scarce natural resources. For example, Toyota developed lithium deposits in Argentina, to secure the supply of lithium for the batteries of hybrid vehicle models (Orocobre, 2010). The other items refer to specific advantages of ownership, which is the ability to control costs and supply of the natural resource, to react quickly to changes in the availability of the natural resource, avoid higher prices and avoid government price controls and taxes over the specific natural resource.

Table 3-5 Ownership of the scarce natural resource sub-construct

| Measurement items | Source | Adopted measures |
|---|---|---|
| 1. It is advantageous for a firm to own its fixed assets in use<br>2. It is important for a firm to possess all of an asset's property rights<br>3. Company-owned equipment allows us to quickly react to market requirements | Wittkowski et *al.* (2013) | 1. It is important for my company to own resource X as it helps us to gain competitive advantage (because competitors will face barriers to entry and use resource X).<br>2. It is important for my company to own resource X as it helps us to gain greater control over costs and supply of resource X.<br>3. By owning resource X we can react quickly to changes in its availability.<br>4. By owning resource X we can avoid higher prices of resource X.<br>5. By owning resource X we can avoid government price controls and taxes over resource X. |

The accessibility is based on the items developed by Çavus (2008) who measured the access to organisational resources, such as the time and equipment that the employee needs to do their job in the best way. As the focus is on the natural resources some main modifications are needed. For the first item the word 'access' was changed to 'easily obtain' and makes specific reference to the scarce natural resource that is needed in the manufacturing process. As mentioned above location and competition play a crucial role for accessing natural resources so two items were added to understand the impacts of location and the competition on obtaining the needed scarce natural resources.

Table 3-6 Accessibility to the scarce natural resource sub-construct

| Measurement items | Source | Adopted measures |
|---|---|---|
| 1. I have access to the resources I need to do my job well<br>2. When I need additional resources to do my job, I can usually get them<br>3. I can obtain the resources necessary to support new ideas | Çavus (2008) | 1. My company can easily obtain the needed quantities of resource X in order to manufacture products.<br>2. Resource X is abundant in the regions where are factories are based so as we can easily access it.<br>3. If there is a need for additional quantities of resource X my company can easily obtain them.<br>4. There is a low level of competition (i.e. from other buyers) for accessing resource X.<br>5. My company has no issues in accessing resource X (e.g. local |

| | | |
|---|---|---|
| | | community concerns and/or reactions). |

The sub-construct *Usage of the scarce natural resource* depends on government regulations. The items developed by Golicic et *al.* (2014) were used to measure the regulatory pressure in wine supply chains. All the items were adapted to the usage of scarce natural resources. The first item referred to the compliance with government regulations such as $CO_2$ reduction. Companies have to properly use resources as they can face severe penalties e.g. fines imposed for non-compliance with waste legislation and to safeguard the interests of the local community. Another item is based on the regulations that impose restrictions on the use of some resources owned by suppliers in specific countries such as China's export quotas for rare earth metals (Weatherford, 2011) or conflict minerals such as gold ore, which is extracted from the Eastern Congo (BSR, 2010). The fourth item of Golicic et *al.* (2014) was not used as it is a repetition of the above issues highlighted in the previous items.

Table 3-7 Usage of the scarce natural resource sub-construct

| Measurement items | Source | Adopted measures |
|---|---|---|
| 1. In managing the relationship with this customer, my company is required to comply with a large number of government regulations.<br>2. In managing the relationship with this customer, my company is subject to severe penalties if we fail to comply with government regulations<br>3. In managing the relationship with this customer, my company is forced to do business with them due to government regulations.<br>4. In managing the relationship with this customer, my company has very few alternatives when it comes to choosing a different customer due to government regulations | Golicic et *al.* (2014) | 1. In using resource X, my company is required to comply with a large number of government regulations (e.g. CO2 reduction, use of recycling water).<br>2. In using resource X my company is subject to severe penalties if we fail to comply with government regulations (e.g. fines imposed for non-compliance with waste legislation).<br>3. In using resource X, my company is required to do business with suppliers in specific countries that control resource X (e.g. China's export quotas for rare earth metals).<br>4. In using resource X my company is subject to severe penalties if we fail to safeguard the interests of the local community. |

Product and process (re-)configuration could be employed in order for a company to reduce and/or avoid the use of natural resource and recover it. Six measurement items that were gleaned and compiled from the works of Singhal (2012) and Eltayeb and Zailani (2009) (Table 3.8) were considered for measuring product and process (re-)configuration. Specifically, the first four items refer to the ones developed by Singhal (2012) that focus on resource efficiency specifically the reduction of materials during the manufacturing phase that means in the product and process design to minimise the use of scarce natural resources. The other items adapted from Eltayeb and Zailani (2009) emphasise the usage of recycled natural resources and the return process which means that the waste of natural resources will be returned to suppliers for reuse.

Table 3-8 Product and process (re-)configuration

| Measurement items | Source | Adopted measures |
|---|---|---|
| 1. Design for resource efficiency, including reduction of materials and energy consumption of a product during use, in addition to promoting the use of renewable resources and energy<br>2. Design for reduction or elimination of environmentally-hazardous materials such as lead, mercury, chromium and cadmium<br>3. Design for reuse, is a design that facilitates reuse of a product or part of it with no or minimal treatment of the used product<br>4. Design for recycling, is a design that facilitates disassembly of the waste product, separation of parts according to material, and reprocessing of the material<br>5. Design for remanufacturing, is a design that facilitates repair, rework, and refurbishment activities aiming at returning the product to the new or better than new condition | Singhal (2012) | 1. Our company (re-)designs products in order to minimise or avoid the use of resource X.<br>2. Our company has adopted innovative practices (e.g. new technologies) to minimise use of resource X.<br>3. Our company (re-)designs processes in order to minimise or avoid the use of resource X.<br>4. Our company produces products or designs production processes that include recycled resource X.<br>5. Our company returns the waste generated by the use of resource X to suppliers for reuse. |

| | | |
|---|---|---|
| 1. Produces products that have reused or recycled materials in their contents such as recycled plastics and glass.<br>2. Uses life cycle assessment to evaluate the environmental load of its products.<br>3. Produces products that are free from hazardous substances such as lead, mercury, chromium and cadmium.<br>4. Makes sure that its products have recyclable or reusable contents.<br>5. Produces products that reduce the consumption of materials or energy during use.<br>6. Makes sure that its packaging has recyclable contents.<br>7. Makes sure that its packaging is reusable.<br>8. Minimizes the use of materials in its packaging.<br>Avoids or reduces the use of hazardous materials in its packaging. | Eltayeb and Zailani (2009) | |

In Table 3.9, the measurement items that were adapted and adopted from Umar et *al.* (2013) and Park (2011) are presented. Umar et *al.* (2013) utilised five items to measure the facility location but the focus here will be on the first two items. Based on the first item of Umar et *al.* (2013) two items were created that highlight the impact of socio-political climate, thus companies build plants (or plan to build plants) to overcome political pressures or the competition. Companies build their plants in places that the political environment or competition can help them to gain access to the natural resources.

The second item refers to the accessibility to materials and energy which was modified to fit in this research for the scarce natural resources. Specifically, the argument is that companies build their facilities close to the suppliers or where this natural resource is located. These scarce natural resources are also being recycled which means companies may build collection/acquisition centres, inspection/sorting centres and disposal facilities for the natural resource. For example, in 2001 HP opened its printer cartridge recycling plant in Smyrna, Tennessee. Between 2007 and 2011 they have recycled over £100 million of plastic.

The items that referred to the accessibility to skills and to knowledge were not used as they were not relevant to this study. The fifth item refers to the use of safety stock. As discussed above increasing the safety stock of scarce natural resources can assure the continuity of the production in the case of changes in the availability and demand of this resource. One item was used based on Park's work (2001) that refers to the use of safety stock as a strategy to respond in case of disruption. The other items were not used as they were almost repeating the same meaning of the item selected.

Table 3-9  Supply Chain Configuration Sub-construct

<table>
<tr><th>Measurement items</th><th>Source</th><th>Adopted measures</th></tr>
<tr><td>1. Favourable socio-political climate with government support for business and corruption free policies<br>2. Accessible to raw materials and cheap energy<br>3. Location ensures transportation reliability to meet customer requirement at consistent lead times<br>4. Access to markets and technological resources<br>5. Accessibility to low production cost, skills and knowledge</td><td>Umar et al. (2013)</td><td rowspan="2">1. We have built/plan to build our facility as close as possible to where supplier (-s) of resource X or where resource X is located.<br>2. We have designed a closed-loop supply chain (e.g. collection/acquisition centres, inspection/sorting centres and disposal facilities) in order to be able to recycle resource X.<br>3. We have built/plan to build our facility in a place where competition cannot act as a barrier to obtaining resource X.<br>4. We have built/plan to build our facility in a place where political pressures cannot act as a barrier to acquiring resource X.<br>5. We maintain safety stock in order to have time to respond in the case of availability and/or demand changes for resource X.</td></tr>
<tr><td>1. Uses safety stock to have time to prepare response and recovery in case of disruption<br>2. Maintains safety stock to reduce the likelihood of supply chain disruptions (e.g., supplier failure, machine breakdown)<br>3. Maintains safety stock in case of supply chain disruptions keeps extra inventory of strategic items (e.g., raw materials, parts, and finished goods<br>4. Holds safety stock to deal with variable demand rate or lead time<br>5. Holds buffer stock to mitigate the risk of stock-out</td><td>Park (2011)</td></tr>
</table>

Thus, transactional mechanisms, relational mechanisms and vertical integration will be the main sub-constructs of the bridging strategies (see Table 3.10).

Table 3-10 Bridging strategies: Transactional, Relational and Hierarchy Mechanisms

| **Transactional Mechanisms** | | **Relational Mechanisms** | | **Hierarchy Mechanism** |
|---|---|---|---|---|
| Type I (Cooperation) | Type II (Coordination) | Type III (Collaboration) | Joint Venture | Vertical Integration |

Concerning transactional mechanisms, they will be measured (see Table 3.11) based on the measurement items of contract and transaction specific investments that are developed by Liu et *al.* (2009). Contracts make clear the mutual expectations before the exchange and are precise along with penalties in case of failures. Transactional mechanism refers to the transactional investments that increase interdependence between buyer and supplier and motivate them to continue the relationship. For the transactional mechanisms the constructs of Liu et *al.* (2009) were adapted and six constructs were kept that are more relevant to this research.

Table 3-11 Transactional Mechanisms Sub-construct

| **Original measures** | **Source** | **Adopted measures** |
|---|---|---|
| 1. Our relationship with this supplier (buyer) is governed primarily by written contracts<br>2. We have formal agreements that detail the obligations and rights of both parties<br>3. Over time we have developed ways of doing things with this supplier (buyer) that never need to be expressed contractually or formally (R) | Liu et *al.* (2009) | 1. We have formal agreements with the supplier (-s) of resource X that detail the obligations and rights of both parties.<br>2. We have formal agreements that precisely state the legal remedies for failure to perform.<br>3. We spend much time and efforts in developing processes in order to meet the practices of the supplier (-s) of resource X.<br>4. We do a lot to help supplier (-s) of resource X (e.g. provide training).<br>5. Our formal agreements outline warranty policies.<br>6. The contract with the supplier of resource X does not describe the entire agreement between us as some clauses or provisions can be modified without mutual consent (e.g. the supplier (-s) of resource X can increase the price). |
| 1. We have made a substantial investment in shipping and storage (distribution) facilities tailored for the supplier (buyer)<br>2. We have made significant investments in training this supplier's (buyer's) employees<br>3. We specifically designed and developed programs to enhance this supplier's (buyer's) overall business<br>4. We do a lot to help this supplier (buyer) become a more efficient and effective supplier (buyer), such as providing functional and management training | | |

| | | |
|---|---|---|
| 1. We have formal written agreements outlining warranty policies.<br>2. We have formal written agreements outlining how to handle complaints and disputes.<br>3. We have formal agreements detail the obligations and rights of both parties.<br>4. We have formal written agreements that precisely state the legal remedies for failure to perform. | Blome et *al.* (2013) | |

Relational mechanisms are based also on contracts, but trust plays a crucial role. Relational contracts assume that formal contracts are incomplete by definition. According to Macneil (1980) in one relational exchange firms cannot anticipate all contingencies and design complete contracts. When partners trust each other, they feel confident that the other firm will cooperate in good faith rather than behave opportunistically (Liu et *al.*, 2009). Thus, in contrast to transactional mechanisms that are all written in the contracts no formal alternatives in the event of unresolved conflict exist.

Apart from trust partners share the same norms and values. These norms enable the firms to exchange information in order to promote harmonisation of conflict and honesty (Liu et *al.*, 2009). Relational mechanisms are measured (see Table 3.12) based on the measurement items of trust and relational norms that are developed by Liu et *al.* (2009). For the relational mechanisms four constructs were adapted that seem more relevant to this research.

Table 3-12 Relational Mechanisms Sub-construct

| **Original measures** | **Source** | **Adopted measures** |
|---|---|---|
| 1. In this relationship, both parties expect<br>that any information that may help the<br>other party will be provided to that party<br>2. In this relationship, ideas or initiatives<br>of both sides are widely shared and | Liu et al. (2009) | 1. In the relationship with the supplier (-s) of resource X, both parties expect that any information that may help the other party will be provided to that party.<br>2. In the relationship with the supplier (-s) of resource X, ideas or initiatives of both sides are widely |

| | | |
|---|---|---|
| welcomed via open communication<br>3. In this relationship, problems or conflicts<br>are expected by both parties to be solved through joint consultations and discussions<br>4. In this relationship, both parties play a healthy role in the other party's decisions via mutual understanding and socialization | | shared and welcomed via open communication.<br>3. In the relationship with the supplier (-s) of resource X, problems or conflicts are expected by both parties to be solved through joint consultations and discussions.<br>4. The supplier (-s) of resource X will be ready and willing to offer us assistance and support in case of unexpected events.<br>5. When making important decisions, the supplier (-s) of resource X is taking into consideration our interests. |
| 1. Though the circumstances change, we believe that the supplier (buyer) will be ready and willing to offer us assistance and support<br>2. We believe in the supplier (buyer) because it is sincere<br>3. When making important decisions, the supplier (buyer) is concerned about our welfare or interests<br>4. We can count that the supplier (buyer)'s future decisions and actions will not adversely affect us<br>5. When it comes to things that are important to us, we can depend on the supplier's (buyer's) support | | |

According to Guldbrandsen and Haugland (2000) vertical integration can be assessed on the willingness of the manufacturing company to continue to buy materials from a supplier and/or their decision to perform the activity in-house in the future. These measurement items will be adapted in this research and are presented in the Table 3.13.

Three items were adapted but the last one was not used as it is a reversed item and as previously mentioned such items will not be used. It is supported that reversed (negatively-worded) items should not be employed to control response bias, as they may affect response accuracy (Salazar, 2015; Schriesheim and Hill, 1981). The other items are based on the following arguments originated by secondary data such as companies' reports and news websites: when there are few suppliers or price fluctuations over the scarce natural resource companies would like to have access to this resource. For example, some automotive companies tried to be vertically integrated with mining companies to have access to rare earth metals. Rare earth metals also can be banned from export by governments such as China which will make companies willing to own the scarce natural resource in order to secure its supply.

Table 3-13 Hierarchy Mechanisms Sub-construct

| Measurement items | Source | Adopted measures |
|---|---|---|
| 1. We are considering taking over the principal responsibility for performing the maintenance activity in-house in the future.<br>2. If the need for maintenance should arise unexpectedly, next time the activity will be performed internally within our own organization<br>3. If the need for maintenance can be foreseen, next time the activity will be performed by our own organization<br>4. It is very unlikely that our own staff will perform the activity next time. | Guldbrandsen and Haugland (2000) | 1. We are considering taking ownership over resource X as there are only a few suppliers.<br>2. We are considering taking ownership over resource X as there are fluctuations in the price of resource X.<br>3. We are considering taking ownership over resource X as government regulations make not easily accessible resource X.<br>4. We are considering taking ownership over resource X in order to reduce the cost of resource X.<br>5. We are considering taking ownership over resource X in order 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). |

This research will adopt and adapt the constructs developed by Kumar et *al.* (2012) in order to measure the environmental performance of resource efficiency. Economic performance is the most important outcome for companies as a result of reducing the use of resources and recycling their materials (Zhu and Sarkis, 2004). By minimising the use of natural resource companies can have a positive effect on their financial performance. Zhu and Sarkis (2004) believed that resource efficiency strategies can reduce the cost of materials purchasing and energy consumption. Waste also can be used more beneficially (Tsoulfas and Pappis, 2006). However, other researchers concluded that environmental management performance leads to lower manufacturing costs by eliminating waste (Allen, 1992). This research we will adopt the measurements of Zhu and Sarkis (2004) in order to measure the economic part of resource efficiency.

From the environmental perspective, the focus is on the minimisation of the usage of the scarce natural resource and the waste generated. The economic perspective focuses on the price of the scarce natural resource thus on the purchasing cost, but it will also include the overall manufacturing cost (i.e. the cost to convert raw materials into products). Thus, two items will be used from Kumar et *al.* (2012) and the one item that refers to purchasing cost from Zhu and Sarkis (2004). However, one more item will be added that will measure the minimisation of the manufacturing cost while changing processes (see Table 3.14).

Table 3-14 Resource efficiency Sub-construct

| Original measures | Source | Adopted measures |
|---|---|---|
| 1. Minimizing use of natural resources during manufacturing<br>2. Minimizing toxic/hazardous waste during manufacturing<br>3. Possibility of product being recyclable, reusable<br>4. Avoid or minimize the amount of hazardous material used in product production<br>5. Inclusion of recycling program for manufacturing operation<br>6. Are designers using life cycle engineering to improve the environmental performance and production efficiency of the products<br>7. Measures taken to reduce material, water & energy used in manufacturing<br>8. Optimizing the use of energy generated from renewable sources in manufacturing operations<br>9. Industry has established program to increase the service intensity of the products<br>10. Determination of environmental impacts and costs of the products throughout their life-cycle<br>11. Optimum energy consumption during manufacturing process | Kumar et *al.* (2012) | 1. My company has achieved reduction of the usage of resource X.<br>2. My company has reduced the waste of resource X.<br>3. My company has decreased the purchasing cost of resource X.<br>4. My company has decreased the cost of processing of resource X (e.g. changing processes).<br>5. My company has increased the recycling rate of resource X. |

| | | |
|---|---|---|
| 12. Integrated environmental & efficiency criteria implementation in process design<br>13. Consideration of environmental issue in the process of production planning and control<br>14. Environmental issue considered during selection of manufacturing process Reduced setup time | | |
| 1. Decrease of cost for materials purchasing<br>2. Decrease of fee for waste treatment<br>3. Increase of operational cost<br>4. Decrease of cost for energy consumption<br>5. Decrease of fee for waste discharge<br>6. Decrease of fine for environmental accidents<br>7. Increase of training cost<br>8. Increase of investment<br>9. Increase of costs for purchasing environmentally friendly materials | Zhu and Sarkis (2004) | |

Koufteros et *al.* (1997) propose the following attributes to measure the competitive advantage: competitive pricing, premium pricing, value-to-customer quality, dependable delivery, and production innovation. These dimensions with one more (time to market) are also described by other researches (Vokurka et *al.*, 2002, Li et *al.*, 2006).

In this study, the arguments of Bell et *al.* (2013) that refer to closed-loop supply chain advantages were adopted (see Table 3.15). They determine that through closed loop supply chains companies can get leveraged access to natural resources which other buyer's may face difficulty to access, secure natural resource at a lower price than other buyers. Also companies that follow any buffering and/or bridging strategies enhance the intangible internal resources of the firm that other buyers may find difficult to replicate. Two items were also added as companies can also have leveraged access to a scare natural resource to which other competitors may face shortages or spiking prices and through the efficient use of resources they can offer new and/or improved products to markets. For example, the new Jaguar XE is the first new car in the world to use new, high recycled content aluminium.

Table 3-15 Competitive advantage Sub-construct

| Original statements | Source | Adopted measures |
|---|---|---|
| 1. Companies through closed loop supply chains can get leveraged access to natural resources which other buyer's may face difficulty to access<br>2. Companies can secure natural resource at a lower price than other buyer's<br>3. Companies can enhance the intangible internal resources of the firm that other buyer's may find difficult to replicate. | Bell et al. (2013) | 1. My company has got leveraged access to resource X to which competitors may face difficulty to achieve.<br>2. My company has secured resource X at a lower price than other competitors.<br>3. My company has enhanced the intangible internal resources (technical skills, knowledge etc.) that other competitors may find difficult to replicate.<br>4. My company got leveraged access to resource X to which other competitors may face shortages or spiking prices.<br>5. 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). |

## 3.7 Conclusion

The conceptual framework was developed based on the literature review and RDT. Following a comprehensive literature review this chapter focused on the operationalisation of the main constructs of the framework: Natural Resource Dependence Level, Supply Chain NRS Strategies and Organisational Performance. The following chapter discusses in detail the methodology that was followed to test the propositions as well as the hypotheses in order to answer the main research questions.

# Chapter 4 RESEARCH DESIGN CONSIDERATIONS

## 4.1 Introduction

This section outlines the philosophical perspective of this research. As mentioned in the literature review, there is a lack of empirical studies let alone cross-industry studies regarding the topic of NRS in the field of supply chain management. Also, supply chain NRS strategies and their antecedents have not been studied to a great extent thus an exploratory approach was deemed more appropriate for this research. In particular, the research focus of this exploratory study is theory building and testing and it aims to identify key variables (i.e. the natural resource dependence level dimensions, supply chain NRS strategies, organisational performance) and the existing relationships between them.

In order to identify these strategies and their drivers the approach of positivism was used A mixed methods approach is utilised, using an exploratory, instrument development model. Two sequential phases are involved: Phase one used qualitative methods namely case study to explore the drivers, strategies and its impact on organisational performance. The findings from the first phase (see further in Chapter 5 and Chapter 6) are used to adapt and develop the survey questionnaire. For the case study methodology, the selection of cases is discussed in Section 4.3 together with the data collection and units of analysis. For the survey methodology, the development of the survey instrument and the data collection procedure is discussed in Section 4.4, along with the sampling strategy. Subsequently, Section 4.5 provides the ethical issues.

## 4.2 Research Philosophy: Ontology and Epistemology

Ontology is how the researcher conceptualises the reality (nature of being) and how this shape knowledge about the specific study. According to Blaikie (2007) social reality can be described based on what exists, what it looks like, what unit’s entails, and what is the relationship between them. There are two main perspectives of ontology, objectivism (realism) and subjectivism (constructionism or constructivism or nominalism) (Bryman and Bell, 2007). Objectivism is the belief that social entities exist in reality external to social actors regarding their existence (physical sciences approach and deals with facts, causality), whereas subjectivism entails the notion that social phenomena are created from the perceptions and actions of those social actors regarding their existence (the goal is to understand people's perceptions and interpretations) (Easterby-Smith et *al.*, 2008; Meredith et *al.*, 1989; Saunders et *al.*, 2007).

Epistemology is about understanding the nature of knowledge and how it is acquired. It entails the most relevant ways of enquiring into the nature of the world (Easterby-Smith et *al.*, 2008) and focuses on the data collection processes (research methods). The different combinations of ontological and epistemological philosophies determine the methodological perspectives (paradigms) for the investigation of theory and data. According to Blaikie (2007, p.6):

"*The methodological perspectives are defined in terms of their ontology and epistemology, and include reference to the logic of theory construction, what counts as data, explanations and theory, criteria of validity, and views on the particular nature of social reality and the relationship between the natural and social sciences*".

### 4.2.1 Research Paradigms

According to Bryman and Bell (2007, p. 25) paradigm is *"a cluster of beliefs and dictates which for scientists in a particular discipline and influence what should be studied, how research should be done, and how results should be interpreted"*. There is no common agreement regarding the terms for these paradigms that is used and it is common for different names to be used to describe apparently similar paradigms. Concerning epistemology there are two main extremes, exist positivism and interpretivism (anti-positivism or constructivism) (Bryman and Bell, 2007).

Supply chain and logistics research is dominated by the positivistic tradition (Adamides et *al.*, 2012). In the following sub-sections these 2 paradigms are explained in detail.

#### 4.2.1.1 Positivism

From the first positivist research examples is the work of Pugh et al. (1963) at Aston University on organisational structure that made use of highly structured interviews or questionnaires over a large sample. Thus, the focus is on quantitative data, and includes research methods such as simulation, mathematical modelling, and structured questionnaires (Bryman and Bell, 2007; Easterby-Smith et *al.*, 2008). The positivist position believes that there are 'absolute truths' about the real world and the researcher is separated from the observed phenomena (ontology). Quantitative research searches for general laws and such research highlights the measurement and the analysis of causal relationships between variables. The positivism paradigm usually tests a set of hypotheses; which are developed from existing theory (deductive logic). The theoretical models developed from the positivist stance are generalizable and can describe cause and effect relationships (Easterby-Smith et *al.*, 2008). The main strengths of positivism are that its methods can be fast and economical. However, they are inflexible, artificial and not effective in understanding processes or the significance that people attach to actions (Easterby-Smith et *al.*, 2008). According to Habermas positivism reaches the ideal knowledge and ignores the moral choices, values and judgments researchers make (Cohen et *al.*, 2007, p. 18). The majority of studies in the field of supply chain management are following the positivism paradigm (Adamides et *al.*, 2012) by using methods such as survey (e.g. Green et al., 2012), heuristics such as genetic algorithm (e.g. Wang and Hsu, 2010), simulation (e.g. Van Der Vorst et *al.*, 2009). In this research empirical findings derived from mixed methods. Case studies are used to develop and support the findings from the survey. Within the positivist paradigm the case study investigator expects the same outcome from each case, provided that all the variables of interest are replicated. Cases are selected from various sectors to achieve replication (similar outcomes) or finding differences with respect to the variables of interest, thus contradictory outcomes (theoretical replication).

#### 4.2.1.2 Interpretivism

This position is described differently in the research such as constructivism or by Hatch and Cunliffe (2006) as anti-positivist and by Blaikie (2007) as post-positivist. The Interpretivist approach starts from data and views the reality subjectively (researcher's knowledge for a specific topic relies on the perceptions of the participants). Interpretivism considers the differences between people (Bryman, 2001) and the researcher is trying to understand the interpretations of social actors (what they are thinking, feeling etc.), their world from their point of view which is highly contextual and hence is not widely generalizable (Easterby-Smith et *al.*, 2008; Saunders et *al.*, 2007). Interpretivist researchers look at organisations in depth by using qualitative methods such as interviews, observations and secondary data analysis in order to overcome generalisability critiques (Bryman and Bell, 2007; Easterby-Smith et *al.*, 2008). Constructivism is based on inductive reasoning, where data is collected first and then theory developed (Saunders et *al.*, 2007). At the centre of this paradigm is that all knowledge is socially constructed. One of the limitations of interpretive research is that it does not verify the results and thus cannot be generalised to other situations (Mack, 2010). Another limitation of this paradigm is the subjective nature of it (Mack, 2010). The interpretivist paradigm by means of the case study method is not well utilised in the field of supply chain management but is widely used especially to research topics that are new and need further exploration such as in the field of sustainable supply chain management. For example, sustainability in supply chains is explored by using the method of case study (e.g. Caniato et *al.*, 2012; Hassini et *al.*, 2012).

### 4.2.2 Research Design and Research Strategy

Given that currently there is lack of NRS research in the field of supply chain management, an initial exploration of the topic which involved a detailed and focused literature review, was necessary. This initial exploration led to the development of the conceptual framework representing possible factors, responses to handle the issue of scarcity and impacts of the above strategies. The first phase consists of the case study method that can provide more insights and rich real life stories (Voss et *al.*, 2002). Thus, the topic is first explored with the multiple case study approach

These results are then used to develop a survey that was administered electronically via the Internet to determine relationships (test the hypotheses) between natural resource dependence level, supply chain NRS strategies and organisational performance. In this research both case study and survey, for theory building and testing, are used. An overview of the two phases and methods namely case study and survey is given followed by the research setting, access to participants and permissions.

The type of research question, the control of investigator over events and the type of events (contemporary, historical) determine the appropriateness of the chosen research strategy (Yin, 2003). There are five research strategies: experiments, survey, archival analysis, histories and case studies (Yin, 2003). The research strategies that adopted in this thesis are case study and survey. The case study method based on interviews are adopted for this research because it is the most suitable method which can provide in-depth information in different aspects of supply chain management and knowledge management to this research. The interview method is selected in particular because it covers a wider area of application than questionnaires.

The option of the experiment can be used when the researcher has direct control over the behaviour of the variables under inspection (Yin, 2003). Experiments are used by researchers when they have a strong control in their laboratory environment where they can change the variables that could impact upon the outcome of the experiment. Experiments are commonly used methods in physical sciences and are not so valuable in management research (Beech, 2005). Participant observation, ethnography or discourse analyses are commonly conducted over a long period of time (longitudinal). Action research cannot be employed due to time, economic and accessibility constraints. Grounded theory and ethnography were excluded as they are purely qualitative.

## 4.3 Qualitative phase (Phase One)

Due to the exploratory nature of this study and the need to obtain an in-depth knowledge of the drivers (why companies respond; the factors that make companies aware of the issue of NRS), responses (how do firms respond to these factors by taking specific supply chain NRS strategies) and the relationship between them (drivers and responses), and the implications of them on organisational performance (how these strategies impact the performance) it was thus decided to adopt the case study methodology, as recommended by Yin that can answer "why" and "how" questions (Yin, 2003). Bell et *al.* (2012) also highlighted the need of industry case studies to recognise and implement creative supply chain strategies to altering natural resource availabilities. A multiple case study research method is selected for this study to increase the understanding of the in-depth data gathered relative to each case or event for the purpose of learning more about firm's responses to different factors that influence the awareness of NRS.

### 4.3.1 Case study

The case study method is defined as: *"an empirical inquiry that investigates a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly evident."* (Yin, 2003, p. 13). One of the aims of this research is to find out how the manufacturing supply chains perceive and handle the issue of NRS which is a contemporary phenomenon. Two of the research questions are "how" questions about a contemporary phenomenon (Yin, 2003), that has not yet been thoroughly researched. The nature of this research make multiple case studies the logical methodology.

The case study research method is used in this phase to study the contemporary phenomenon in its real-life context (Yin, 2003). Case study is used when the specific topic and its theory are at formative stages (Benbasat et *al.*, 1987). Given that little research has been conducted on the supply chain NRS strategies and the antecedents of them, there is need to understand the subject area based on real-life practice. Therefore, the case study method seemed appropriate for this phase.

There is a need for more rigorous case-based research in the field of supply chain management (Seuring, 2008). One model, Stuart et *al.* (2002), advocated by Seuring (2008) is Stuart's five stage process. Stuart et *al.* (2002, p. 423) first stage starts with the definition of research question and *"all research starts from an examination of existing theory"*. Stage two is the development of a research instrument. The third stage is collecting data. In the fourth stage, researchers need to analyse the data. In the final stage, researchers need to disseminate the research findings. Based on the Stuart et *al.* (2002) model, this research is divided into five stages. In the first months, the literature was reviewed to identify the gaps and to develop the research questions and the conceptual framework. Case study research can act as a powerful tool in determining how the model should be constructed and what should be changed. As part of the overall planning of this research namely a multiple case study investigation there is a need to have a uniform case study protocol to plan a series of case studies that will give consistent results (Yin, 2003). A case study protocol was developed in the stage two. To ensure a consistent planning process, a case study protocol template was developed to provide guidance on how to construct case studies. In order to satisfy these requirements, Yin (2003) outlines the elements of a case study protocol such as: an overview of the case study project, field procedures, case study questions and a guide for case study report. A complete case study protocol can be found in appendix 2 .
Multiple case studies were conducted in stage three to generate insights into the topic of NRS. Stage four consists of within and cross case analysis. The qualitative stage also facilitated the hypothesis development (Dubois and Araujo, 2007). Individual case reports as well as cross case reports were prepared in this stage. In stage five, the author mainly finalised the doctoral thesis. The research must also be disseminated through papers (i.e. conference papers).

According to Yin (2003), the unit of analysis defines the subject in the study. The scarcity of natural resources impacts on a specific company. The unit of analysis in this study is the firm. Since the departments of purchasing management, logistics management, materials management, and supply chain management are some of the most important links in purchasing critical scarce natural resources, senior level managers from these departments were found to be the most appropriate respondents.

### 4.3.2 Multiple or single case

Case study research can be based on single or multiple case studies. Researchers may concentrate on the study of one case due to its uniqueness or study multiple cases to make comparisons, build theory, and propose generalisations (Yin, 2003). Single case design can be used when the case represents a critical case or is unique (Yin, 2003). For this study none of these criteria were met, therefore, a single case design was not appropriate. A number of researchers have widely used a multiple case study approach and advocated its use to deal with large amounts of data from multiple sources (Yin, 2003).

Multiple case studies are adopted to investigate the antecedents of NRS risk to supply chain strategies, the implementation of these practices and how they influence organisational and environmental performance. Miles and Huberman (1994) suggested that generalisability, deeper understanding and explanation can be enhanced through multiple case studies. Eisenhardt (1991) supports that multiple case studies are from the most appropriate methods for theory creation. In this study the researcher tries to validate the findings externally by employing case studies in dissimilar contexts, thus generalising the conceptual framework and propositions rather than seeking analytic generalisation (Yin, 2003).

A multiple case study method has been adopted in this thesis in order to discover contingency issues that are specific to each case (Yin, 2003). Contingency factors may be different in each case and contingencies are crucial determinants on which to concentrate in critical realist studies. Apart from the in-depth analysis within each case, multiple case study design also contains the cross-case analysis in order that the differences and similarities can be identified (Miles and Huberman, 1994). Common themes are identified across the multiple cases that may contribute to analytic generalisations (Miles and Huberman, 1994). All replication procedures led to a robust conceptual framework. The framework states the antecedents under which specific NRS supply chain strategies are likely to occur or not. An important part of Figure 4.1 is the dotted line feedback loop which is a situation in which a significant discovery happens during the conduct of one of the individual case studies and may alter the criteria for case selection as well as the collection protocol.

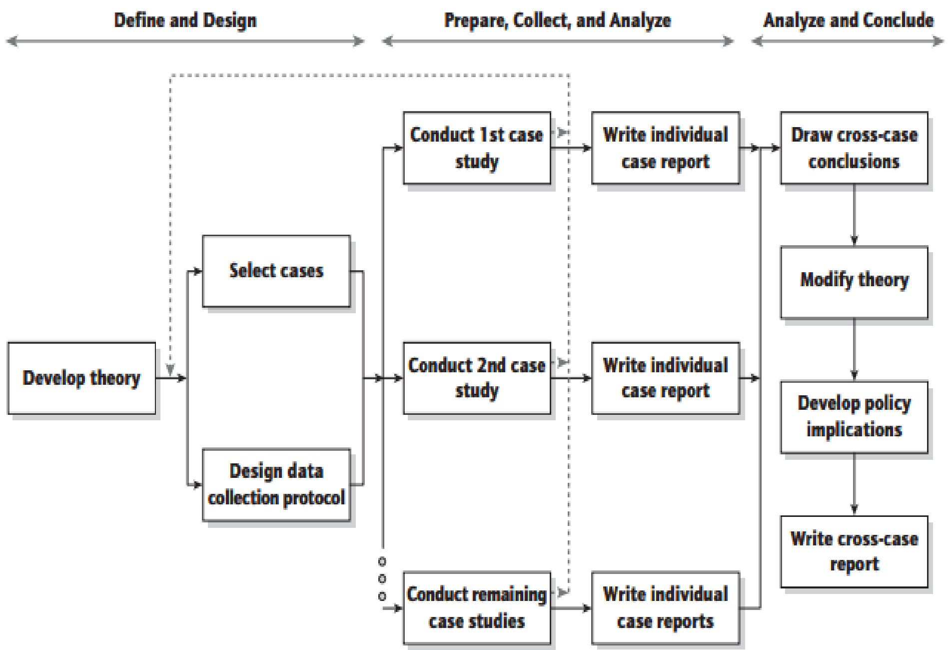


Figure 4.1 Multiple-case Studies (Yin, 2003, p. 57)

A major issue with regard to case studies is the selection of cases in order to fully uncover and confirm the basic constructs. The case selections are based on the requirement to answer the research questions, and a purposeful selection procedure are conducted. "*Purposive sampling is based on the assumption that one wants to understand as much as possible, and thus the sample is selected deliberately in a way that most can be learned*" (Merriam, 1998, p. 61).

This procedure involves the researcher selecting cases that fulfil a specific research objective. Each participant has to have some characteristics to give relevant and accurate data. The first sampling criterion is that the company has to be active in the manufacturing industry. The companies have to be from a different context: a different sector, and have different natural resources as the main key elements in their manufacturing operations and products in order to generalise key findings. Thus, companies from food and drink and the automotive sector etc. can be a sensible choice. The companies are chosen in terms of their ease of access.

The participants are chosen non-randomly by means of theoretical sampling (Corbin and Strauss, 2008). Patton (2002, p. 244) argues that "*Sample size depends on what you want to know, the purpose of the inquiry, what will be useful, what will have credibility, and what can be done with available time and resources*". Thus, the point of redundancy is used which is when no significant enrichment can be achieved by having an extra case added to the sample. Eisenhardt (1989) suggests that four to ten cases are desirable for theory building. A case number of 4 to 8 would be sufficient in identifying the phenomenon with effective size, resource and time available (Eisenhardt, 1989; Meredith, 1998; Yin, 2003). Yin (2003) has proposed that 6 to 10 case studies are adequate for multiple case studies. Miles and Huberman (1994) support that the study will be "unwieldy" with more than 15 cases. Perry (1998) suggests that cases must fall between 2 to 4 as the minimum and 10, 12 or 15 cases as the maximum. Based on this argument, interviews for this research were undertaken with 13 manufacturing companies so this number falls within Perry's (1998) suggestion.

Cases have been selected purposively as it enabled the researcher to select cases that will best answer the research questions and these cases will meet the research objectives (Saunders et *al.*, 2007). Purposive sampling takes into account a range of similar and contrasting features in intra cases (Miles and Huberman, 1994). To find cases for the study, an email was sent to several managers (with the job titles described above) that were identified as taking part in presentations, conferences related to sustainability and NRS. Sending out an email was the first effort to invite companies to this study. A personal message was sent to managers with titles such as purchasing managers, sustainability managers etc. (currently employed in manufacturing companies) through LinkedIn to participate in the interview.

Another source was the industry conferences in where companies participate and especially from the aluminium industry. The thesis supervisor and other academics contacts provided two more companies. The messages described the study's purpose and kindly requested the managers to participate in the study. When they agreed to be interviewed, more details were sent (e.g. interview guide, consent form). In total, thirteen companies participated in this project. Four of the companies were from the automotive sector (two car manufactures and two first tier suppliers), two companies in the chemical industry, two companies in the electronics industry, one company in the food & beverage sector, and three companies in the aluminium industry. Companies were from the UK, the USA, China and Norway.

### 4.3.3 Interviews

The principle data collection method was interviews, which is a widely used qualitative method as it gives insights into how respondents see their world (Easterby-Smith et *al.*, 2004; Bryman, 2001). In order to develop a thorough understanding of the case, a multiple sources of evidence were collected namely interviews as primary data. The main methods for collecting qualitative data are: individual interviews, focus groups, observations and action Research. There are several types of qualitative interview (see figure 4.2) provided that has have to do with the interaction with the participants and the way of interaction (Saunders et al., 2003):

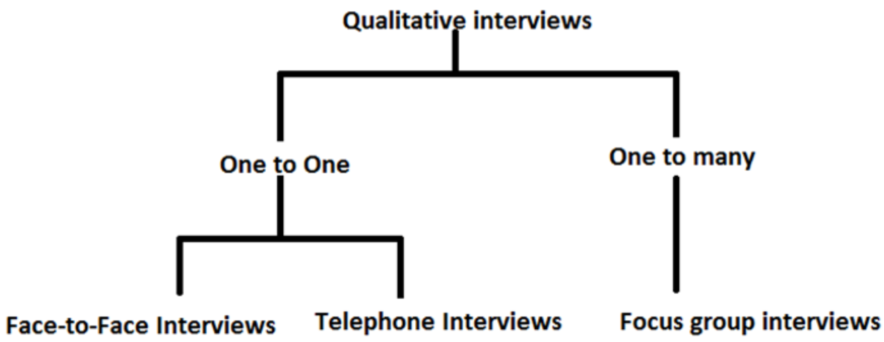


Figure 4.2 Forms of qualitative interview

(Source Saunders et al., 2003, p.247)

The most suitable method for primary data collection for this study is the semi-structured in-depth interviews as qualitative research implies the use of "structured" open-end questions to research deeply in depth (Hair et al., 2007; Ghauri and Grønhaug, 2002). Open-ended questions allow the interviewees to define and describe a situation in their own words. Furthermore, it is designed to encourage the participant to provide an extensive and developmental answers and may be used to expose attitudes or obtain facts (Saunders et al., 2003, p. 262). Observation was not appropriate method as the relevant information cannot be observed directly and the aim of this research is not to collect data from interactions, processes, or behaviours as they occur. Interviews can provide a 'deeper' understanding than would be obtained from other methods, such as questionnaires (Silverman, 2000). Thus, “interviews are most appropriate where little is already known about the study phenomenon or where detailed insights are required from individual participants” (Gill et al., 2008). Another advantage of interviews over methods such as focus groups is the appropriateness for exploring sensitive topics (Jamshedf, 2014) for example in this study participants may not want to talk about resource scarcity issues or the strategies they plan to follow in a group environment. There is flexibility on the method of interviews compare to other methods such as focus groups, observation as interviews can be conducted over the phone and it is well suited in our research as our participants come from a nationwide pool. Thus, we used interviews as the interested of this research is the individual experience, perceptions, regarding natural resource scarcity and could only be attained through interviews. The most suitable method for the primary data collection is semi structured in-depth interviews. The advantage of using the interview method is that it will be possible to obtain results with greater depth (Leedy and Ormrod, 2005). More specifically, interviews were conducted face to face and when necessary or more convenient (e.g. due to the geographical distance) telephone interviews were employed. For each case, information gathered was guided by a data collection protocol consisting of questions regarding the type of information to be collected (Yin, 2003). Although a protocol was developed at the onset of the research in order to plan data collection, the protocol was applied in a flexible manner.

Open-ended questions allowed the interviewees to define and describe a situation in their own words and to provide extensive and developmental answers and may be used to expose attitudes or obtain facts (Saunders et *al.*, 2007). This method selected to collect the views of specific individuals (i.e. supply chain managers, purchasing managers etc.) and help in the phase of the survey questionnaire development.

To ensure content validity, three academics pre-tested the interview questionnaire. They evaluated the appropriateness, clarity, and accuracy of questions by changing the wording of some of the questions and made them easier to be understood by managers. Some discrepancies between their interpretations and the researcher's expectations were also discussed. Based on their feedback, the initial questionnaire was modified. At the end of this process the interview guide was reduced to one page (from three pages). A pilot test was performed with one purchasing manager in order to test the appropriateness of the interview protocol and to ascertain the readability of the questions. The telephone interview conducted developed a basic understanding of the case study processes. The interview questionnaire was refined based on comments received from the participant.

The focus of this research is on purchasing/supply chain/logistics managers or anyone who is involved in the decision making process for the acquisition or utilisation of natural resources or even an employee that takes actions about resource efficiency and sustainability in the organisation. The questionnaire was sent to the key informants before the interview.

The interview questionnaire was designed so as to reflect the themes in the conceptual framework of the research and also to be aligned with the research aim and objectives (see appendix 3). In total, thirty-one interviews were conducted which lasted from 30 minutes to 1 hour. Interviews were recorded (with the permission of the interviewee) and also notes were taken. A consent letter was signed by each interviewee; the letter explained the purpose of the information collected and the interview process. Also, other sources of evidence such as industry databases, company's sustainability reports and company's websites were used in the analysis. All these procedures guaranteed a high level of validity and reliability of this research.

### 4.3.4 Validity and reliability

Qualitative research does have its criticisms; the two most common issues are ‘reliability’ and ‘validity’ (Silverman, 2000). The issue of ‘validity’ includes the criticism of what constitutes a credible claim to the truth. The problem of ‘reliability’ involves how a qualitative researcher categorises events and its goal is by conducting the same case study with the same procedures the same conclusion will be reached.

Silverman (2000) supports that ‘triangulation’ and ‘respondent validation’ can overcome validity issues. Triangulation refers usually to ‘data triangulation’ meaning the use of a various data sources. This research uses interviews as primary data which is *“new data collected for the purpose and the problem solving of present research”* (Saunders et *al.*, 2007, p. 36). Secondary data are also used that is *“data that has already been collected and published for some reason other than solving the current research problem”* (Saunders et *al.*, 2007, p.35). The secondary data helped to add information that interviewees could not readily provide and verifies the quality of the data collected in the case studies. Reports were obtained through the companies’ websites (e.g. sustainability reports). During the fieldwork, more documents were collected (e.g. presentations files of the managers that they did it internally in their company) that enabled the collection of quantitative data (i.e. figures that show the resource efficiency such as recycling rates).

Annual sustainability reports, staff presentations, publications and websites of the organisations used as a secondary data source for research. All the companies are using their websites and company reports to share sustainability information, except from 3 (i.e.) as they were small companies and they did not have a robust sustainability group in order to publish sustainability reports. The detailed data types and sources used can be shown in the table below.

Table 4-2 Secondary data

| Company | Company Website | Sustainability reports | Staff reports | Other websites or reports |
|---|---|---|---|---|
| AutoCo_1 | X | X | | X |
| AutoCo_2 | X | | | X |
| AutoCo_3 | X | X | X | X |
| AutoCo_4 | X | | X | |
| BrewCo_5 | X | X | | X |
| ChemCo_6 | X | X | | X |
| ChemCo_7 | X | X | | X |
| ElectCo_8 | X | X | X | X |
| ElectCo_9 | X | X | | X |
| AlumCo_10 | X | X | | X |
| AlumCo_11 | | | | |
| AlumCo_12 | X | | | X |
| PlastCo_13 | X | | | |

Data triangulation also includes analysis of the notes taken during and after each interview. According to Cohen et *al.* (2007, p. 142) space triangulation is also important. As this research was conducted in different countries (e.g. UK, USA) an attempt was made *"to overcome the "parochialism of studies conducted in the same country"*. This study also encompasses 'informant triangulation' as it considers different informants. By combining various data sources, informants and methods the research can reach credible interpretations. Multiple cases ensure external validity. The researcher asked respondents to examine and review their interviews to ensure the correct representation of the data. The interview guidelines enabled the researcher to repeat the same procedures in each interview (replication guide). Another strategy adopted for increasing validity was the respondent validation by providing a report that summarises the findings of the 13 manufacturing companies. This report was reviewed by the managers in order to validate further the results.

### 4.3.5 Data Analysis

Miles and Huberman (1994) suggest that the analytical process consists of three concurrent flows of activities: 1) Data reduction (summarising the data into a form suitable for interpretation), 2) Data display (enable viewing patterns in the data in a compact way such as matrices) and 3) Conclusion drawing/verification (records themes, patterns and conceptual flows). Qualitative data analysis has some difficulties such as words that can have more than one meaning (Neuman, 2005). Thus the first step is the reduction of the amount of data.

Thematic analysis was adopted and the initial stage is coding. According to Collis and Hussey (2009, p. 179) *"The codes are labels which enable the qualitative data to be separated, compiled and organised*". Open coding was used initially (identify, and categorising the data), followed by axial coding (connecting First-order concepts on Second-order themes) and selective coding (choosing the aggregate dimension to be the core category and relating all other Second-order themes to that category).

The second order themes and aggregate dimension derived from the theory while the first order themes were added during the process of analysis. The analysis is mainly theory driven in that the themes were developed deductively according to RDT and relevant literature. Themes also 'emerged' for example the competitive advantage.

NVivo version 10 was used as it is widely used for qualitative analysis. All the interviews were transcribed by using Word, anonymisedand then were imported to NVivo for analysis. The transcriptions were read several times in order for the researcher to understand and be familiar with the data. A code was assigned to a phrase that gives evidence towards answering the research questions. Code's names were used as predetermined codes when analysing each case (each company). NVivo was used mainly in the cross-case analysis to cluster the themes using a dendogram, tree map methods that can conceptualise the key themes.

## 4.4 Quantitative research (Phase Two)

The thesis, as previously mentioned, adopted a sequential exploratory mixed methods approach. The first phase collected qualitative data through semi-structured interviews and in the second phase quantitative surveys were administered.

### 4.4.1 Survey and Instrument development

A survey was conducted, to explore how companies perceive the issue of NRS and what supply chain strategies are put in place to manage it. A confirmatory or theory testing (explanatory) survey was used as the knowledge of this phenomenon has been articulated in a theoretical form by having a well-defined model and propositions (Forza, 2002).

The latent variables (constructs) were measured by using multi-item manifest variables (measures) in this study. The measures were generated from the literature, but were modified to fit the current research context. The wording of the measures was reviewed by a panel of four academics and one head of operations manager. This resulted in the refinement of some of the measures. Only items that were representative of the constructs (i.e. latent variables that cannot be measured directly) were kept. This process ensured face validity. The researcher used the comments from the panel members to make the necessary modifications to the scale (i.e., paraphrasing, deleting or adding items). This process is detailed in the following paragraphs.

According to Hair et *al.* (2010) the independent variables are the variables selected as predictors of the dependent variables which in turn measure the response to the effect of the independent variables (Ryan et *al.*, 2002). There is also an explanatory variable, the mediator variable that serves to clarify the nature of the relationship between the independent and dependent variables (MacKinnon, 2008). A mediating model tries to find the mechanism that underlies the relationship between an independent variable and a dependent variable (Rudestam and Newton, 2007). In this study, the independent variable is the natural resource dependence level; the dependent variable is the organisational performance while the supply chain NRS strategies are the mediating variables.

The constructs developed were based on both the literature and the multiple-case study to ensure validation and the relevance of the model and constructs. Churchill (1979) approach of systematic scale development procedures that was followed (Figure 4.3).

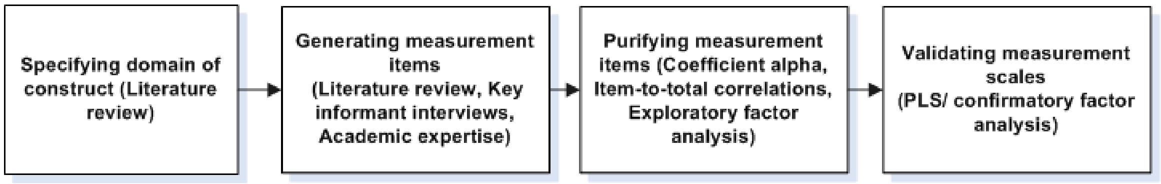


Figure 4.3 Steps in measurement scales development

In the first stage the item generation of the constructs was made based on the literature review and theoretical foundation (Cao and Zhang, 2011; Churchill, 1979). Then items were also evaluated through the interviews with the managers in the qualitative phase. The interviews conducted validated the items clarity from both an academic and practical perspective. The structured interviews indicated whether to keep, delete, or modify, or even generate new items. Next to validate the items a pre- testing of the questionnaire with experts from academia (4 academicians) and professionals (1 manager) was conducted. Details of the operationalisation of the constructs are presented in this section. The experts suggested dropping and modifying items as well as including new items if they felt that the domain of the construct was not covered. The third and fourth stages are described in the Section 4.4.3.

Constructs were measured by multiple-item scales. The questions in the questionnaire used a Likert-type scale. Churchill (1995) highlighted the controversies about the number of points to have on a Likert scale. These controversies mainly fall into two categories: those concerned with the total number of points, and those concerned with the decision to have an even or odd number of points. An even number of points does not allow the respondent to identify a middle or neutral position. This research did not design scales with an even number of points, as this would make it difficult for respondents who held a neutral position to express their views. Instead, the questionnaire was designed with an odd number, as it is easy for a respondent with a neutral position while even numbers try to force respondents to adopt a position. With regard to the total number of points; it is argued that more points give the respondent a better selection from which to make a choice. However, it is also argued that this greater choice may confuse the respondent, and does not necessarily produce richer data.

Each latent construct can be described by reflective or formative indicators. In the reflective indicators *"the latent variable determines its indicators"* (Bollen and Lennox, 1991, p.306). Formative indicators define or cause a latent construct. Reflective constructs are unidimensional (i.e. items are supposed to capture the same aspect of the unobservable construct) whereas formative constructs are multidimensional (i.e. different items capture different sub-constructs and do not overlap). The criticality and purchase important sub-constructs are mixed as they have both reflective and formative items whereas the rest of the indicators are reflective. The need for mixed measures stems from the need to give a more clear picture of constructs as they are new and developed for this research and it was difficult to be measured only unidimensional or multidimensional.

Another empirical study (Dawes, 2008) found that a five-point or seven-point scale can lead to higher mean scores relative to the highest possible attainable score, compared to those produced from a 10-point scale, and this difference was statistically significant. According to Malhorta and Petreson (2006), the five and the seven point scales are the most widely used scales. However, the clarification for the seven-point scale is lengthier (Dawes, 2008) which makes a five-point scale easier for the participants to read and complete the list of scale descriptors such as agree, not agree). For the abovementioned reasons the five point Likert scale was used in this research.

In the first part of the questionnaire respondents were asked to specify the scarce natural resources that were relevant to their company. More specifically, the survey asked the respondents to focus on a ''critical'' scarce natural resource used in their production. The second part of the questionnaire focuses on the contingency factors. The third part of the questionnaire includes questions about the supply chain NRS strategies used or it will or may be use in the future. The fourth part of the questionnaire is related to the implications of these strategies on organisational performance. Respondents were asked in the last part to indicate their title, company size based on the number of employees and annual turnover. At the end of the questionnaire respondents could add their name and email address to take part into a prize draw.

### 4.4.2 Data Collection

The online survey was administered to middle to top management executives from a variety of industries. The data collection period was approximately six months (April – September 2015). Web-based surveys tend to be less costly, resulting in faster response times, allow for detailed tracking of respondent patterns and reduce missing responses (Griffis et *al.*, 2003) and result in more efficient data collection (Boyer et *al.*, 2002). The technical aspect of the online questionnaire enabled no missing values. Unless every question was filled, respondents would not have been able to proceed from one section to another section and to submit the questionnaire.

Purposive sampling was used to identify and select eligible manufacturing companies. Probability sampling was not used due to the limited time and resources (Tongco, 2007). Purposive sampling enabled the researcher to select cases that have the required information to answer the research questions and accomplish the research objectives (Saunder et *al.*, 2007). In this way, respondents were targeted based on their knowledge and ability to provide insights on the issue of NRS. The study employed an online data collection method. The online questionnaire was sent to purchasing managers, logistics managers and product design managers and any manager that is responsible for managing critical scarce natural resources. The population frame for this research was manufacturing companies worldwide.

In order to find the appropriate respondents four main sources were used:

**Source 1:** The first source used was LinkedIn. Managers that are working in manufacturing companies possessing knowledge within the purchasing, sustainability, supply chain and logistics were approached. Thus, the questionnaire was sent to the target audience through LinkedIn. A search was also conducted for relevant groups on LinkedIn in order to target these professionals. Access was gained to relevant groups in LinkedIn including Manufacturing UK, Beer Industry Members, CIPS etc. A discussion started that included the link in a few groups. Personal messages were sent to managers taking in consideration their experience using the professional profile. In the message the research objective was explained by asking them to participate in the survey and when they agreed the link with the questionnaire was sent. About 1000 invites were sent to professionals from several sectors, which resulted in 58 valid questionnaires.

**Source 2:** The Chartered Institute of Purchasing and Supply (CIPS) kindly agreed to include the survey link into its newsletter. The newsletter was sent, opened and clicked by 1,015 members and 10 responses were obtained.

**Source 3:** The researcher purchased email lists from Electric marketing (500 emails) and Unison Data Solutions (1000 emails). After obtaining email addresses from people who are qualified and willing to participate in the survey, personalised emails were sent to email addresses extracted from the database asking managers whether they would like to participate in the research. Reminders for following up were sent excluding those who had already responded. 33 questionnaires where answered while 1000 were undelivered. Another email list (2417 email addresses, 2000 were undelivered) was given to the researcher by a colleague that led to 3 more completed questionnaires. The online surveys were conducted using the Bristol Online Surveys (BOS). The BOS service, is free for Aston University users, and was preferred to other unpaid survey services as it offers an unlimited number of questions and responses permitted and allows the collected data to be exported to Excel format for further analysis. In order to enhance the survey participation rate, relevant incentives were used namely after having filled in the questionnaire there was the option be entered into a draw to win one large amount of money. The anonymity of all respondents was assured and all information disclosed was treated as strictly confidential. To ensure a reasonable response rate, a message was sent to non-responding managers three weeks after the first message.

**Source 4:** An online survey was developed in Qualtrics and SmartSurvey using panel data management. Screening questions were developed to make sure respondents fitted the current study in terms of job title and length of employment which resulted in 43 potential respondents in Qualtrics and another 40 in SmartSurvey. 83 respondents participated in the survey after the launch of the online questionnaire. The first part included two screening questions which aimed to ensure that the respondent was the most appropriate person for taking part in the survey.

A total of 187 survey participants completed the survey and a total of 4 responses were removed (e.g. one answer was referring to people as resources). The usable response rate is calculated as follows (Bryman and Bell, 2011):

$$Response\ Rate = \frac{\text{Number of completed and returned questionnaires}}{\text{Number of respondents in sample} - \text{x}} * 100$$

$$\text{x} = \text{non eligible and non reachable respondents}$$

$$Response\ Rate = \frac{187}{6{,}015 - \text{x}}$$

$$\text{x} = 1000 + 2000 + 4$$

$$Response\ Rate = \frac{187}{6{,}015 - 3{,}004} =$$

$$Response\ Rate = \frac{187}{3{,}011} = 6.2\%$$

Thus, the response rate was 6.2%. Studies suggest that the response rate in online surveys is lower than in mail questionnaires, being as low as 7% in some cases (Braunsberger et *al.*, 2007). Managers are the main source for supply chain management related data and especially for this study high-level managers are needed who are usually busy and they do not usually have time for answering the questionnaires.

Despite the fact that medium level managers were also targeted in most of the cases these respondents perceived the topic as not relevant to their position and felt that they were not the appropriate person to answer it. Thus, mainly senior level managers are needed in order to attain valuable and relevant data. It is difficult to have high response rates to surveys particularly when the target respondent groups are top managers (Abareshi et *al.*, 2008; Inman et *al.*, 2011). Another reason for the low response rate is that the questionnaire was sent to managers by email, which in most cases tend to be ignored by receivers (junk mail) (Wu, 2009).

### 4.4.3 Data Analysis

The Partial Least Squares (PLS) technique, was applied to test the proposed convergent and discriminant validity of the proposed model and the hypotheses. In this thesis, SmartPLS version 3.0 was used for the data analysis. PLS is a second-generation of multivariate analysis tool *"that combine theoretical and empirical knowledge in order to maximise the variance explained"* (Ainuddin et *al.*, 2007, p. 56). A number of researchers (e.g. Hair et *al.*, 2014) stated that there are two kinds of structural equation modelling (SEM) techniques, namely variance-based SEM (PLS) and covariance-based SEM. Table 4.1 outlines the primary differences between PLS and SEM.

Table 4-1 differences between PLS and SEM (adapted from: Gefen et *al.*, 2000; Hair et *al.*, 2014).

| Issue | PLS | SEM |
|---|---|---|
| Objective of overall analysis | Rejects a set of path-specific null hypotheses of no effect. | Shows that the null hypothesis of the entire proposed model is plausible, while rejecting path-specific null hypotheses of no effect. |
| Required theory base | Does not necessarily require sound theory base. Supports both exploratory and confirmatory research. | Requires sound theory base. Supports confirmatory research. |
| Assumed distribution | Relatively robust to deviations from a multivariate distribution. | Multivariate normal, if estimation is through maximum likelihood (ML). Deviations from multivariate normal are supported with other estimation techniques. |
| Required sample size | Small (min.30-100) | High (min.200-800) |
| Epistemic relationship between latent variables and measures | Formative and reflective indicators | Typically only with reflective indicators |

The researcher employed the PLS approach for the following reasons: SEM outperforms in terms of parameter consistency and is preferable as long as there is a large sample. PLS can accommodate small sample sizes (Hair et *al.*, 2014) and is preferred when the emphasis is on prediction and theory development. 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 only problematic but also impractical given the difficulty to reach a great percent of the total population size and time constraints. According to Peng and Lai (2012), the sample size must be at least ten times the maximum number of paths leading to a dependent variable. In this model the number is 5 that means the minimum sample size must be 50 cases which is lower than this sample size.

The PLS path modelling algorithm allows both reflective and formative measurement scales to be used in the analysis of models (Diamantopoulos and Winklhofer, 2001) but SEM analysis can work better only with reflective measures whereas formative scales are acceptable under some circumstances (Howell et *al.*, 2007). Several studies are mis-using formative indicators in SEM as they usually use them as reflective measures (Cohen et *al.*, 1990). In this model both reflective and formative measures were used.

The model and measures for the present study are new and the relationships between them have not been previously tested in that context, thus the PLS path modelling algorithm is more suitable. This model can also be tested by standard procedure (e.g. ordinary least squares regressions) but it is not appropriate to test simultaneously the independent equations. Thus, this model can only be analysed based on the multivariate estimation technique or PLS. Both of them will provide acceptable parameter estimates but the multivariate estimation technique can be used only with single measures but PLS allows having multiple measures of both dependent and independent variables.

Descriptive statistics was conducted with the assistance of SPSS (Statistical Package for Social Science) 21 before assessing the measurement scales. Then, the study followed a two-step approach (Henseler et *al.*, 2009). The first step was to develop an acceptable measurement model prior to assessing the structural model. Reliability tests (the assessment of the Cronbach's Coefficient Alpha and item-to-total correlations) and exploratory factor analysis (EFA) were used as preliminary tests to refine the measures (Churchill, 1979). In order to examine convergent validity, the average variance extracted (AVE) and the cross loadings were used to investigate discriminant validity (see Table 4.3).

Table 4-2 Validity test (adapted from: Hair et *al.*, 2014)

| Validity Type | Description | Assessment criteria/ techniques |
|---|---|---|
| Internal consistency reliability | It measures whether several items measure the same general construct. | Cronbach Alpha<br>Composite reliability<br>Individual item reliability |
| Convergent validity | Is concerned with the correlation between different items | Average variance extracted (AVE) |
| Discriminant validity | Evidence that the concept as measured can be differentiated from other concepts. | Cross loadings |
| | The AVE of each latent variable should be higher than the squared correlations with all other latent variables. | Farnell-Larcker criterion |

Satisfactory results in the previous phase are necessary to proceed to the final stage of the measurement models assessment. This stage involves conducting PLS structural equation modelling. Thus, the relationship among the constructs was examined. These relationships are tested by estimating the paths between the constructs and a number of criteria to evaluate the structural model was used (e.g. R-square, Goodness-of-Fit, Q-square, path coefficients).

## 4.5 Ethical considerations

Ethical issues involve the protection of human rights. In this study the researcher interacted with people working for other organisations and this therefore may raise ethical issues. A cover letter was sent to each potential participant with detailed information about the research aims and the questions was given to each participant and it was explained to them that the information would be used only for research purposes. The informed consent was also obtained by sending an information letter. Anonymity of the respondents was assured. The names for companies are not referred (e.g. automotive companies named by giving the initial of the words ‘automotive company’ and a number to differentiate them i.e. Auto_Co1, Auto_Co2, Auto_Co3, Auto_Co4).

Regarding interviews, consent was also required from the interviewees. Participation was voluntary and any participant could end the conversation at any time they wanted. Confidentiality was assured thus no company name or interviewee name are given in the following chapters. Access to the recorded files was limited only to the researcher and the thesis supervisor. Permission to record the interviews was asked in order to recall the interview.

Bias in the interviews was avoided by the formulation of questions (simple without guiding in one particular direction) and the avoidance of influence of interviewees (interpreting their views differently). Electronic files stored on the Aston’s University personal computer of the researcher were secured as they had password protection. Hard copies of transcripts were kept in a locked filing cabinet at Aston University.  A brief report was sent to the informants that highlights key issues. Ethical approval was given by the School of Engineering & Applied Science ethics committee at Aston University.

## 4.6 Conclusion

This chapter presented a discussion and justification for the methods followed in this research. A mixed (qualitative and quantitative) methods approach was used. The first phase of the study, semi-structured interviews were conducted with 13 manufacturing companies. The second phase incorporated the quantitative method of survey (183 responses) that was used to test the conceptual framework. In the following chapter the findings of the qualitative phase are presented and discussed.

# Chapter 5 FINDINGS FROM MULTIPLE-CASE STUDIES

## 5.1 Introduction

This chapter describes the findings from the analysis of the case studies conducted in 13 manufacturing firms (see Table 5.1). This presents an overview of each case (within-case analysis findings) and it focuses on the different natural resources used by each company and the strategies that each company follows to handle the scarcity of them. All fieldwork took place in the period between July 2014 and February 2015. The aim of the case studies is to understand how the availability of critical natural resources influences the implementation of specific supply chain strategies enabling reduction of natural resource dependence level and improving organisational performance.

For each case study, a general view of the company background is given, followed by the three main themes explored in this research: natural resource dependence level, supply chain NRS strategies and organisational performance. Each case is presented based on the key issues found in order to validate and improve the proposed conceptual model (see Chapter 4). The discussion of each case is based on the interviews, key documents and reports from each company. From all this data gathered, competitive advantage emerged as a new theme that was identified.

All the cases are linked to the proposed conceptual framework and propositions. Each key theme (e.g. natural resource dependence level) is explained and discussed, and also tables are provided with some key quotes from the semi-structured interviews, based on the empirical findings. At the end of each case analysis, a list of propositions is presented. The next section presents the 13 cases.

Table 5-1 Profile of companies in the case studies

| Company Name | Industry | Number of Employees (approximately) | Turnover (approximately) | Interviewees / Key Informants |
|---|---|---|---|---|
| AutoCo_1 | Automotive: One of the largest multinational OEM. | 181,000 | £94 billion | 2 Purchasing Managers |
| AutoCo_2 | Automotive: International Tier 1 supplier of automotive Body-in-White products and services. | 650 | £66 million | Logistics Manager, Purchasing Manager, Purchasing and Logistics Director |
| AutoCo_3 | Automotive: Multinational OEM | 30,000 | £19 billion | Sustainability Manager, Supply Chain Manager, Purchasing Corporate Social Responsibility Manager, Product Environment Manager, Product Stewardship Manager, Materials Engineer, Group Leader in Sustainable Aluminium Strategies, Materials Engineering Manager |
| AutoCo_4 | Automotive Industry: Seat Manufacturer for a variety of applications. | 300 | £66 million | Purchasing Director, Environmental Manager Logistics Manager |
| BrewCo_5 | Food and Beverages: One of the largest beer companies in the United States. | 5,313 | £6 billion | Sustainability Manager |
| ChemCo_6 | Chemical: A leading multinational manufacturer of chemicals delivering products to sectors such as electronics, water. | 53,000 | £37 billion | Director of Sustainability Programs |
| ChemCo_7 | Chemical: This company manufactures products in the health, hygiene and home sectors. | 37,000 | £10 billion | Supply Chain Manager |
| ElectCo_8 | Electronics: One of the largest manufacturers of electronic products (e.g. personal computers, laptops). | 317,500 | £72 billion | Business Operations Manager |
| ElectCo_9 | Electrical and Electronic Manufacturing: A manufacturer of secure identity solutions such as smart cards. | 2,100 | $6.1 billion | Director of Operations, Director of Global Sustainability, Vice President of Global Supply Chain |
| AlumCo_10 | Aluminium: A producer of extruded aluminium. | 23,500 | £2.5 billion | Director of Global Strategic Sourcing , Vice President of Corporate Social Responsibility Manager, Vice President of Strategic Sourcing |
| AlumCo_11 | Aluminium: A manufacturer of finished flat rolled aluminium lithographic strip | 8000 | £1.8 billion | Sales & Marketing Manager |
| AlumCo_12 | Aluminium Industry: A global supplier of industrial aluminium. | 11,000 | £7 billion | Environmental Manager , Plant Manager, Senior Purchasing Manager |
| PlastCo_13 | Plastics Industry: A family-owned company that provides rotational moulding. | 33 | £ 1 million | Director of the Company |

## 5.2 Case study AutoCo_1

AutoCo_1 is one of the largest OEMs in the world that sells cars and commercial vehicles. AutoCo_1 consumes a set of natural resources such as water, energy, steel, aluminium, some REEs such as palladium, platinum and other metals such as gold. This company is proactive as it utilises a specific set of strategies to overcome the risk of NRS.

**Natural Resource Dependence Level and Supply Chain NRS Strategies**

Interviewees from the AutoCo_1 show that the price of the natural resource, the number of suppliers and regulations are the key factors that led them to adopt specific supply chain NRS strategies (see Table 5.2).

Table 5-2 Themes, Concepts, and Quotations for the Natural Resource Dependence Level dimension (AutoCo_1) (Source: Derived from empirical data)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"The reasons that led us to take some specific strategies are cost….By referring to cost we mean price of the raw materials."*<br>(Purchasing Manager B)<br><br>*"If you are missing a nut that you need to make a car that box of thousand hypo nuts loses you thousand dollars that has overhead profit costing 10 million dollars. So that box of nuts is worth ten million dollars if you don't have them when you need them."*<br>(Purchasing Manager A) | Price of the natural resource | Importance of the scarce natural resource | Natural Resource Dependence Level |
| *"We don't have many suppliers."*<br>(Purchasing Manager B)<br><br>*"Usually we have single source supplier"*<br>(Purchasing Manager A) | Number of suppliers | Supplier substitutability of the scarce natural resource | |
| *"There is a legal responsibility to recycle cars."*<br>(Purchasing Manager B)<br>*"Drives car makers the legislation."*<br>(Purchasing Manager A) | Legislation | Discretion over the scarce natural resource | |

The case revealed that the importance of natural resources (e.g. high price) leads mainly to buffering supply chain strategies such as substitution. In Table 5.3 the strategies that AutoCo_1 is following are presented.

Table 5-3 Themes, Concepts, and Quotations for the Supply Chain NRS strategies dimension (AutoCo_1) (Source: Derived from empirical data)

| **Representative quotations** | **First-order themes(Nodes)** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *"We try to use the minimum of a scarce natural resource such as gold" (Purchasing Manager B)*<br><br>*"We have to move to dense paint that uses more paint but a bit less water" (Purchasing Manager A)* | New technologies to minimise the usage of resources in the product | Product and process (re-) configuration (Buffering Strategies) | Supply NRS Strategies |
| *"We try to find alternative sources of power" (Purchasing Manager B)* | Substitution | | |
| *"We also recycle the scrap of the metal" (Purchasing Manager A)* | Recycling | | |
| *"We usually have long term contracts up to 5 years" (Purchasing Manager B)*<br><br>*"We collaborate with wiring suppliers" (Purchasing Manager A)* | Trust and relational norms | Relational Mechanisms and Transactional mechanisms (Bridging Strategies) | |
| *"We do have some contracts with recyclers" (Purchasing Manager A)* | Contract and transaction specific investments | | |

Buffering strategies are used such as substitution to reduce the importance of specific natural resources.

> *"If you are going to lose 3 million dollars a day for not having the part you need you will find a way… well in that case we search for substitutes" says Purchasing Manager A.*

> *"The normal testing time for a substitute is about six months...So we get a cross-functional team together (engineer, quality engineer, production planner) and we go look at how we are going to overcome this shortage" (Purchasing Manager A).*

For instance, the company tries to reduce the dependence on petroleum oil (and thus reduce the carbon footprint) by using renewable resources such as soy-based polyurethane foams for automotive applications. It also tries to use a tropical plant, to reinforce plastic and to substitute the oil-based resin in the plastic. Wheat straw is also used to replace some minerals to reduce petroleum usage. Also, in some plants a new technology to reduce the amount of oil needed to machine an engine is being implemented.

For AutoCo_1, energy is also a crucial resource and it tries to use alternative energy instead of coal, oil, natural gas and nuclear energy. In the late 1970s there was a shortage of coal that led to increased cost of extracting the coal and the process of extracting it became more energy intensive (Purchasing Manager B). Thus, the company is trying to use alternative sources of power such as solar panels, hydro, winder power and biofuels.

Wind turbines are used to generate electricity from renewable sources, which helps reducing further the $CO_2$ emissions from its European operations. Specifically, a manufacturing plant in Belgium is partly powered by two wind turbines. In the UK AutoCo_1 has an automotive plant that takes all electrical power from three on-site wind turbines and in another UK plant they have grid-connected solar/photovoltaic installations.

Safety stock from *“oil is also kept in order to manage power interruption”* in the past (Purchasing Manager B). However, safety stock is not preferred due to price volatility and it also ties up cash unnecessarily. AutoCo_1 also had a bad incident of stockpiling; when the price of palladium increased they bought a great deal of safety stock of this natural resource and after some months the price fell and they lost about $1 billion.

Product redesign is also utilised for example in the case of copper, which is used for making wire. As a result, they are using thinner wires which means less of the scarce natural resource (Purchasing Manager A). Besides, aluminium is used in combination with copper in order to make the wires. Process redesign is also followed; for example, the cooling system changed (indirect counter-flow evaporative) in order to use less energy and achieve energy cost savings. Currently, the lighting system already installed in some plants, will be upgraded, moving from metal-halide to LED lighting in order to reduce annual energy consumption.

From a business standpoint, it is really crucial to reduce water usage before there will be significant price increases or water use restrictions enacted. New technologies have been introduced that reduce water use for example, the technology in the painting of a car, one of the processes normally uses of a great deal of water. Reusing and recycling of water is used as a practice in the company's operations. This technology uses less energy and reduces carbon dioxide and particulate emissions compared with conventional paint processes. Waterless toilets also exist to reduce the water usage.

> *"We are using waterless toilets thus we can minimise the water use. Moreover, we are reusing waste water in our production plants." (Purchasing Manager B).*

> *"So we are working on reducing the usage of water … recycling of the water by using a filter to clean it and the water goes through the entire factory it mixes with the paint and goes out again." (Purchasing Manager A).*

The case study demonstrates that there are a few suppliers for the same resource. In particular, long-term contracts exist with suppliers up to five years but the company does not collaborate so closely nor has joint ventures.

> *"We are sourcing from a single supplier with whom we have a long term contract" (Purchasing Manager A).*

Contracts can last about twelve years (Purchasing Manager A). Close collaboration with suppliers exists to some extent. For example, AutoCo_1closely collaborates with the wiring connector supplier. The supplier located its plant close to the automotive company so that AutoCo_1 can be involved in the design of the part. The company collaborates closely with the suppliers by discussing challenges and working together towards solutions. For water utilities, energy and recycling of the materials they have short-term contracts with the suppliers. There is no evidence that the small number of suppliers will lead to buffering strategies.

> *"When we design our network of course we look at resources that we can have access such as water power. But we are also looking at transportation and people" pointed out by Purchasing Manager B.*

The interviewees stated that the company will not reconfigure its plants because of NRS despite the fact that some plants operate in water stressed regions.

> *Purchasing Manager A argues that "I don't think we have any factories in water stressed regions ... There is no need for relocation of factories".*

However, they will follow strategies such as recycling. A factory in the East of England is considered to be a water stressed region. But there are various channels and the water can come from the west of England to the dry east of England. However, in another water-scarce region the company did apply some strategies. Specifically, over the decades, many international corporations, including beverage companies are located in this region.

The government authorities of this country where the plant is located limit the water usage and imposes stricter permission due to water demand outstripping supply. Recycling of water is used at this plant and other actions implemented such as applied ecological concrete (the rain can re-enter easier to the ground) and achieved 58% reduction in water use per vehicle produced between 2000 and 2013 in this plant.

REEs are also a concern due to their geographic concentration. However, AutoCo_1 is not directly affected as the company does not purchase REEs directly but their suppliers (or third tier suppliers) that provide the company with parts for their vehicles buy these REEs. These metals are used in conventional internal combustion vehicles in small quantities. However, hybrids, plug-in hybrids and full electric vehicles use a great deal of these in magnets in their electric motors and in battery systems. As their production increases, the importance of the supply and production of certain REEs is growing and the company is forced to take specific measures.

For example, in the battery production they try to reduce the need for REEs. Specifically, they move away from nickel-metal-hydride batteries to lithium-ion. In nickel-metal-hydride batteries are used REEs such as neodymium, cerium, lanthanum and praseodymium that are not used in the new lithium-ion batteries. AutoCo_1 also introduced a new diffusion process that reduces the need for dysprosium - the most expensive rare earth metal- by 50% in magnets that are used in hybrid's electric machines.

Therefore, the results confirm that the accessibility of scarce natural resources will lead to buffering strategies. For example, catalysts are redesigned in order to use less of such valuable metals. The case study supports that in the catalytic converters they have mixed the gold with palladium and platinum. This means less usage of the scarce resource *"such as gold which is mixed with other natural resources that are not considered to be scarce"* (Purchasing Manager B).

Apart from the issue of accessibility to REEs that China mainly provides, the company is also concerned about the conflict minerals. Conflict minerals originating from the Democratic Republic of Congo and the nine surrounding countries. The company cannot purchase products that entail any natural resource namely rare earth metals from this country. The company is required to report annually to the U.S. Securities and Exchange Commission whether their products contain "conflict" minerals. They are working closely with suppliers globally that provide parts and require from them to support this effort.

**Supply Chain NRS Strategies and Organisational Performance**

The case study demonstrates the benefits of applying supply chain NRS strategies. There are two outcomes identified namely resource efficiency (i.e. reduce the cost and usage of resources) and competitive advantage as a result of implementing buffering and bridging strategies (see Table 5.4).

Table 5-4 Themes, Concepts, and Quotations for the Organisational Performance Dimension (AutoCo_1) (Source: Derived from empirical data)

| **Representative quotations** | **First-order themes (Nodes)** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *"Less use of the scarce resources" (Purchasing Manager B)*<br><br>*"Minimise the water use" (Purchasing Manager B)*<br><br>*"Reduce annual energy consumption" (Purchasing Manager B)* | Reduction of the usage of resources | Resource Efficiency | Organisational Performance |
| *"Less energy and energy cost savings" (Purchasing Manager A)* | Decrease of the purchasing cost | | |
| *"Renewable sources which help to reduce further the CO2 emissions" (Purchasing Manager B)* | Minimisation of $CO_2$ | | |
| *"No waste and we get money for these metals" (Purchasing Manager A)* | Waste reduction | | |
| *"We will need to get better fuel economy not only to meet regulations, but as a competitive advantage" (Purchasing Manager A)* | Provide new or/and improved products to markets | Competitive Advantage<br><br>**(Newly Emerged Theme)** | |

> *Purchasing Manager B states that "We do have targets such as to reduce energy…and we can see reduction on costs".*

Therefore, it can be realised that financial and non-financial performance are positively influenced by buffering and bridging strategies. For instance, by using wind turbines and the new cooling system led to energy cost savings and also less energy used. The amount of electricity used to produce each vehicle in their manufacturing facilities has been reduced by about 800 kWh — from 3,576 kWh in 2006 to 2,778 kWh in 2011. They improved global energy efficiency by 6.4 %.

> *"We are quite happy to recycle" parts of the car as they are reasonable valuable is supported by Purchasing Manager A, such as aluminium, steel.*

They have produced $225 million in new revenue from recycling scrap metals. The company has cut the amount of water used by 61% globally. This means water savings and cost savings. 65% of a plant's wastewater is reused in cooling towers, cleaning. The changing of the painting process is expected to reduce the carbon dioxide emissions by 9,500 tons. $CO_2$ emissions are reduced by approximately 47% from 2000 to 2012.

AutoCo_1 is working closely with suppliers to bring innovative technologies such as the use of soy-based polyurethane foam. The usage of soybean leads to saving of approximately 5 million pounds of petroleum annually. The use of soy foam reduces also the $CO_2$ emissions apart from cost savings. Developing the new material of wheat straw was based on a collaboration with a plastic supplier that developed moulding compounds that contain renewable materials. The use of wheat-straw reduced petroleum usage by 20,000 pounds and $CO_2$ emissions by 30,000 pounds annually.

Dysprosium usage reduced that led to AutoCo_1 saving up to 500,000 pounds of REEs annually. Therefore, the results confirm that the supply chain NRS strategies have a positive impact on the organisational performance of AutoCo_1. Based on the secondary data (i.e. their sustainability report) the company has launched a new series of cars that use mainly aluminium instead of steel. In order to implement this innovation, they have closely collaborated with their aluminium suppliers that led the company to a tough competitive position against its competitors. The new aluminium cars differentiate AutoCo_1 from its competitors.

Based on the discussion of the findings in AutoCo_1, the effect of each factor found from the findings can be shown. AutoCo_1 confirms most of the suggested associations between the key three themes. A list of propositions for the themes explored and newly emerged themes in this case study is documented in Table 5.5. These propositions are based on the propositions developed earlier and presented in Chapter 4. Based on the data analysis (e.g. the tables provided above for each dimension) these propositions are supported or not.

Table 5-5 The Research Propositions for AutoCo_1 (together with newly emerged theme) (Source: Derived from empirical data)

| **Sub-Propositions supported and Newly Emerged Themes** | **Level of support** | **Propositions** |
|---|---|---|
| P1.a: The importance of the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | P1, P2, P3 (Natural Resource Dependence Level and Supply Chain NRS Strategies ) |
| P1.b: The importance of the scarce natural resource has an impact on the adoption of bridging strategies. | Not supported | |
| P2.a: Supplier substitutability has an impact on the adoption of buffering strategies. | Not supported | |
| P2.b: Supplier substitutability has a positive impact on the adoption of bridging strategies. | Supported | |
| P3.a: Discretion over the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | |
| P3.b: Discretion over the scarce natural resource has a positive impact on the adoption of bridging strategies. | Supported | |
| P4: The adoption of buffering strategies has a positive impact on resource efficiency. | Supported | P4, P5(Supply chain NRS strategies and Organisational Performance) |
| P5: The adoption of bridging strategies has a positive impact on resource efficiency. | Supported | |
| Competitive Advantage<br>The new aluminium-bodied car and the use of recycled materials that was created through close collaboration with suppliers led the company to:<br>• Differentiation from rivals<br>• Enhanced technical skills, knowledge making replication difficult | | Newly Emerged theme (Organisational Performance) |

## 5.3 Case study AutoCo_2

AutoCo_2 is Tier 1 automotive supplier and one of the largest users of automotive grade aluminium in Europe who specialises in stampings and assemblies. It produces a wide range of products for both low and high volume vehicles. In terms of natural resources, AutoCo_2 mainly uses steel, aluminium, energy, oil and recently started to apply some strategies for minimising the use of resources. The main reason for following these strategies is the pressure from its major customers (i.e. a specific OEM). This argument is supported by the following quotes:

> *"…and predominantly I have to say that the customer leads us to take actions for minimising the usage of resources" (Logistics Manager)*
>
> *"We are make to print company so basically the customer will ask us to make a product we have a very little input only to make it to be manufactured more easily" (Purchasing Manager)*
>
> *"So we are engaged heavily because our two most costly items are the materials and energy" (Purchasing and Logistics Director).*

**Natural Resource Dependence Level and Supply Chain NRS Strategies**

AutoCo_2 identifies the prices of the resources as an important factor to employ several strategies. The Purchasing and Logistics Director stated:

> *"We have I would say an engine, we spend probably 3 million per annum that is going to increase because there is an increase in cost in charges for energy. That is going to increase for the next 10 years significantly. We just started an energy kaizen program, energy saving program with a power agency…and that is to look at reduction in consumption both in electricity, gas across all the sites."*
>
> *"So natural resources are becoming more scarce, that's driving cost up and we are using more recycled materials " (Purchasing Manager)*

Also the number of suppliers and the legislation are considered as the key drivers that led AutoCo_2 to specific strategies (see table 5.6).

Table 5-6 Themes, Concepts, and Quotations for the Natural Resource Dependence Level dimension (AutoCo_2) (Source: Derived from empirical data)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"One is looking at the cheapest possible KW or MW of electricity"* (Purchasing Manager) | Price of the natural resource | Importance of the scarce natural resource | Natural Resource Dependence Level |
| *"We don't really have a choice"* (Logistics Manager)<br><br>*"There is only a handful of people"* (Purchasing Manager)<br><br>*"Its limited where you can go and buy"* (Purchasing and Logistics Director) | Number of suppliers | Supplier substitutability of the scarce natural resource | |
| *"Target what the government said"* (Purchasing and Logistics Director) | Legislation | Discretion over the scarce natural resource | |

Several buffering strategies such as product redesign, substitution, recycling, and process redesign but also bridging strategies such as relational mechanisms and transactional mechanisms are utilised by the automotive supplier (see Table 5.7).

Table 5-7 Themes, Concepts, and Quotations for the Supply Chain NRS strategies dimension (AutoCo_2) (Source: Derived from empirical data)

| **Representative quotations** | **First-order themes** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *"Before you go into full production you make the blank smaller"* (Logistics Manager) *"Sensors in the lights in the rooms"* (Logistics Manager) *"Efficient lighting, any motors and parts that we buy for the equipment that will be low energy pumps and heating equipment"* (Purchasing and Logistics Director) | New technologies or process to minimise resource usage | Product and process (re-) configuration and supply chain (re-)configuration Buffering Strategies | Supply NRS Strategies |
| *"We will be looking at solar energy"* (Purchasing and Logistics Director) | Substitution | | |
| *"So we do recycle copper"* (Logistics Manager) | Recycling | | |
| *"We would have a vehicle model typically last for 7 years so we would have that supply"* (Purchasing Manager) | Relational Mechanisms | Relational Mechanisms and Transactional mechanisms (Bridging Strategies) | |
| *"We have consumable contracts for water , gas , power they will be reviewed normally 2-3 years fixed contracts"* (Purchasing and Logistics Director) | Transactional mechanisms | | |

By working closely with top customers, AutoCo_2 reduced the usage of aluminium specifically through the adoption of the minimisation of the blank size. This is explained by the following quote:

> *"So when you first design a blank it might be the size of this piece paper but once you try to make a part out of it you may decide it doesn't need to be actually this big …so before you go into full production you make the blank smaller" (Logistics Manager)*

A new technology introduced to replace welding to reduce energy consumption by not using heat. Welding uses a lot of energy, but recently many motors and parts are utilising low energy pumps and heating equipment. Light weighting is not only applied to the pressings, but to the dies themselves thus, less energy is used. The company will look at solar energy and in the feasibility of using wind power. Biomass heaters are also considered.

Closed loop system is used for aluminium, any scrap metals are recycled and reused. AutoCo_2 main customer became more heavily focused on renewable and recyclable material so they had to follow their practices. Specifically, they collaborate with the nominated supplier of aluminium in recycling. A specific supplier provides them with aluminium that has a higher content of recyclable material.

> *"So what will happen is our scrap" will be sent to the nominated supplier and "the scrap then go back to a melting cast" of this supplier. (Purchasing Manager).*

AutoCo_2 sites have dedicated scrap bins for aluminium as they have different specifications (thus different value) so they do not aggregate them. This company also recycles some copper in one of their sites. There is a difference in the way that the scrap material is used. The Purchasing and Logistics Director stated that:

> *"Aluminium is obviously high value scrap no one really recycles steel scrap…just it goes to the market and it is sold and it goes back but it's not a close loop process. Steel is sold in the open market as the cost of scrap steel does not have high value compared to aluminium"*

Concerning energy, they not only start to use providers of renewable energy but also have kaizen activities for example sensors in the lights or

> *"So for example we will look at do you stop auto-motors on the press so when the press is not running say through a break time or do you put the press down so it's not using electricity" states the Purchasing Manager*

After some years they are considering taking a closer look at water as a resource. They keep some safety stock for the steel and aluminium for about two days as keeping more inventory is expensive. As the Purchasing and Logistics Director and Purchasing Manager confirmed:

> *"Obviously too much stock you are holding too much cash…we will try to hold in terms of raw materials steel and aluminium may be 2 days….3 days max depends on the component and depends on the volume of that component"*

*"The supplier holds the stock and we have minimum stocks so the cash flow in products is low"*

There are two aluminium suppliers in Europe and one steel supplier in the UK and maybe three other steel suppliers on the continent. The company established long -term contracts that are usually equal to the general life cycle of a vehicle that is about seven years. However, there are cases that the most important customer tells AutoCo_2 to source from suppliers they should buy from and they are called "nominated suppliers" as illustrated in the following quote.

*"Aluminium and steel because its automotive standards one is nominated by the customer and its limited where you can go and buy" (Purchasing and Logistics Director)*

For example, the company could buy steel cheaper from China or India, but the steel does not meet the specification of the European market.

Materials from nominated suppliers are tested and their company would not buy material from anyone else because they have to retest the vehicle. Consumable contracts for water, gas, power are reviewed normally 2-3 years as fixed contracts for the utilities.

AutoCo_2 tries to be close to its customers not to their suppliers. So if their customer plans to go to make cars in Australia, AutoCo_2 will probably relocate.

*"Our driving factors we will build our facility based on our customer so to reduce the logistic cost for them… so the location close to natural resources is not really a driving factor" states the Purchasing Manager*

Until now the company has not encountered any accessibility issue and thus no specific strategy has been considered.

**Supply Chain NRS Strategies and Organisational Performance**

Reduction of the usage of resources, minimisation of $CO_2$ and decrease of the purchasing cost (see Table 5.8) are the main benefits that can be achieved according to the interviewees of AutoCo_2.

Table 5-8 Themes, Concepts, and Quotations for the Organisational Performance Dimension (AutoCo_2) (Source: Derived from empirical data)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"Reduce gas and electricity consumption by 25% that will give us cost benefit but also $CO_2$ benefit"* (Purchasing and Logistics Director) | Reduction of the usage of resources | Resource Efficiency | Organisational Performance |
| *"We can reduce our emissions , our $CO_2$ footprint"* (Purchasing Manager) | Minimisation $CO_2$ | | |
| *"So for us its obviously to save cost that will increase over the next 10 years"* (Purchasing and Logistics Director) | Decrease of the purchasing cost | | |

AutoCo_2 key customer aims to produce a car that entails 75% recycled aluminium of which 45% comes from recycling strategy of scrap utilisation. Thus, through the recycling process (100% of the materials collected are recycled), the company reduced its costs. As the Logistics Manager stated in the following quote:

*"There is a financial implication, because it is very valuable".*

The Logistics manager stated that: *"we get about quarter a million a month"* from recycling. Their customers also try to utilise less resources as can be seen in the quote below:

> *"The only example of redesign or changing process is the blank size reduction project is called…so it's working with the customer to use a smaller amount of material in the first place" Logistics Manager*

Specifically by the blank reduction program they achieve savings of £660 million. Scrap material (i.e. left over materials from product manufacturing that can be recycled) is also measured:

> *"We do have key performance indicators so what we have is… scrap out so we know that currently for example 70,000 tones steel in and 30-32,000 tons of steel scrap out" (Purchasing Manager)*

Energy usage is also monitored.

> *"We do monitor that but it's not just the usage…so we do have a report about our energy usage but it's like if we are busy the usage will be higher if not it will be lower so it's more about the unit cost the driver and we try to use less if we can"(Purchasing Manager)*

By implementing the new program for energy reduction, several benefits have been encountered regarding their performance. Concerning the energy kaizen program, they want to achieve 5% reduction in energy consumption per annum so over a 5 year period they will achieve a 25% reduction in energy consumption. Apart from improving the environmental performance, also economic performance (cost reduction) is improved. This is supported by the Purchasing and Logistics Director in the following quotes.

> *"The energy strategy is obviously a major reduction in cost, major reduction in consumption we know the cost per unit will increase so we can't do anything about that….but we are looking to reduce our consumption" (Purchasing and Logistics Director)*

> *"So for the next 5 years the target is to reduce gas and electricity consumption by 25% that will give us a cost benefit but also $CO_2$ benefit " (Purchasing and Logistics Director)*

Overall, all of the interviewees agree that buffering and bridging strategies have positive impacts on performance namely resource efficiency.

Table 5.9 below illustrates each proposition linked with the findings of AutoCo_2 in order to see if the conceptual model works. AutoCo_2 shows some level of support for 4 suggested associations between the three key themes in general.

Table 5-9 The Research Propositions for AutoCo_2 (Source: Derived from empirical data)

| Sub-Propositions supported and Newly Emerged Themes | Level of support | Propositions |
|---|---|---|
| P1.a: The importance of the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | P1, P2, P3 (Natural Resource Dependence Level and Supply Chain NRS Strategies ) |
| P1.b: The importance of the scarce natural resource has a positive impact on the adoption of bridging strategies. | Not supported | |
| P2.a: Supplier substitutability has a positive impact on the adoption of buffering strategies. | Not supported | |
| P2.b: Supplier substitutability has an impact on the adoption of bridging strategies. | Supported | |
| P3.a: Discretion over the scarce natural resource has a positive impact on the adoption of buffering strategies. | Not Supported | |
| P3.b: Discretion over the scarce natural resource has a positive impact on the adoption of bridging strategies. | Not Supported | |
| P4: The adoption of buffering strategies has a positive impact on resource efficiency. | Supported | P4, P5(Supply chain NRS strategies and Organisational Performance) |
| P5: The adoption of bridging strategies has a positive impact on resource efficiency. | Supported | |

## 5.4 Case study AutoCo_3

AutoCo_3 is multinational automotive company that sells vehicles. AutoCo_3 consumes a set of natural resources such as water, energy, steel and aluminium.

**Natural Resource Dependence Level and Supply Chain NRS Strategies**

According to the interviewees, the price of the natural resources, number of suppliers, geopolitical risk but also switching costs and legislation are the main factors that create the dependence so AutoCo_3 takes them into consideration.

The quotes below with the Table 5.10 show the managers' perceptions.

> *"It's not an easy process we have to go through various steps to do that including you need to a lot of verification test work to ensure particularly if it is a safety feature in the vehicle you need to make sure that a new supplier or a different supplier is able to meet all the company's requirements around of the material standards." (Sustainability Manager)*
>
> *"We are very narrow-minded when it comes to the supplier base. For instance steel and aluminium are sourced from one supplier" (Supply Chain Manager)*
>
> *"That strategy was developed to enable us to manufacture the vehicles and to meet weight targets associated with fuel consumption and $CO_2$ efficiency" (Product Environment Manager)*

Table 5-10 Themes, Concepts, and Quotations for the Natural Resource Dependence Level dimension (AutoCo_3) (Source: Derived from empirical data)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"I think the main reason focusing as a business come down to cost"* (Sustainability Manager) | Price of the natural resource | Importance of the scarce natural resource | Natural Resource Dependence Level |
| *"There are 5 -6 aluminium suppliers that I can think of globally"* (Product Environment Manager) | Number of suppliers | Supplier substitutability of the scarce natural resource | |
| *"I guess the nature of business doesn't mean that there is always an alternative once the supplier may exist who does something different it may be not always possible to go and use them"* (Sustainability Manager) | Switching costs | | |
| *"Legislation if there is any legal requirement that we have to make sure the vehicles comply with."* (Sustainability Manager) | Legislation | Discretion over the scarce natural resource | |
| *"At the moment we have very few limitations in the availability of materials to our product but in the future there are likely to be severe restrictions and this not only depends on the acquisition mining availability but also to an extent it depends on political objectives We are starting recognise the issue as you look at lithium batteries and where the materials coming from is from China, Russia so there is politically sensitive on those materials."* (Purchasing Corporate Social Responsibility Manager) | Geopolitical risk | | |

AutoCo_3 increased the quantities of recycled aluminium in order to reduce energy usage and to reduce $CO_2$ emissions by collaborating closely with their aluminium supplier (see Table 5.11).

> *"We are trying to optimise every single part and component in the vehicle by using less of that material and obviously where possible if we can use recyclable material that tends to have lower energy or lower embedded energy to produce that particular product."(Sustainability Manager)*

Table 5-11 Themes, Concepts, and Quotations for the Supply Chain NRS strategies dimension (AutoCo_3) (Source: Derived from empirical data)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"We have quite a lot of recyclable polymers in our cars so for example we use recyclable ABS in our cars in the interior"* (Group Leader in Sustainable Aluminium Strategies) | New technologies or process to minimise resource usage | Product and process (re-) configuration And (Buffering Strategies) | Supply NRS Strategies |
| *"We have used some organic fibres and we introduced the light photovoltaics"* (Sustainability Manager) | Substitution | | |
| *"Create a close loop system where basically aluminium that is coming from the production line"* (Sustainability Manager) | Recycling | | |
| *"We source from a supplier for a vehicle or a vehicle life by vehicle platform line… then they will have given a contract to the supplier that supplies the parts and depending on the commodity either will be for the life of the vehicle or the life of that platform or alternatively will be one a model year."* (Purchasing Corporate Social Responsibility Manager) | Relational Mechanisms | Bridging Strategies | |

Recycled aluminium uses 5% energy that leads to fewer greenhouse gas emissions and reduces water usage. Waste reduction achieved by reusing or recycling waste materials. AutoCo_3 have initiated a program with their aluminium supplier who is responsible to take back the scrap that is produced through the stamping processes. Thus, any scrap metal aluminium and steel is segregated and sent back to suppliers for recycling. The supplier will convert the scrap into secondary metal sheets and supply them to AutoCo_3.

> *"We set up a system where the kind of waste elements goes back to our supplier and stays" says the Sustainability Manager.*

25% of recycled post-consumer, non-automotive scrap (e.g. cans) are used in order to produce a new aluminium alloy. One type of car is using in its body 50% of recycled aluminium.

Recycling of other resources such as plastics, leather, and natural rubber is in the main scope of the company. Despite that the from 2000 onwards the company has been required to design cars to be 85% recyclable and 95% recoverable, they have not yet started to use recycled material from the end of life vehicles. However, it is seen as an opportunity in the future. AutoCo_3 does not keep any safety stock says the Sustainability Manager.

The current focus is also on substitution. They are trying to find new types of natural fibres such as sugar and replace plastic that is oil based. Car manufacturers consume a lot of water in the painting shops. For example, a few plants recycle water from the paint shop and reuse it in their manufacturing processes. One of their plants also stores the rainwater for use in the plant. Solar photovoltaic panels have been installed in a plant.

Renewable sources are trying to be used more such as biofuels. Advanced combustion technology may be used in one of their plants that would burn waste wood in order to fulfil most of the site's electricity needs. A solar wall heating system was introduced in one of their plants. Manufacturing systems and equipment were changed to minimise energy usage while a long term strategy to reduce energy use is under development at the moment.

*"It's not an easy process"* to find alternative suppliers as there are costs and specific requirements around of the material standards. So they mainly follow relational mechanisms as can be seen in the quotes below:

> *"We look to establish longer term relationships with suppliers because that is beneficial to both sides." (Sustainability Manager).*

> *"In terms of the partnerships we are looking rather than doing partnerships we are looking to have strategic partners, we are looking at strategic supplier partnerships in the real sense, don't think that there are any but in terms of having our strategic suppliers we know where our supplier base is and with who we want to work with and we encourage them to do as much as they can" (Purchasing Corporate Social Responsibility Manager).*

Contracts with suppliers last either for the life of the vehicle or the life of that platform that is almost seven years.

Concerning accessibility, the practice of relocation of existing plants is not considered as a strategy. However, AutoCo_3 is going to manufacture cars in Saudi Arabia because of the huge quantity of aluminium that exists in this country and also they are considering building a factory in Brazil that has massive amounts of copper non-ferrous metals and the petrochemicals. This is illustrated in the quote below:

> *"We are going to manufacture cars in Saudi Arabia the driver for that is because the Saudis have a huge quantity of aluminium, aluminium bauxite they have just build a massive refinery in Saudi Arabia. We also thinking to produce cars in Brazil that has massive amounts of copper nonferrous metals and the petrochemicals of course to avoid shipping finished products and also you avoid taxation on imports" (Product Environment Manager).*

**Supply Chain NRS Strategies and Organisational Performance**

> *"The main one that we will look at it must be a cost benefit" (Purchasing Corporate Social Responsibility Manager).*

They also look at $CO_2$ as the Sustainability Manager states *"We are able to measure a number of different environmental indicators six in total but the main one that we focus on because a) its more understandable and b) because it tends to be in most cases the highest impact is around $CO_2$ equivalent conversation of all greenhouse gasses into a $CO_2$ figure and that's what we use as a key metric on vehicle programs. So we have achieved a range of results in kind 8 - 12 % reduction on a number of vehicle programs by using those metrics. So we are going beyond that the car industry historically had."* Table 5.12 shows the implications of the above strategies

Table 5-12 Themes, Concepts, and Quotations for the Organisational Performance Dimension (AutoCo_3) (Source: Derived from empirical data)

| **Representative quotations** | **First-order themes** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *"So you are reducing the consumption of resources, reducing the amount of energy required to process the material and obviously generating better value for us as a company; reducing our cost."* (Sustainability Manager)<br><br>*"Minimise energy usage"* (Purchasing Corporate Social Responsibility Manager) | Reduction of the usage of resources | Resource Efficiency | Organisational Performance |
| *"The main metric that we use of a product perspective is the $CO_2$ equivalent."* (Sustainability Manager) | Minimisation of $CO_2$ | | |

Based on corporate figures, $CO_2$, water usage and waste are reduced by 21%, 17% and 75% respectively. The company target is to reduce $CO_2$ emission and water use by 30% by 2020. The photovoltaic panels will reduce $CO_2$ footprint in the plant by about 2,000 tonnes per year. £235,000 was invested in a closed loop system in one of their plants. 50% recycled aluminium is used in their products and the rates of recycled content increased to 75%. The total waste sent to landfill was reduced by 54% by sending mixed waste to recycling facilities.

The construction of more efficient buildings and refurbishment of existing ones and the changes to manufacturing systems and equipment have reduced energy usage by nearly 6% per vehicle produced in 2013.

> *"We totally redeveloped this current building as a part of the energy efficiency program" (Supply Chain Manager)*

The competitive advantage emerged as a theme through the secondary data. AutoCo_3 tries to expand to Saudi Arabia to have access to cheap aluminium supplies as there is low-cost energy and cheap inputs of caustic soda, which is required to transform bauxite into alumina thus AutoCo_3 derives a competitive advantage. Another competitive advantage is through the close collaboration with suppliers they have launched into the market aluminium-bodied cars which in some of them they also use recycled material.

AutoCo_3 is one of the best examples as it supports most of the suggested association between the three key themes (see Table 5.13). The interviewees believe that buffering and bridging strategies can lead to better performance.

Table 5-13 The Research Propositions for AutoCo_3 (together with newly emerged theme) (Source: Derived from empirical data)

| **Sub-Propositions supported and Newly Emerged Themes** | **Level of support** | **Propositions** |
|---|---|---|
| P1.a: The importance of the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | P1, P2, P3 (Natural Resource Dependence Level and Supply Chain NRS Strategies ) |
| P1.b: The importance of the scarce natural resource has an impact on the adoption of bridging strategies. | Not supported | |
| P2.a: Supplier substitutability has an impact on the adoption of buffering strategies. | Not supported | |
| P2.b: Supplier substitutability has a positive impact on the adoption of bridging strategies. | Supported | |
| P3.a: Discretion over the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | |
| P3.b: Discretion over the scarce natural resource has a positive impact on the adoption of bridging strategies. | Supported | |
| P4: The adoption of buffering strategies has a positive impact on resource efficiency. | Supported | P4, P5(Supply chain NRS strategies and Organisational Performance) |
| P5: The adoption of bridging strategies has a positive impact on resource efficiency. | Supported | |
| Competitive Advantage<br>The new aluminium-bodied car created through close collaboration with suppliers and the expansion to Saudi Arabia will lead the company to:<br>• differentiation from rivals<br>• Enhanced technical skills, knowledge making replication difficult<br>• leveraged access to resources | | Newly Emerged theme (Organisational Performance) |

## 5.5 Case study AutoCo_4

AutoCo_4 manufactures seats for various types of vehicles (e.g. commercial, agricultural, bus) but also develops office work chairs. AutoCo_4 is also not a really proactive company in terms of using the resources more efficiently. The following quote confirms it:

> *"It's not reducing use of them from a weight point of view for environmental or sustainability needs is not the highest item in our agenda perhaps it should be" Purchasing Director*

**Natural Resource Dependence Level and Supply Chain NRS Strategies**

Cost was identified as in the previous cases as one of the most important factors (see Table 5.14) and as the Purchasing Director argues:

> *"We do try to minimise the use of resources in the materials but actually more from a cost point of view to stay competitive and to save money."*

Another factor is the switching costs as illustrated from the quote below:

> *"It is quite difficult, we have a certain type of steel bar it is called mileage bar which is produced by a rolling process that it gives the steel a certain structure quality with a grain structure of material and there are a very few people who do that." (Purchasing Director)*

The Environmental Manager supports that legislation can also lead companies to minimise the use of resources:

> *"There is a government legislation that is called ESOS and this is a directive by the government that said if your company is bigger than 250 employees you must have a plan in place at the end of the year to reduce your energy consumption within the building."*

Table 5-14 Themes, Concepts, and Quotations for the Natural Resource Dependence Level dimension (AutoCo_4) (Source: Derived from empirical data)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"The steel costs, very much"* (Purchasing Director) | Price of the natural resource | Importance of the scarce natural resource | Natural Resource Dependence Level |
| *"The biggest by weight, the biggest amount of the material we use is steel and we use it in the manufacturing of seats frames and seat suspension systems."* (Purchasing Director) | Quantity of natural resource | | |
| *"So if we change the compounds or the supplier all of that testing has to be redone. So we can't just switch."* (Purchasing Director) | Switching costs | Supplier substitutability of the scarce natural resource | |
| *"You have to prove to the government that you are proactively reducing your impact on the environment."* (Environmental Manager) | Legislation | Discretion over the scarce natural resource | |

There are some strategies such as recycling of scrap metal that have started to be implemented but they still do not focus on the implementation of comprehensive strategies to handle the issue of scarcity (see Table 5.15).

Table 5-15 Themes, Concepts, and Quotations for the Supply Chain NRS strategies dimension (AutoCo_4) (Source: Derived from empirical data)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"All of the plastic components will have a recycling stamp on them"* (Purchasing Director)<br><br>*"A process for low energy lighting across the factory and the offices"* (Environmental Manager) | New technologies or process to minimise resource usage | Product and process (re-) configuration (Buffering Strategies) | Supply NRS Strategies |
| *"Clearly all of the steel components can be recycled"* (Purchasing Director) | Recycling | | |
| *"With our production suppliers we have very few long term agreements"* (Purchasing Director) | Relational Mechanisms | Relational Mechanisms And Transactional mechanisms (Bridging Strategies) | |
| *"Everything is managed at the moment by nomination and purchasing order"* (Purchasing Director) | Transactional mechanisms | | |

There are two paint lines that are using a great amount of water. One is the electrostatic powder coat line and the other one is an electrostatic deep coating line and in those processes (prior to the paint application) is used a water based paint bath (35,000 litres). However, the water in these processes is being recycled.

Another strategy is the recycling of scrap metals or plastics. Some material is difficult to be recycled such as steel. Even though steel is not physically scarce the energy that it takes in the manufacture leads to a high price and thus it is worth being recycled as supported in the following quotes by the Purchasing Director:

> *"We have controlled waste streams for steel scrap, cardboard, plastics some of the materials can't be recycled so the foams for example it's very difficult"*
>
> *"No-one talks about steel running out but of course there is a quite a huge energy burden to producing steel"*
>
> *"All of the plastic components will have a recycling stamp on …clearly all of the steel components can be recycled"*

Chairs also started to be manufactured from recycled and/ or recyclable materials. AutoCo_4 is not keeping any safety stock for any natural resource as the purchasing director says “We do not hold safety stock”.

> *“Concerning energy usage, air compressors are using a lot of energy. AutoCo_4 have introduced speed drivers into the compressors to run more efficiently and in order to minimise energy usage. Efficient lighting (LED lighting) was used in the entire factory. Alternatives sources of energy are not used at the moment but solar power was suggested by the environmental and Health and Safety Manager. However, the payback period for this investment can hinder them as they have to comply with 3.5 years payback. From the operational point of view for the equipment one of the biggest users of energy is the welding shell we have 23 welding robots and they are all quite old anything to 20 to 23 years old. We are now looking for next year replacement cycle for those and of course the new cells will be much more efficient” says the Purchasing Director.*

Thus, AutoCo_4 will replace them with more efficient machinery.

There are a few long term agreements and most of the other purchases are managed by nomination and purchasing order. However, they have a goal to pursue long term agreements with the key suppliers.

> *“We haven’t had a supply strategy; now we have the global strategy which will feature long term agreements with key suppliers”* (Purchasing Director)

Long terms agreements (2-3 years contracts) are in place for the suppliers according to the Logistics Manager for metals. Switching costs lead mainly to long term relationships as the Purchasing Director confirms:

> *“The suppliers of metal have to make an investment or allocating their capacity in terms of press and welding, welding facilities or welding stations. And then the other type that we will look for in the long term agreements is where we have agreed on the back of commercial benefit so we will give them a confidence where we will have high spend either locally or globally gives the supply confidence that we are not going to go to another supplier as soon we will get a better price but discourages for looking for cheaper prices and gives us year to year price improvements”*

AutoCo_4 has also signed a contract with a waste management company for resources such as metal, plastics, cardboard.

**Supply Chain NRS Strategies and Organisational Performance**

There are no compressive KPIs that the company needs to follow at the moment but the Purchasing Director states that:

> *"I don't think we considered using a KPI to measure the effectiveness but I believe is next year where we have to because of the government energy reduction targets we have to look at smart meters in the plant"*

Table 5.16 below shows that the company achieved some degree of resource efficiency.

Table 5-16 Themes, Concepts, and Quotations for the Organisational Performance Dimension (AutoCo_4) (Source: Derived from empirical data)

| **Representative quotations** | **First-order themes** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *"We could reduce our lighting energy by 50%"* (Environmental Manager) | Reduction of the usage of resources | Resource Efficiency | Organisational Performance |
| *"We will be saving around 37,000 pounds in our electricity "* (Environmental Manager) | Decrease of the purchasing cost | | |
| *"Our reduction in C* $O_2$ *is 191 thousand kg"* (Environmental Manager) | Minimisation $CO_2$ | | |

The aim of AutoCo_4 is the minimisation of energy (i.e. lighting) by 50%. They have invested about £130,000 and the payback period is 3.5 years. After this period savings of about £37,000 will be made annually in the electricity bill. Also $CO_2$ will be reduced by 191 thousands kg and their cost of power will drop from £61,000 to £25,000.

Regarding the waste, a supplier will provide them with the performance. Specifically

> *"We introduced a new waste management company that they will start in November (e.g. metal, cardboard). This company will provides much more with the KPIs, how much waste is coming out and the cost associated with that" says the Environmental Manager*

Thus, buffering and bridging strategies have a positive influence on the company's economic and environmental performance.

AutoCo_4 is not so proactive that means that almost all of the key propositions are not verified (Table 5.17). As the Purchasing Manager argues:

> *"We should be more proactive in analysing the materials and the utilities the resources that we use to actually plan ahead and be ready when they start to be scarce before political or economic reasons.*

Table 5-17 The Research Propositions for AutoCo_4 (Source: Derived from empirical data)

| **Sub-Propositions supported and Newly Emerged Themes** | **Level of support** | **Propositions** |
|---|---|---|
| P1.a: The importance of the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | P1, P2, P3 (Natural Resource Dependence Level and Supply Chain NRS Strategies ) |
| P1.b: The importance of the scarce natural resource has a positive impact on the adoption of bridging strategies. | Not supported | |
| P2.a: Supplier substitutability has an impact on the adoption of buffering strategies. | Not supported | |
| P2.b: Supplier substitutability has a positive impact on of bridging strategies. | Supported | |
| P3.a: Discretion over the scarce natural resource has an impact on the adoption of buffering strategies. | Not Supported | |
| P3.b: Discretion over the scarce natural resource has an impact on the adoption of bridging strategies. | Not Supported | |
| P4: The adoption of buffering strategies has a positive impact on resource efficiency. | Supported | P4, P5(Supply chain NRS strategies and Organisational Performance) |
| P5: The adoption of bridging strategies has a positive impact on resource efficiency. | Supported | |

## 5.6 Case study BrewCo_5

BrewCo_5 is one of the largest beer companies in America and it has a broad portfolio from premium beer to cider. From a natural resource perspective, BrewCo_5 uses mainly water and energy in their operations and it is really proactive by applying a number of supply chain NRS strategies to secure mainly water resources. As the Sustainability Manager points out:

> *"Sure I think that the company has taken a very proactive approach we are known as innovators"*
>
> *"These water risk assessments are beyond the concept of likelihood of disruption in the supply chain...they essentially merge these perceptions, the perceived risk of a disruption operational wise with its financial implication and reputation implication"*

**Natural Resource Dependence Level and Supply Chain NRS Strategies**

The importance of the scarce natural resource namely price of the natural resource, quantity of natural resource but also the supplier substitutability (number of suppliers and switching costs), legislation and the social forces (discretion over the scarce natural resource) that can act as a barrier for a company to access water resources are identified as the most crucial contingency factors (see Table 5.18).

Table 5-18 Themes, Concepts, and Quotations for the Natural Resource Dependence Level dimension (BrewCo_5) (Source: Derived from empirical data, Sustainability manager)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"They don't realise how expensive is to treat water but right now there are new frameworks, calculators that allow you to account for embedded energy if you are heating water, If you reduce the pressure and things like that .so essentially you have an accurate pricing point and financial indicator of the real cost of water"* | Price of the natural resource | Importance of the scarce natural resource | Natural Resource Dependence Level |
| *"Right now if you look to the global performance of brewers that a 5 to 1 ratio and that means 5 gallons of barley 5 litres of water to produce 1 gallon of beer"* | Quantity of natural resource | | |
| *"We essentially engaged with at least 850 families of farmers that they produce all the grain and we have personal relationships with each one of those families, so these families have been working and partnering with the company for at least 50 to 70 years"* | Number of suppliers | Supplier substitutability of the scarce natural resource | |
| *"That's why the beer business is so particular it's not a supplier that you could change over a contract or you could change every quarter it's really a long term relationship"* | Switching costs | | |
| *"Water from a global perspective it's a certain regulate aspect"* | Legislation | Discretion over the scarce natural resource | |
| *"Water has very particular link with the community"* | Social forces | | |

Water is vital to brew beer and thus BrewCo_5 aims to reduce their dependence on water by utilising a variety of strategies with the goal to reduce the water usage (e.g. replacing water-dependent processes with new technologies that use less water or no water at all). All the strategies implemented by BrewCo_5 are presented in Table 5.19.

Table 5-19 Themes, Concepts, and Quotations for the Supply Chain NRS strategies dimension (BrewCo_5) (Source: Derived from empirical data, Sustainability manager)

| **Representative quotations** | **First-order themes** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *“Our corporate goal is to achieve 3.5 litres of water to produce 1 litre of beer”*<br>*“Change of process for drying lubricants”* | New technologies to minimise the usage of resources in the product | Product and process (re-) configuration and supply chain (re-) configuration (Buffering Strategies | Supply NRS Strategies |
| *“We are using alternative energies...we have a number of turbines in different parts of the supply chain”* | Substitution | | |
| *“We have a significant amount of reserves in each facility”* | Safety stock | | |
| *“So that’s interesting because you are not only downgraded or trying to recycle that water for irrigation but actually taking that water and upcycling it”* | Recycling | | |
| *“We are actively collaborating in terms not recovering but really reducing the water in agricultural section of the business. Our supply chain is based on long term commitment.”*<br><br>*“We really want to be engaged and develop our suppliers”* | Relational Mechanisms | (Relational Mechanisms) Bridging Strategies | |

> *“If any of our facilities shut down immediately we are looking at 40 million dollars’ loss immediately just because of shut down of water resource” (Sustainability Manager).*

Specifically, they reuse water and the recycled water is for non-production purposes. The Sustainability Manager argues that:

> *“A lot of companies pay for each gallon of water really low … they don’t realise how expensive it is to treat water”.*

The Sustainability Manager also states that due to political and ethical pressure they do not use recycled water in their products but he believes that in:

> *“The next 20-40 years as water scarcity becomes more apparent those technologies will play a different role than are playing right now.”*

They also use a chlorine dioxide cleaning system and water reclamation system by introducing a new cooling system. They produce nearly 80 types of beer so the systems have to be cleaned completely during changeover. For this reason, they use dry lubricant or waterless dry lubricants instead of the conventional water-based lubricants.

The rinse time was reduced and eliminated a redundant pre-rinse which led to water savings. They have also implemented tertiary water reuse systems that is using effluent water (treated water that is permissible to discharge) for specific uses not directly related to beer products but in other production areas e.g. cooling towers.

In 2011 they faced a drought in one region and they used a system of reservoirs to seize rainwater. In one of their facilities that produces 20 million barrels of beer a year, they have water reserves for that single facility for at least three years in advance as a safety stock. But they have adjusted the size of water reserves based on local water supply conditions.

The company also changed the way they clean aluminium cans and it installed a new rinser that uses ionically-charged, compressed air to clean cans. The substitution of bleach for hot water in the sterilisation processes was introduced and this speeded up the process and reduced electricity and water usage.

> *"In the brewing process, generally energy and water go hand in hand" (Sustainability Director).*

Thus, when water usage is reduced, the amount energy is also reduced. As one of their managers stated: *"without energy there is no beer"*

They have utilised wind turbines in one brewery. Four of their breweries are also using anaerobic wastewater treatment systems. They also generate biogas from the wastewater that is used mainly in their boilers and for electricity generation. Recently in one region as energy costs are increasing they have installed solar panels that can give the company up to 40 % of its power for 25 years. This investment was supported in that it will increase the company's energy independence.

Concerning water usage, most of the water is used in the agricultural supply chain. The Director of Sustainability stated that:

> *"More than 90% of the water we use is in our agricultural supply chain".*

Another theme that surfaced throughout the interview is the importance of partnerships. Their supply chain is based on long term commitment for raw materials. They only use first tier suppliers.

> *Specifically, they have "nearly 95%" of their "brewing material supply chain is barley or its barley that is a specific crop and the remaining 5% is hop" (Sustainability Manager).*

The company found that most of the barley farms are located in drought-prone areas. They buy 70% of barley directly from about 850 growers that produce all the grain and they have personal relationships with each one of those families and who they have been partnering with for at least 50 to 70 years. It is a long term relationship.

They also have strengthening relationships (partnerships) with 150 barley farmers (representing about 80% of their overall procurement activity annually) in order to take specific actions to reduce water and energy.

> *"So even though we have significant capital investment in manufacturing in new technology in lean manufacturing and others the real opportunity for this company in the next 20-25 years is really on the fields" stated by Sustainability Manager.*

They made a partnership with one of the largest farmers to test out new water reduction techniques such as soil sensor technology. The sensors have GPS connections to smartphone apps that are triggered to add water when it is absolutely needed. While the new technology certainly reduced water usage, the farmer also used less water in daily operations. Also this technique changes the recommended water supply by taking into account the need of the plants rather than using the same amount of water.

He also highlights that water conversation is in early stages because the farming businesses are very family owned businesses and he states that:

> *"Something that companies with an agricultural component need to understand over time…that it's not that easy as it could be as implementing a project within the manufacturing facility".*

The accessibility to the water resources is hindered in one place that one of their breweries is located. Due to the depletion of water in that region, the authority has issued a quota to each user. This region also purchases imported water that adds to the cost of the water, as well as the prodigious energy used to pump it. They have enacted specific practices such as belts that do not need water lubrication to reduce the water usage by 30% in this region.

They will not relocate plants but actually they are investing additionally in water stressed regions that their plants or their suppliers are located. They are proactive and start working by expanding and investing in the long term instead of waiting for 10 years when the issue of water scarcity will be even more crucial.

They are not keeping a distance from the suppliers and water stressed regions as justified by the following quote.

> *"15-20 years you cannot relocate to anywhere else and every company will be subject to some source stressed" (Sustainability Manager).*

The water rights usually are allocated according to the number of years that the company has been established in the country thus it is one more reason of not relocating because their water rights will be affected.

**Supply Chain NRS Strategies and Organisational Performance**

BrewCo_5 has specific resource conservation targets. By implementing strategies such as innovative waterless lubrication techniques the company reduced their dependence and uncertainty caused by the water scarcity with economic and environmental benefits (see Table 5.20).

Table 5-20 Themes, Concepts, and Quotations for the Organisational Performance Dimension (BrewCo_5) (Source: Derived from empirical data, Sustainability manager)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"The effect of implementing dry lubricant in all of our facilities has saved in the last 3 years almost half a billion gallons of water"*<br><br>*"We committed to reduce the energy of its facility by 50%"* | Reduction of the usage of resources | Resource Efficiency | Organisational Performance |
| *"We significantly reduced the overall carbon footprint by 25% that means several millions tonnes of carbon"* | Minimisation of $CO_2$ | | |
| *"Waste minimisation opportunity"* | Waste reduction | | |
| *"That's a major capability really that it doesn't only increase the profile of the company as a corporate citizen also putting at the leading edge of how do you put at the service of the community, the technical capabilities that you have on site. That's one of the major benefits"* | Leveraged access to resource<br><br>Enhanced technical skills, knowledge | Competitive Advantage<br><br>**(Newly Emerged Theme)** | |

In one brewery where they installed a $5 million new cooling system, the water circulation system helped save 100 million gallons of water annually and the dry lube saved 1.1 billion gallons of water from 2011 to 2013. The water reclaiming system also saved 55 million gallons of water. By using bleach, they reduced the water usage by 2% for every barrel of beer.

The quote below that is taken from the interview with the Sustainability Manager describes how collaboration with the suppliers is used to improve the firm's performance:

> *“But we are actively collaborating in terms of not recovering but really reducing the water in this agricultural section of the business”.*

The money BrewCo_5 has spent on the new technology in the farms has paid off. By pumping less water, the farm cut its energy usage by more than a half. A farm saved about 270 million gallons of water in a year and another farm about 429.5 million gallons of water over the past three years. BrewCo_5 also developed crops that have earlier maturity and have lower water requirements. The company, with the help of the farmers, achieved 20% reduction of water usage in farms. The goal is to reduce water usage by 15% from 2008 to 2015. Thus they use a water to beer ratio.

> *“The water to beer ratio that I described earlier that is the amount of water you use but also the final product you use” (Sustainability Manager).*

Five of their eight breweries have achieved a water-to-beer ratio about 3.48:1.0 which means 3.48 litres of water are used to produce 1 litre of beer. The company now uses about 3.6 barrels (113 gallons) of water to produce one barrel of beer which led to cost savings (about 0.20 USD cents per barrel). Overall 657 million gallons of water were saved.

In their sustainability report, it is highlighted that there is a reduction of energy consumption by about 15% and GHG emissions by 14%. Concerning energy, they try to reduce it in their plants by 50% as is stated in the below quote.

> *“We committed to reduce the energy of its facility by 50%, so we are operating at the order of 140 MJ per barrel of beer and that’s top of the class in terms of manufacturing.” (Sustainability Manager).*

The also recycle 99% of the brewery waste. The waste turns into energy for their own use and the remainer is sent to companies that can use it for other purposes. The waste was reduced by about 1,000 tons in 2013.

The quote below is provided to support the new second-order theme that emerged during the interviews. This theme is also found in the interviews with AutoCo_1.

*“So that’s really a leading practice” (Sustainability Manager).*

This is significantly below the 5:1 industry standard. By controlling the access to water (e.g. partnership with an environmental organisation and with barley farmers in order to use water more efficiently by new irrigation-technologies) and energy resources (e.g. investing in the largest solar panel array that exists in the brewery industry), BrewCo_5 achieved a competitive advantage.

BrewCo_5 may face lower risks associated with the issue of water scarcity or if the cost of water increases as it is expected to in the next 20 to 50 years. BrewCo_5 may take advantage of situations and locations that other brewing companies may not be able to cope with. So based on the findings of this case study, buffering and bridging strategies improves resource efficiency and also led BrewCo_5 to gain competitive advantage which means that the supply chain NRS strategies impacts on the firm’s performance in a positive way.

This list of propositions is developed in Table 5.21 according to the data analysis (from the semi- structured interviews, observation, photographs and document review), and based on the propositions in Chapter 3.

Table 5-21 The Research Propositions for BrewCo_5 (together with newly emerged theme) (Source: Derived from empirical data, Sustainability manager)

| **Sub-Propositions supported and Newly Emerged Themes** | **Level of support** | **Propositions** |
|---|---|---|
| P1.a: The importance of the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | P1, P2, P3 (Natural Resource Dependence Level and Supply Chain NRS Strategies ) |
| P1.b: The importance of the scarce natural resource has an impact on the adoption of bridging strategies. | Supported | |
| P2.a: Supplier substitutability has an impact on the adoption of buffering strategies. | Not supported | |
| P2.b: Supplier substitutability has a positive impact on the adoption of bridging strategies. | Supported | |
| P3.a: Discretion over the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | |
| P3.b: Discretion over the scarce natural resource has a positive impact on the adoption of bridging strategies. | Supported | |
| P4: The adoption of buffering strategies has a positive impact on resource efficiency. | Supported | P4, P5(Supply chain NRS strategies and Organisational Performance) |
| P5: The adoption of bridging has a positive impact on resource efficiency. | Supported | |
| Competitive Advantage<br>The new innovation technologies and the close collaboration with farmers offer:<br>• Leveraged access to resource<br>• Enhanced technical skills, knowledge making replication difficult | | Newly Emerged theme (Organisational Performance) |

## 5.7 Case study ChemCo_6

ChemCo_6 is a multinational chemical company that supplies its products to multiple industries. This company consumes a lot of water and energy. It is a proactive company as it recognises the issue of scarcity of natural resources and it utilises a specific set of strategies.

**Natural Resource Dependence Level and Supply Chain NRS Strategies**

The cost of resources, the switching costs and the legislation are identified as key factors that lead to certain strategies to minimise the risk of NRS (see Table 5.22).

Table 5-22 Themes, Concepts, and Quotations for the Natural Resource Dependence Level dimension (ChemCo_6) (Source: Derived from empirical data, Director of Sustainability Programs)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"When you have limited supply and increasing demand , there will be increased prices so increased cost, increased value for the ecosystem services in which we are depending and in many cases they are undervalued today and they will be valued differently in the future and we recognise that"* | Price of the natural resource | Importance of the scarce natural resource | Natural Resource Dependence Level |
| *"So let's say for example our supplier has developed a less expensive and more environmentally friendly process to produce our raw material that we need but they have to take the business risk building a new manufacturing facility for this situation or perhaps they have to modify an existing facility but it cost them capital to do that. Well often times what they will do is to say its fine for us to build this facility but we need a long term guarantee contract so we can recoup our investment."* | Switching costs | Supplier substitutability of the scarce natural resource | |
| *"So you have not only the cost of the emissions themselves which trade openly in the market but also the kinds of emission controls that get increasingly extensive"* | Legislation | Discretion over the scarce natural resource | |

Concerning the importance of the natural resources, ChemCo_6 tries to reconfigure its processes and also collaborate closely with suppliers or other bridging strategies (Table 5.23).

Table 5-23 Themes, Concepts, and Quotations for the Supply Chain NRS strategies dimension (ChemCo_6) (Source: Derived from empirical data, Director of Sustainability Programs)

| **Representative quotations** | **First-order themes** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *"A lot of energy comes from the combustion of fossil fuels but we are looking at all kinds and different ways from wind to solar and nuclear to make sure we can meet energy needs in the future."* | Substitution | Product and process (re-) configuration (Buffering Strategies) | Supply Chain NRS strategies |
| *"So if you are looking at water in a critical dependent situation we do sometimes own and maintain reservoirs ourselves."* | Safety stock | | |
| *"We recycle water especially in some water stressed areas"* | Recycling | | |
| *"We produce technologies to clean water and provide fresh water"* | New technologies or process to minimise resource usage | | |
| *"There will be in some cases long term contracts."* | Relational Mechanisms | Relational Mechanisms, Transactional mechanisms And Hierarchy mechanism (Bridging Strategies) | |
| *"In other situations we will have short term contracts based on commodity types of materials where we know the prices are going to be fluctuating and we think we can get a better price at some point in the future."* | Transactional mechanisms | | |
| *"The strategy of vertical integration is inherent to our company's success over the past sixty to seventy years because what we have done is to have built relatively large integrated chemical facilities"* | Hierarchy mechanism | | |

ChemCo_6 takes water scarcity into consideration as some of its facilities are located in water-stressed regions by introducing new purification technologies such as reverse osmosis. The chemical industry is known as one of the major industrial users of water with the cooling and washing seeing the highest usage stage. ChemCo_6 uses around 900 billion pounds (approximately 300 million gallons per day) of fresh water per year.

The Director of Sustainability Programs stated that water is an "incredibly scarce and precious resource" that leads us to create a new system that can deliver 40% better purification with 30% less energy which is used by other organisations as well. Apart from desalinating water, this technology to convert wastewater into water that can be reused where potable water is not required (e.g. industrial processes, irrigation, and gardening).

The focus on a water recycling strategy is based on zero discharge; recycling and reusing are used as strategies in order to conserve and reduce the site's overall water demand. The Director of Sustainability Programs states that:

> *"Sometimes we are in a better position to be able to clean and use that water and even to return it to the river or to a municipality in a better state than it was when we got it."*

In the agricultural industry they also provide farmers with products that are drought resistant in order to minimise water usage. Safety stocks for critical raw materials in any of their facilities exist. For example, for water *"we do sometimes own and maintain reservoirs ourselves"* says the Director of Sustainability Programs. Also innovative waterless toilets are implemented in their facilities.

The chemical industry is also energy intensive and thus renewable sources of energy such as solar energy, wind power, recaptured landfill gas, eucalyptus biomass as a fuel source are utilised as the company pursues a policy to use energy alternatives in its operations.

The company has also developed a clean technology to convert recycled plastic into energy. Hydrogen that is created as a by-product is captured *and "bring it back into the* *plant as energy"* ((Director of Sustainability Programs). Another strategy that is facilitated in order for ChemCo_6 to be more energy efficient is the new ways of making chemicals such as to turn hydrogen peroxide into propylene oxide.

Another practice that ChemCo_6 is following is the utilisation of waste from one facility used at another facility inside the company or outside that can lead to savings and environmental benefits. *"The term by product synergy is a normal part of our discussions"* (Director of Sustainability Programs) as waste in one process is *"food"* for another product. Operation processes was optimised (minimise the start-up and shut down time) to reduce energy usage. Another energy strategy was utilised is the insulation.

Considering the relationship with their suppliers, ChemCo_6 purchases raw materials on both short and long-term contracts. They follow long term contracts when suppliers have been taken some business risk such as developing a less expensive and more environmentally friendly process to produce their raw material or they build a new manufacturing facility or modify the existing one.

For example, they signed a long-term agreement with the wind farm who will supply their manufacturing facility with 200 MW of wind power annually. In other situations short term contracts are preferred where they know they can get a better price at some point in the future. Suppliers are actively invited to collocate with them in the same location in order to share site services such as electricity and water.

> *"The strategy of vertical integration is inherent to our success over the past sixty to seventy years because what we have done is to have built relatively large integrated chemical facilities" (Director of Sustainability Programs).*

Water stress areas resulted in ChemCo_6 not being able to access water and thus reused water is utilised. Specifically, collaboration with the local municipal water provider is utilised to alleviate local water stress by recycling waste water for its manufacturing operations. Relocation is the least appropriate strategy for a large chemical plant particularly a large scale chemical plant. However, reconfiguration of its operations was followed by shutting down some facilities and relocating them in areas where natural resources are less scarce.

For example, they have moved recently into a joint venture with an oil Company from Saudi Arabia in order to have access to plentiful and inexpensive raw materials. Regulations affect its operations in China for example that has strict environmental and emission laws. In order to solve these issues the company has to install modern up-to-date emissions control technologies in order to manage emissions.

**Supply Chain NRS Strategies and Organisational Performance**

The case study shows financial benefit; resulting in approximately $5 billion of savings with a $1 billion investment in technology and processes to achieve resource efficiency (see Table 5.24).

Table 5-24 Themes, Concepts, and Quotations for the Organisational Performance Dimension (ChemCo_6) (Source: Derived from empirical data, Director of Sustainability Programs)

| **Representative quotations** | **First-order themes** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *"So at one large facility we saved about 10% of our water consumption"* | Reduction of the usage of resources | Resource Efficiency | Organisational Performance |
| *"We also look at our emissions in a variety of emissions, air, land and to water"* | Minimisation of $CO_2$ | | |
| *"I mean we track the waste per pound or kg or product it produced."* | Waste reduction | | |
| *"if you have an integrated facility that is essentially vertically integrated within the company so you are taking advantage of the economies of scale in that situation"* | Leveraged access to resource<br><br>Enhanced technical skills, knowledge | Competitive Advantage<br><br>**(Newly Emerged Theme)** | |

The annual energy used has reduced by 20% since 2005 (1994 basis for comparison). Energy efficiency prevents about 270 million metric tons of $CO_2$ emissions. By using 2005 as a baseline the target is the energy intensity to be minimised by 25% in 2015 and to use 400 MW of clean energy by 2025. ChemCo_6 has also tried to use resources more efficiently and reduce waste that will enable them to achieve 300 million pounds between 2005 and 2015. This initiative already exceeded to 322 million pounds in 2013. They also reduced waste water by 183 billion pounds. In one of their largest facilities, a reduction of 10% of the water usage was achieved.

> *"So at one large facility we saved about 10% of our water consumption just by valuing differently and looking at it from the perspective of what the value will be not now, not next year but 5 to 10 years in the future." (Director of Sustainability Programs).*

The reused water from municipal and industrial wastewater is about 30,000 $m^3$ (30,000,000 litres) per day. The same amount of water is also recycled for conversion to high-pressure steam and for cooling per day. The technology with waterless toilets saves about 20,000 gallons of water annually. Another facility has achieved a 95% reduction in energy usage. The change of peroxide into propylene oxide led the company to cut the energy usage by 35%.

Buffering and bridging strategies positively influence the performance namely resource efficiency, but also ChemCo_6 has achieved a competitive advantage as can be seen in the following quotes:

> *"Natural resource scarcity drives some of our investment decisions" for example a joint venture being made recently can enable ChemCo_6 "in the future having the kind of plentiful and inexpensive raw materials that is needed to serve growing Asians markets" (Director of Sustainability Programs).*

Thus, this joint venture may lead ChemCo_6 to gain a competitive advantage. ChemCo_6 currently became one of the largest purchasers of wind energy in the U.S that can lead them to a *"long-term competitive advantage*" as they can mitigate the risk of energy and power price volatility and improving their overall carbon footprint said the Global Business Director of the Energy and Climate Change portfolio.

Based on the discussion of the findings the list of propositions for themes explored and the newly emerged theme in AutoCo_1 and BrewCo_5 are presented in Table 5.25.

Table 5-25 The Research Propositions for ChemCo_6 (together with newly emerged theme) (Source: Derived from empirical data, Director of Sustainability Programs)

| **Sub-Propositions supported and Newly Emerged Themes** | **Level of support** | **Propositions** |
|---|---|---|
| P1.a: The importance of the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | P1, P2, P3 (Natural Resource Dependence Level and Supply Chain NRS Strategies ) |
| P1.b: The importance of the scarce natural resource has an impact on the adoption of bridging strategies. | Supported | |
| P2.a: Supplier substitutability has an impact on the adoption of buffering strategies. | Not supported | |
| P2.b: Supplier substitutability has a positive impact on the adoption of bridging strategies. | Supported | |
| P3.a: Discretion over the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | |
| P3.b: Discretion over the scarce natural resource has a positive impact on the adoption of bridging strategies. | Supported | |
| P4: The adoption of buffering strategies has a positive impact on resource efficiency. | Supported | P4, P5(Supply chain NRS strategies and Organisational Performance) |
| P5: The adoption of bridging strategies has a positive impact on resource efficiency. | Supported | |
| Competitive Advantage<br>The wind energy and the joint venture offer:<br>• Leveraged access to resource<br>• Enhanced technical skills, knowledge making replication difficult | | Newly Emerged theme (Organisational Performance) |

## 5.8 Case study ChemCo_7

ChemCo_7 is a multinational consumer goods manufacturer that supplies products in the health, hygiene and home sectors. The company uses water, energy and materials such as palm oil, resin, gum and rubber in its daily operations.

**Natural Resource Dependence Level and Supply Chain NRS Strategies**

The interviewee recognises the social forces as a crucial element in the decision of handling the issue of scarcity.

> *"Because of the nature of the company it becomes easily targeted by some organisations, say Greenpeace, those organisations have always had an eye on us"* (Supply Chain Manager)

The price of the natural resource, the low availability of alternative suppliers and legislation were identified as contingency factors that shape specific supply chain strategies (see Table 5.26).

Table 5-26 Themes, Concepts, and Quotations for the Natural Resource Dependence Level dimension (ChemCo_7) (Source: Derived from empirical data, Supply Chain Manager)

| **Representative quotations** | **First-order themes** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *"The cost is important as you know our customers demand our products at low cost so that pushes us to pay more attention on how to reduce the usage of water and electricity in order to reduce the cost"* | Price of the natural resource | Importance of the scarce natural resource | Natural Resource Dependence Level |
| *"We cannot get from other suppliers"* | Number of suppliers | Supplier substitutability of the scarce natural resource | |
| *"If the plant is located in a water scarce area then I think the company will face more pressure from the government to save water"* | Legislation | Discretion over the scarce natural resource | |
| *"It has a lot of pressure from society and the media"* | Social forces | | |

They are mainly focusing on buffering strategies such as product and process redesign (see Table 5.27) as is confirmed by the Supply Chain Manager.

> *"The main strategies we use are mainly related to the process redesign and apply new technologies that are the two major strategies that we are using"*

Table 5-27 Themes, Concepts, and Quotations for the Supply Chain NRS strategies dimension (ChemCo_7) (Source: Derived from empirical data, Supply Chain Manager)

| **Representative quotations** | **First-order themes** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *"We used a new lighting system with an LED system and this will help us achieve cost savings"* | New technologies or process to minimise resource usage | Product and process (re-) configuration and Supply Chain Configuration (Buffering Strategies) | Supply NRS Strategies |
| *"Using alternative sources that are considered renewable sources"* | Substitution | | |
| *"We focus more on water recycling"* | Recycling | | |
| *"We do have a small electricity generator as a backup plan"* | Safety Stock | | |
| *"We just have the normal contract with the national power grid for electricity supply and with local water supply contractor for water supply"* | Transactional Mechanisms | Bridging Strategies | |

> *"The major consumption of electricity in our factories includes machine operating, air-conditioning system, heating system and lighting system"* (Supply Chain Manager).

The energy usage is optimised by upgrading to more energy efficient lighting (LED lighting to certain plants) and through projects to further optimise the heating facilities. Small electricity generators are in place in some plants as a backup plan. Using non-renewable fossil fuels (e.g. coal, oil) to generate electricity is commonly used but renewable sources of energy started to be used such as biomass, hydroelectricity and solar power on several sites.

Also, ChemCo_7 has used natural lighting as much as possible and they have used insulating pipes in their system in order to reduce energy usage. ChemCo_7 have also changed the manufacturing technology (i.e. thermoforming process) that demands less energy and this can lead to $CO_2$ savings.

Considering water usage, the focus is on recycling and reuse of water especially in the plants located in India and China. As the Supply Chain Manager states that:

> *"We had a project several months ago that is using cooling water in the air conditioning system that makes the whole loop close"*

For instance, they have minimised the water use by implementing process changes that enable recycling, reuse and rationalisation of the water distribution system. In other plants they have reduced the frequency of washing gravel filters, they have upgraded the line cooling system or they have installed new air conditioning chillers replacing the water-based cooling system. They have installed new equipment in one of their factories that uses 40% less water. It uses the water from the local canal for cooling mostly which is returned to the canal cleaner than it was when it was extracted.

Collaboration with suppliers also is a common strategy. An example is when they tried to re-design the trigger sprays that enable them to avoid wasting huge amounts of metal and plastic per year. Talcum powder waste is used by ChemCo_7 for the production of plastic granules. Waste pressing machines have been located close to the waste generation points, waste bins for any waste have been bought and thus there is a recycling of all the types of materials that are reused.

The company also focuses on designing with the suppliers a better packaging that can lead to a lower carbon footprint and a lower water impact. The initiatives are based on making use of less packaging per dose of product, increase post-consumer recycled content, and make use of sustainable materials. There are medium-term contracts with certain key suppliers but for water and energy there are short term contracts with the national power grid for electricity supply and with local water suppliers. Concerning accessibility, the company will try to redesign products or processes and collaborate closely with suppliers but not to relocate its plants.

> *"The first choice of the company will not be relocation of the plants but […] the focus will be more on process redesign, using alternative sources that are considered renewable sources" (Supply Chain Manager).*

However, two plants in Africa had to shut down due to shortages of raw materials, power and water that led to the increase of cost of these natural resources. Thus, it can be seen that if ChemCo_7 cannot resolve the issue of scarcity then relocation may be applied. As the Supply Chain Manager argues that:

> *"When you encounter this kind of issue I think the first choice of the company won't be relocated the plants but alternatively I think company will focus more on process redesign using alternative sources that are considered renewable sources that kind of thing and applying new technologies because in the short term this will be more feasible but for the long term if the resource is too scarce and too critical for the company maybe then the choice for the company will be supply chain network restructure relocate the plant"*

**Supply Chain NRS Strategies and Organisational Performance**

> *"I think the major direct benefit is cost savings" (Supply Chain Manager).*

For example, a certain plant has achieved savings of £300,000 annually from the initiative of zero waste to landfill. Thus as can be seen it Table 5.28 a decrease of purchasing cost is an outcome of the implementation of the supply chain NRS strategies.

Table 5-28 Themes, Concepts, and Quotations for the Organisational Performance Dimension (ChemCo_7) (Source: Derived from empirical data, Supply Chain Manager)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"We used 0.78 cubic metres of water for every one thousand consumer units of production that is 19% less than in 2012"* | Reduction of the usage of resources | Resource Efficiency | Organisational Performance |
| *"By focusing on reducing natural resources usage, the common cost applied to each product is also reduced"* | Decrease of purchasing cost | | |

They have reduced energy and water usage by 6% and 19% respectively. In their plants in Canada they had 37% savings by reducing heat output in the warehouse. Water consumption was reduced by 70% and 37% in the plants in Germany and in Austria respectively.

The target is to achieve a 35% reduction in water and energy consumption per unit of production by 2020. Greenhouse gas emissions have fallen 48%. The aim is reduce GHG emissions by 40% per unit of production by 2020. 60% of the factories have achieved zero manufacturing waste to landfill. The goal of the reduction of waste is 10% by 2020. All these can be summarised in the following quote:

> *"We also have the target each year that is also for the 2020 target.We need to achieve 35% reduction in energy consumption per unit of production. So in 2013 we have already achieved 5.6% reduction" (Supply Chain Manager)*

Apart from cost saving the company can achieve a competitive advantage, this can be seen in the quote below (Supply Chain Manager).

> *"For example our project that focuses on cooling water circulation helps us achieve around 3 thousand tonnes of water per month and by focusing on reducing natural resources usage the common cost which is applied to each product is also reduced…and this in turn reduces the cost of making a piece of output. As a result, the company becomes more attractive to customers in the cost aspect."*

Thus, ChemCo_7 has improved their overall performance by product redesign, substitution, recycling and by using safety stock as main buffering strategies and transactional mechanisms as the main bridging strategy. ChemCo_7 supports some of the propositions and the possible association between the key themes. Table 5.29 below shows each proposition and if it is supported or not.

Table 5-29 The Research Propositions for ChemCo_7 (together with newly emerged theme) (Source: Derived from empirical data, Supply Chain Manager)

| Sub-Propositions supported and Newly Emerged Themes | Level of support | Propositions |
|---|---|---|
| P1.a: The importance of the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | P1, P2, P3 (Natural Resource Dependence Level and Supply Chain NRS Strategies ) |
| P1.b: The importance of the scarce natural resource has an impact on the adoption of bridging strategies. | Supported | |
| P2.a: Supplier substitutability has an impact on the adoption of buffering strategies. | Not supported | |
| P2.b: Supplier substitutability has a positive impact on the adoption of bridging strategies. | Supported | |
| P3.a: Discretion over the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | |
| P3.b: Discretion over the scarce natural resource has an impact on the adoption of bridging strategies. | Not Supported | |
| P4: The adoption of buffering strategies has a positive impact on resource efficiency. | Supported | P4, P5(Supply chain NRS strategies and Organisational Performance) |
| P5: The adoption of bridging strategies has an impact on resource efficiency. | Not Supported | |
| Competitive Advantage<br>The use of less of resources will lead to:<br>• differentiation from rivals<br>• leveraged access to resource | | Newly Emerged theme (Organisational Performance) |

## 5.9 Case study ElectCo_8

ElectCo_8 is a multinational corporation that provides hardware, software and services to consumers and businesses. The company uses water, energy, oil, metals and REEs as main natural resources.

**Natural Resource Dependence Level and Supply Chain NRS Strategies**

The interviewee identified the issue of the importance of scarce natural resources and the discretion over the scarce natural resources as the main natural resource dependence level dimensions (see Table 5.30).

Table 5-30 Themes, Concepts, and Quotations for the Natural Resource Dependence Level dimension (ElectCo_8) (Source: Derived from empirical data, Business Operations Manager)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"Continuity of supply (prices) and ethical issues"* | Price of the natural resource | Importance of the scarce natural resource | Natural Resource Dependence Level |
| | Social Forces | Discretion over the scarce natural resource | |

ElectCo_8 tries to reduce environmental impacts and has developed programmes for reducing waste, redesigning products, and increasing recycled content in its products. These are supported by the interviewee (see Table 5.31) but also from the secondary data.

Table 5-31 Themes, Concepts, and Quotations for the Supply Chain NRS strategies dimension (ElectCo_8) (Source: Derived from empirical data, Business Operations Manager)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"We recycle the natural resources"* | Recycling | Product and process (re-) configuration and (Buffering strategies) | Supply NRS Strategies |
| *"We tend to closely collaborate with a few suppliers"* | Relational Mechanisms | Relational Mechanisms (Bridging Strategies) | |

Energy is a natural resource that is used in large quantities by ElectCo_8. In seven sites more efficient chillers have been installed. They have moved to LED lighting and they have also started to use renewable energy sources in order to reduce greenhouse gas emissions while minimising the risk of rising fossil fuel prices.

Specifically in places such as Israel and Mexico they have installed solar panels. A server that consumes less energy than existing data centre servers was introduced. Water-reduction initiatives have also been implemented by ElectCo_8. Another example is in Singapore where ElectCo_8 will make use of reclaimed water in cooling towers and in the USA they are reclaiming reject water from their operations will be reused back into the process or in acid exhaust scrubbers.

They also recycle any electronic waste as there is an increase in the price of the recoverable resources. They have developed a closed loop model (e.g. built recycling facilities) to handle their own waste. As they manufacture electronic products they have to comply with the WEEE Directive and thus set collection, recycling and recovery targets. Apart from recycling they are also expecting a large amount of personal computers to be refurbished, and reused in the secondary market. As the Business Operations Manager explains that:

*“It is not a real close loop, we do not use these resources in our products we give it to secondary market and maybe these resources will come to us from a secondary market or our suppliers”*

However, the company has found in the secondary market that they have start recycling the plastic from its cartridges and reusing it into the manufacturing process for new cartridges. The scarcity of resources and the increasing cost of the extraction leads companies to use waste as a recycling material.

They are trying to substitute some natural resources such as copper wires with optical wires within computers and also moving from hard disks to solid state memory that will reduce the usage of REE. One of their products is using 100% recycled plastic thus they try to substitute the virgin material.

*Also relational mechanisms are preferred: “We tend to closely collaborate with a few suppliers but we do want to have more than one supplier” (Business Operations Manager).*

Almost 500 million kWh of renewable energy was purchased through energy contracts in 2013. So they follow short term contracts to access energy.

For example, with one specific company that offers design and manufacturing support ElectCo_8 has over 15 years of close relationship. ElectCo_8 relationships with suppliers can be either highly contractual, or very loose. ElectCo_8 has a joint venture with a wholly owned subsidiary of a Canadian metal mining company. In this subsidiary they are providing all the process technologies for disassembly and recycling operations. These recovered components have value on the secondary market but the recovered metal is sent to the smelters of the metal mining company.

**Supply Chain NRS Strategies and Organisational Performance**

By implementing both buffering and bridging strategies the company achieved a reduction in the usage of water, energy and oil based resources (see Table 5.32).

Table 5-32 Themes, Concepts, and Quotations for the Organisational Performance Dimension (ElectCo_8) (Source: Derived from empirical data, Business Operations Manager)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"We try to minimise our energy usage and other natural resources consumption"* | Reduction of the usage of resources | Resource Efficiency | Organisational Performance |

Globally, in 2013, ElectCo_8 recycled and/or reclaimed more than 350,000 cubic meters of water. In water-stressed regions water usage was decreased by 11.7% and the overall water usage in their operations by 10% in 2013 (baseline year 2012). For example the use of rainwater and the use of industrial wastewater in India will save 98,000 cubic meters of water annually.

By using recycled plastics the carbon footprint of plastics was reduced by 33 % and they have saved 42,000 barrels of oil in 2013. They also used the waste from the ink-manufacturing process so they recycled about 140 tonnes of waste and they use some of this in a boiler in order to reduce the need for diesel. The vertical integration also leads to recycling about £4 million of electronic equipment a month.

By using renewable energy sources such as solar energy ElectCo_8 reduced emissions while it can be protected against the rising prices of fossil fuels. In 2013 energy usage was reduced by 4.5% (baseline year 2010). They aim to reduce greenhouse gas (GHG) emissions by 20% by 2020 (baseline year 2010). The company aims to reduce carbon emissions by 40% from 2010 to 2020. Based on 2013 data by recycling and reusing a specific type of plastic, ElectCo_8 has reduced its carbon footprint by 33%, energy usage by 54% and water usage by 75%.

Therefore, buffering and bridging strategies have a positive impact on organisational performance. A few propositions are supported in this case as can be seen in the Table 5.33 below. It should be noted that ElectCo_8 was researched mainly from secondary data because the findings in ElectCo_8 came from only one informant who did not have much experience in the scarcity issues in their manufacturing operations.

*Table 5-33 The Research Propositions for ElectCo_8 (together with newly emerged theme)*
(Source: Derived from empirical data, Business Operations Manager)

| Sub-Propositions supported and Newly Emerged Themes | Level of support | Propositions |
|---|---|---|
| P1.a: The importance of the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | P1, P2, P3 (Natural Resource Dependence Level and Supply Chain NRS Strategies ) |
| P1.b: The importance of the scarce natural resource has an impact on the adoption of bridging strategies. | Not supported | |
| P2.a: Supplier substitutability has a positive impact on the adoption of buffering strategies. | Not supported | |
| P2.b: Supplier substitutability has a positive impact on of bridging strategies. | Supported | |
| P3.a: Discretion over the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | |
| P3.b: Discretion over the scarce natural resource has an impact on the adoption of bridging strategies. | Not Supported | |
| P4: The adoption of buffering strategies has a positive impact on resource efficiency. | Supported | P4, P5(Supply chain NRS strategies and Organisational Performance) |
| P5: The adoption of bridging strategies has a positive impact on resource efficiency. | Supported | |

## 5.10 Case study ElectCo_9

ElectCo_9 is a manufacturer of access control and secure identity solutions. Its product portfolio includes readers, cards, and controllers. ElectCo_9 mainly consumes natural resources of water, energy, natural gas and oil in some factories and some metals. It has just started to enact supply chain strategies for minimising the use of resources.

One of their manufacturing facilities was awarded the Leadership in Energy & Environmental Design (LEED) Platinum for Commercial Interiors certification as their plant was designed and built based on practices such as water conservation, waste and irrigation management that are trying to minimise the usage of natural resources. They aim to go through an educational process over the next 3-5 years in order to reduce the usage of natural resources. There is a tendency at the moment of the company not to look at the minimisation of natural resources in order to achieve business continuity but rather in becoming a "green" company. This is confirmed by the Vice President of Global Supply Chain:

> *"There is a tendency for people to look at sustainability as whole green and not really as business continuity and that kind of scares me".*

So they have not achieved that level to redesign in products in order to reduce natural resources in order to handle the issue of NRS.

**Natural Resource Dependence Level and Supply Chain NRS Strategies**

It was argued that a firm's dependence is determined by the price of the natural resource, number of suppliers, geopolitical risk and legislation (see Table 5.34).

Table 5-34 Themes, Concepts, and Quotations for the Natural Resource Dependence Level dimension (ElectCo_9) (Source: Derived from empirical data)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"The main issue is that it is a substantial expense for us" (*Director of Global Sustainability)<br><br>*"I think the pressure that drives us is the cost, you know we have to run a profitable business so cost and scarcity will obviously drive it"*<br>(Director of Operations) | Price of the natural resource | Importance of the scarce natural resource | Natural Resource Dependence Level |
| *"We don't always have available suppliers"*<br>(Vice President of Global Supply Chain) | Number of suppliers | Supplier substitutability of the scarce natural resource | |
| *"Conflicts in these countries […] what China is doing to check the natural resources in Africa is because they want to be the owner of most of the natural resources on the planet"*<br>(Vice President of Global Supply Chain) | Geopolitical risk | Discretion over the scarce natural resource | |
| *"There is an element of compliance"*<br>(Director of Operations) | Legislation | | |

Based on the following quotes by the Director of Global Sustainability of ElectCo_9 it can be claimed that water is a really vital resource for the company:

> *"Water is probably our main thing we are working in reclaiming, we have a reclamation system"*
>
> *"The other thing we are looking at is how do we use water, how do we use some steam water if we don't use it all for the chillers. How can we use some of this water for outdoor use whether it's in taking care of the plants or any kind of non-drinkable non potable usage that may happen in the building"*

Table 5.35 shows the buffering and bridging strategies utilised by ElectCo_9.

Table 5-35 Themes, Concepts, and Quotations for the Supply Chain NRS strategies dimension (ElectCo_9) (Source: Derived from empirical data)

| **Representative quotations** | **First-order themes** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *"We want to emphasise the use of recycling content"* (Director of Global Sustainability) | New technologies or process to minimise resource usage | Product and process (re-) configuration and (Buffering strategies) and Supply chain (re-configuration) (Buffering Strategies) | Supply NRS Strategies |
| *"We are looking for solar electricity projects where we have more sunny environment locations."* (Director of Global Sustainability) | Substitution | | |
| *"We gather rainwater and use it for irrigation and also for flushing toilets and cleaning"* | Recycling | | |
| *"As a backup plan I have a power generator for the building."* (Director of Global Sustainability) | Safety Stock | | |
| *"We have subcontracts with outsource components and long term contracts with the suppliers that assemble our products"* (Director of Operations) | Relational Mechanisms | Relational and Transactional Mechanisms (Bridging Strategies) | |
| *"I would say there are performance contracts."* (Director of Operations)<br><br>*"So we have the standards short term contracts with specific terms and conditions"* (Director of Operations) | Transactional mechanisms | | |

In their facilities reclamation systems are installed and the wastewater is treated to remove solids and impurities, and is re-routed from the manufacturing processes to their chillers. So the water is reused continuously. ElectCo_9 has a project in Asia where the environment is extremely humid, in order to collect rain water for specific purposes e.g. flushing toilets and cleaning etc.

In the UK facility, based on the Waste Electrical and Electronic Equipment (WEEE) regulations, ElectCo_9 has to collect, recycle and recover their products from their customers. In their manufacturing plants they also recycle plastic, aluminium and gold as they try to increase the recycling role and reduce waste. Through this way, the company generates revenues from recycling and does not need to pay for disposal of those materials. They are also thinking of recovering metals but no actual plan has been decided yet.

Electricity is also generated from renewable sources. For instance, the use of renewable electricity such as a solar electricity project where they have sunny environment locations is promoted. LED lighting is also used with sensors that can lead to energy efficiency and cost reduction. It also uses a safety stock of water. The company has some safety stock of components such as semi-conductors, capacitors, plastic but not in large quantities. In Europe, one of the company's IT departments reduced the power consumption as well as heat and noise emissions. Specifically a new approach that makes more flexible and efficient use of the hardware was followed that resulted in energy reduction.

Considering the availability of suppliers, the manager stated that they have a large number of suppliers and they use short term performance contracts that consist of the operational pieces: cost, quality, delivery. So for these contracts:

> *"We renew our agreements with the main suppliers on an annual basis and re-negotiate the terms" (Director of Operations)*

There are a few long term contracts with the suppliers that assemble products that entail detailed terms and conditions about the performance which are renewed with them on an annual basis and re-negotiated. The lack of collaboration and partnerships is seen as an issue and the researcher was surprised with the key quote:

> *"So I think the biggest problem we have right now is that suppliers are not seen as integrated partners […] is kind of purchasing let's go and buy it" argued by the Vice President of Global Supply Chain.*

There was once a component that became obsolete and they continued to try to purchase the items for four years.

> *"So how you will know how you will be in four years? That's how they will approach a thing in a natural resource, within a shortage they will say then we have to look at this scarcity issue" (Vice President of Global Supply Chain).*

The company worries about natural resources such as mined iron that goes into a lot of their metal products. They recently took a closer look at conflict minerals. Conflict minerals are metals that are located in specific regions and companies are forbidden to purchase those minerals from these countries. So they try to redesign their products and manufacturing processes with the help of engineers.

According to the Director of Operations the major risk is *"the raw material at the mines"* which becomes a major threat. Until now they do not have any issue but if something happens, they do not have a contingency plan for that. The majority of their purchasing items stem from Asia so they are looking to source outside of Asia.

The quotation below shows that they do not consider relocating any of their plants as they are proactive and before starting doing business in one region they investigate the availability of natural resources.

> *"I understand what their plans are and there are alternative energy resources? So it's just gas or they have also been looking at solar and wind and other sources, geothermal energy, they get their energy from other sources that limits the risk where my site is." (Director of Operations)*

However, in one of their facilities they had an issue with power generation and they had to find another source of energy, so they utilised a buffering strategy. The following quote illustrates this situation:

> *"There might be periods during summer where the power grade is going be maximised and so how do I ensure the operation will still run? As a backup plan I have a power generator for the building. So if the event happened we have to lower power or re-set the power just a little bit. There is a generator backup that can help us get through for a number of hours that might be before the power comes back up from the main city source." (Director of Operations)*

**Supply Chain NRS Strategies and Organisational Performance**

ElectCo_9 has some key performance indicators (see Table 5.36) but they do not have a robust measurement of their performance.

The quote below, from the VP Global Supply Chain explains the situation.

> *"I don't have numbers but again we are very immature of our data"*

Table 5-36 Themes, Concepts, and Quotations for the Organisational Performance Dimension (ElectCo_9) (Source: Derived from empirical data)

| **Representative quotations** | **First-order themes** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *"Use LED lighting in all our the factories and that's extremely cost effective"* (Director of Global Sustainability) | Decrease of the purchasing cost | Resource Efficiency | Organisational Performance |
| *"Every year, we set targets for each site to minimise water, energy and benchmark them with each other (Supply Chain Manager)* | Reduction of the usage of resources | | |
| *"We monitor waste and typical waste in terms of cost but also in terms of the amount or weight"* (Director of Global Sustainability)<br><br>*"Encourage the increase of recycling role, it has a natural effect and we reduce our waste."* (Director of Global Sustainability) | Waste reduction | | |

The aim of ElectCo_9 is to reduce operating costs and environmental impacts. This is supported by the Director of Global Sustainability:

> *"We monitor electricity consumption in KW and also dollars…and we do that globally but we also do it at the site level […] we monitor water consumption in terms of quantity and dollars, we convert all of that into greenhouse gas emissions or carbon footprint"*

In its new facility 86,200 kilograms of metal, 44,600 kilograms of concrete and 12,200 cubic metres of asphalt have been saved. Also, water usage was cut by 55% with a saving of 142,000 litres monthly and a 46% reduction in lighting power for the entire building by using LEDs. Indoor water use reduction led to a 35% reduction in water use. By optimising energy performance (e.g. heating/cooling, equipment efficiency, renewable sources of energy etc.) a 30% lower electricity usage was achieved.

The new approach at the manufacturing site makes the hardware more efficient and the power consumption was reduced from 22,600 KWh to 12,614 KWh. In total, electricity costs were reduced by 44%, a total saving per year of 1,247 EUR. The company also wants to reach a reduction of 45% of solid waste (e.g. scrap reduction, product design, recycling, reuse, repurpose).

As the Director Global Sustainability noted:

> *"We monitor waste and typical waste in terms of cost but also in terms of the amount or weight. We monitor it both globally and at a factory level […] and we emphasise recycling of metals and plastics"*

By minimising the organisation's environmental impact and improving environmental performance (e.g. minimising the use of energy and others), ElectCo_9 was awarded an ISO14001 certification. Thus, buffering strategies have led ElectCo_9 to have a better organisational performance.

Based on the findings, the researcher has discovered if the earlier propositions presented in this Chapter can be verified in Table 5.37. It would appear that ElectCo_9 need a lot of effort to understand the implications of NRS. The propositions are partly supported in this case as they do not have well-established strategies and they just try to understand the issue of scarcity and the relationships with key suppliers.

Table 5-37 The Research Propositions for ElectCo_9 (Source: Derived from empirical data)

| **Sub-Propositions supported and Newly Emerged Themes** | **Level of support** | **Propositions** |
|---|---|---|
| P1.a: The importance of the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | P1, P2, P3 (Natural Resource Dependence Level and Supply Chain NRS Strategies ) |
| P1.b: The importance of the scarce natural resource has an impact on the adoption of bridging strategies. | Not supported | |
| P2.a: Supplier substitutability has a positive impact on the adoption of buffering strategies. | Not supported | |
| P2.b: Supplier substitutability has a positive impact on the adoption of bridging strategies. | Not Supported | |
| P3.a: Discretion over the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | |
| P3.b: Discretion over the scarce natural resource has a positive impact on the adoption of bridging strategies. | Supported | |
| P4: The adoption of buffering strategies has a positive impact on resource efficiency. | Supported | P4, P5(Supply chain NRS strategies and Organisational Performance) |
| P5: The adoption of bridging strategies has a positive impact on resource efficiency. | Not Supported | |

## 5.11 Case study AlumCo_10

AlumCo_10 is a world leading supplier of aluminium solutions for different industries (e.g. automotive, electrical and engineering market sectors). AlumCo_10 uses in their operations aluminium, energy and water.

### Natural Resource Dependence Level and Supply Chain NRS Strategies

There are four main factors that were identified as most important that will lead the aluminium company to specific strategies namely the price of the natural resource, the low availability of alternative suppliers and the low discretion over the scarce natural resource due to legislation and geopolitical reasons (see Table 5.38).

Table 5-38 Themes, Concepts, and Quotations for the Natural Resource Dependence Level dimension (AlumCo_10) (Source: Derived from empirical data)

<table>
<tr><th>Representative quotations</th><th>First-order themes</th><th>Second-order themes</th><th>Aggregate dimension</th></tr>
<tr><td>“The energy cost as such doesn’t allow companies to start producing more capacity of aluminium”<br>(Director of Global Strategic Sourcing)</td><td>Price of the natural resource</td><td>Importance of the scarce natural resource</td><td rowspan="4">Natural Resource Dependence Level</td></tr>
<tr><td>“There are 8-9 largest primary suppliers and they are not easily replaced. That will be hard.”<br>(Director of Global Strategic Sourcing)</td><td>Number of suppliers</td><td>Supplier substitutability of the scarce natural resource</td></tr>
<tr><td>“We expect that the NGOs will put pressure”<br>(Vice President of Strategic Sourcing)</td><td>Social forces</td><td rowspan="2">Discretion over the scarce natural resource</td></tr>
<tr><td>“We have import duties in Europe for example on aluminium so definitely effect how we source it”<br>(Director of Global Strategic Sourcing)</td><td>Geopolitical risk</td></tr>
</table>

The main mechanisms that AlumCo_10 follows (see Table 5.39) are to minimise the dependence on specific natural resources (e.g. rising cost of the resources), product redesign, recycling, substitution (buffering strategies) and relational mechanism and transactional mechanisms (bridging strategies).

Table 5-39 Themes, Concepts, and Quotations for the Supply Chain NRS strategies dimension (AlumCo_10) (Source: Derived from empirical data)

| **Representative quotations** | **First-order themes** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *"We run a program which is called e-drop, energy drop that tries to reduce our energy usage."* (Vice President of Strategic Sourcing) | New technologies or process to minimise resource usage | Product and process (re-) configuration (Buffering Strategies) | Supply NRS Strategies |
| *"We are trying to use recycled aluminium as much as possible about 50% of our produced raw material"* (Vice President of Corporate Social Responsibility Manager) | Recycling | | |
| *"We work towards moving from iron or copper into aluminium"* (Director of Global Strategic Sourcing) | Substitution | | |
| *"Most of our metals come from long term strategic suppliers"* (Director of Global Strategic Sourcing) | Relational Mechanisms | Relational Mechanisms Transactional Mechanisms (Bridging Strategies) | |
| *"We have arms lengths contracts"* (Vice President of Strategic Sourcing) | Transactional Mechanisms | | |

For the production of aluminium a great deal of bauxite is demanded. Bauxite at the moment is considered as an abundant resource. However, Vice President of Strategic Sourcing supports that:

> *"If we continue consuming at the current rate we should be, for the next 180 years it's sufficient, but if you want to consider a higher growth rate then this period can be shorter like 25 years"*

During the process of refining the alumina a critical amount of energy is used. AlumCo_10 tries to recycle scrap aluminium as it requires almost 5% of the energy used to make primary aluminium. They try to decrease scrap in production and fabrication. This can be explained in the following quote.

> *"We are trying to have quite a large portion of internal supplier of metal from re-melt cast houses" (Director of Global Strategic Sourcing).*

The high value of aluminium scrap leads the company to investing in improving productivity (increase re-melting capacity) in existing cast houses but also they build new ones. Scrap is also sent to external cast houses to re-melt if there is an issue from a logistical point of view *“but we are also active in the market buying scrap from scrap dealers” in* order to fill our cast houses. They also have initiated a closed loop programme for old aluminium light poles including fittings and cabling with a few cities.

> *“So instead of buying new metal, we are trying to reuse scrap” (Director of Global Strategic Sourcing).*

However, re-melting is the most energy consuming activity. They try to utilise the cast smelters as much as possible in order to use energy as efficiently as possible.

In some plants in Europe they have installed solar panels in order to use more renewable resources; “*in many of places we have LED lighting”* (Vice President of Corporate Social Responsibility Manager) and make their equipment use less energy. In India, they also have buffers of energy (electric generators) to enable the Company’s business continuity. Water is used mostly in the phases of rolling, extrusion, anodizing and painting but it is not a huge amount. Water reservoirs also utilised and also rain water to minimise the implications of water scarcity.

Concerning the suppliers, the Director of Global Strategic Sourcing stated that *“they are not easily replaced. That will be hard”*. Thus, the primary aluminium is purchased from a limited number of suppliers that AlumCo_10 has long-term contracts with. Energy is highly regulated and in most of the countries there is only one supplier that can offer this natural resource and it is often the same with water, however they usually have shorter term contracts.

The access to aluminium resources is regarded as a really important issue for AlumCo_10. For instance, in China they have export duties. Specifically they use coal as an energy source and they have built a lot of smelters in the north west of China where they have coal mines.

But as their energy is depleted China does not want to export aluminium, therefore they have set up export duties says the Director of Global Strategic Sourcing in the following quote:

> *"15% export duty and there is also an extra VAT that you have to pay … so you will have to pay an additional 30%-35% on top of everything to export it so it's not economically possible really to export"*

Thus, relocation from China is not possible as it will take AlumCo_10 out of the business permanently. Also, there is quite a regulated market for energy in Europe that makes it costly to produce aluminium in Europe. There is also an energy issue in India. The state owns the coal mines and they distributed allowances for companies to consume the coal.

> *But there is "an issue with those allowances in the last couple of years and now they have a new government who want to redistribute those allowances again" states the Director of Global Strategic Sourcing.*

> *The Director of Global Strategic Sourcing states that "for India absolutely we do consider if we want to consider domestic sources at all".*

The Indonesian bauxite export ban and falling Chinese stocks may lead to higher prices for aluminium in 2015. North America and Europe have tried to produce metal from hydropower but Europe and North America are dependent on the Middle East that produced aluminium based on gas.

> *"So I would say sure we do our best to use hydropower from Norway, Siberia and Iceland and Canada but we are dependent on the Middle East sources" where the production of aluminium is not so environmentally friendly (Director of Global Strategic Sourcing).*

**Supply Chain NRS Strategies and Organisational Performance**

The company can identify a lot of benefits in their organisational performance as can be seen in the following quotes and in Table 5.40.

> *"I see a lot of benefits of course on cost to consume less energy but also on performance because once you start reviewing how much energy we use we also try to optimise the process a bit" (Vice President of Strategic Sourcing)*

> *"We measure greenhouse gas emissions and water per produce tonne and so on and it is available in our sustainability report" (Vice President of Strategic Sourcing)*

Table 5-40 Themes, Concepts, and Quotations for the Organisational Performance Dimension (AlumCo_10) (Source: Derived from empirical data)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"We try to minimise our energy consumption"* (Director of Global Strategic Sourcing) | Reduction of the usage of resources | Resource Efficiency | Organisational Performance |
| *"So you try to minimise energy to have less* $CO_2$ *emissions"* (Vice President of Corporate Social Responsibility Manager) | Minimisation of $CO_2$ | | |
| *"If you can minimise your electricity use, cost will be reduced"* (Vice President of Corporate Social Responsibility Manager) | Decrease of the purchasing cost | | |
| *"If you can reduce your waste ,you will also save money because it costs quite a lot to take care of waste so waste management is also important"* (Vice President of Corporate Social Responsibility Manager) | Waste reduction | | |

> *"So it usually takes an investment initially but we can see that this investment is paying off", states the Vice President of Strategic Sourcing.*

In January 2012 they invested $34 million to install state-of-the-art rod and bar production and distribution. They are using 50% of recycled aluminium in order to reduce energy consumption and carbon emissions. There was a slight decrease in recycling in 2013 (73%) in comparison with the 2012 figure (76%). Water usage fell by 8% in 2013 compared with 2012. In the production phase, water input per production tonne was reduced by approximately 5% in 2013 when compared with 2012.

As discussed above, the processes of heating, pressing and cooling demand a huge amount of energy. Thus they are trying to reduce energy usage.

> *"We try to focus on with the products we make actually to reduce energy" (Vice President of Strategic Sourcing)*

The figures for energy consumption for the year 2013 rose slightly by 3% using 2012 as the basis for comparison. The reason behind this increase is the inclusion of a newly acquired extrusion business. However, they will adapt this facility and improve their efficiencies in line with their current locations. This has also had an effect on $CO_2$ emissions that have increased by 3.2% in 2013 compared to 2012. However, there is a decrease in waste by 2.9% that was produced in 2013 compared to the 2012 waste production.

AlumCo_10 is a good supporter of the propositions and the possible association between the key themes discussed above (see Table 5.41). All the interviews supported that the dependence on specific scarce natural resource will lead to buffering and bridging strategies which in turn will positively influence Company's organisational performance.

*Table 5-41 The Research Propositions for AlumCo_10* (Source: Derived from empirical data)

| **Sub-Propositions supported and Newly Emerged Themes** | **Level of support** | **Propositions** |
|---|---|---|
| P1.a: The importance of the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | P1, P2, P3 (Natural Resource Dependence Level and Supply Chain NRS Strategies ) |
| P1.b: The importance of the scarce natural resource has an impact on the adoption of bridging strategies. | Not supported | |
| P2.a: Supplier substitutability has an impact on the adoption of buffering strategies. | Not supported | |
| P2.b: Supplier substitutability has a positive impact on the adoption of bridging strategies. | Supported | |
| P3.a: Discretion over the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | |
| P3.b: Discretion over the scarce natural resource has a positive impact on the adoption of bridging strategies. | Supported | |
| P4: The adoption of buffering strategies has a positive impact on resource efficiency. | Supported | P4, P5(Supply chain NRS strategies and Organisational Performance) |
| P5: The adoption of bridging strategies has a positive impact on resource efficiency. | Supported | |

## 5.12 Case study AlumCo_11

AlumCo_11 is one of the three manufacturers of lithographic (printing plate) material in Europe. AlumCo_11 uses aluminium, energy and water in their operations.

### Natural Resource Dependence Level and Supply Chain NRS Strategies

The cost of the natural resources, the low number of alternative suppliers and the legislation makes AlumCo_11 aware of the issue of scarcity as can be seen in the quotes below of the Sales and Marketing Manager and in Table 5.42.

> *"I think we had had concerns about aluminium not so much about the supply but the cost or energy for gas and electricity… and I think also water not so much the supply but the cost" (Sales and Marketing Manager).*
>
> *"No obviously for things like water we deal with the local water utility authority"*

Table 5-42 Themes, Concepts, and Quotations for the Natural Resource Dependence Level dimension (AlumCo_11) (Source: Derived from empirical data, Sales and Marketing Manager)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"I know cost is driven by scarcity so the cost will go up"* | Price of the natural resource | Importance of the scarce natural resource | Natural Resource Dependence Level |
| *"Metal supply is a little bit better, there are more options but it is quite limited"* | Number of suppliers | Supplier substitutability of the scarce natural resource | |
| *"In Europe because of energy pricing and carbon taxation it is becoming less interesting for companies to smelt and cast aluminium so we are facing potentially a shortage and a cost increase"* | Legislation | Discretion over the scarce natural resource | |

The main mechanisms that AlumCo_11 follows (see Table 5.43) to minimise the dependence on specific natural resources (e.g. rising cost of the resources) are product redesign, recycling, substitution (buffering strategies) and relational mechanisms, transactional mechanisms and hierarchy mechanism (bridging strategies).

Table 5-43 Themes, Concepts, and Quotations for the Supply Chain NRS strategies dimension (AlumCo_11) (Source: Derived from empirical data, Sales and Marketing Manager)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"We have done things like LED lighting"* | New technologies or process to minimise resource usage | Product and process (re-) configuration (Buffering Strategies) | Supply NRS Strategies |
| *"We recycle water...we clean it, we have water that we reuse on site"* | Recycling | | |
| *"Looking at installing a pipeline that is a couple of km from here and they are producing power from biomass"*<br><br>*"We have change things like motors to upgrade them"* | Substitution | | |
| *"So where possible for raw materials we have the same partners every year"* | Relational Mechanisms | Relational Mechanisms Transactional Mechanisms and Hierarchy Mechanism (Bridging Strategies) | |
| *"On things like energy… we have a contract if we find a good partner we stay with them"* | Transactional Mechanisms | | |
| *"We made a new cast house that was a big investment to process commodity ingots that you can buy on the world market and that means we have a wider portfolio of suppliers and that some security is provided by vertical integration"* | Ownership over scarce natural resource | | |

LED lighting was installed to reduce energy usage. Motors were upgraded and also AlumCo_11 moved to renewable sources of energy. Currently they are working with one local biomass plant in order to provide the plant power from biomass. They also collaborate with suppliers to take their waste material and recycle it. These materials are going to secondary markets.

Water is also being recycled and reused in their production facility or they return to the public system. They are using a great amount of water in their chemical process. They try to remove oil from the metal and there is a system that cleans the water and separates the oil from the water. *"So we use a lot of filtration systems to reuse water and oil."* (Sales and Marketing Manager).

Considering the availability of suppliers there is not a high number of suppliers.

> *"Obviously for things like water we deal with the local water utility authority" (Sales and Marketing Manager).*

There are a few suppliers in the metal market but quite limited. So with the suppliers for metals *"we try to have long term partnerships…and we try to develop ways of working that are mutual beneficial"* says the Sales and Marketing Manager but they signed short term contracts for the supply of energy and water.

They have also invested in a casting facility that heats the block of ingots and rolls it. They have a facility that takes the scrap generated by their operation processes so they can re-melt it and cast it back to a block.

*The Sales and Marketing Manager says:*

> *"We have the facility to heat the block and to roll it and we already had a facility to take the scrap that we generate in our own process so to re-melt this and cast it back to a block" Thus, "some security is provided by vertical integration".*
>
> *So "we had to spend in the upstream process and that's clearly secured the supply chain".*

They are also using safety stock but not due to the issue of NRS. As the following quote explains:

> *"We have safety stocks, I won't say it's because of the scarcity of natural resources, it's because possible disruption between the supply chain maybe production issues at the supplier or some issue with the shipment time, so yes we have safety stocks in the supply chain for supply chain disruption" Sales and Marketing Manager.*

Concerning relocation of the plant, the Sales & Marketing Manager says *"We may open up in another location if the company grows but we won't close this one"* as their industry is a "*very capital intensive business"*.

**Supply Chain NRS Strategies and Organisational Performance**

The Sales and Marketing Manager states that their parent company requires them to have specific KPIs in place that are trying to measure the resources used and the energy usage and waste. The main focus is on minimisation of energy and water usage, reduction of waste and emissions, and maximisation of recycling rates (see Table 5.44).

Table 5-44 Themes, Concepts, and Quotations for the Organisational Performance Dimension (AlumCo_11) (Source: Derived from empirical data, Sales and Marketing Manager)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"We measure all the resources that we are using and the waste and recycle and what isn't recycled because we have to pay for that so we try to minimise that"* | Reduction of the usage of resources | Resource Efficiency | Organisational Performance |
| | Waste minimisation | | |
| *"We built our own casting facility so that we can buy the aluminium ingots, which for the small bars on a global market is a commodity and we can bring it in and we can melt that and cast it into the rolling block"* | Leveraged access to resource<br><br>Enhanced technical skills, knowledge | Competitive Advantage<br><br>**(Newly Emerged Theme)** | |

> *"We measure on time delivery, delivery accuracy, speed of throughput, energy per tonne per output for example total cost per tonne so we have a lot metrics measuring performance"*

According to secondary data AlumCo_11 has a certified Environmental Management System in place. 47% of recycled materials were used to produce aluminium in their products but 94% of their waste was recycled. They also reduced by 17% per ton of end product the $CO_2$ emissions by reducing energy consumption by 14% per ton of end product. By reusing water, the water usage reduced by 13.2% in 2012 (baseline year 2011).

Vertical integration also offered the company gaining control over aluminium resource thus a competitive advantage. Thus, buffering and bridging strategies are positively related with resource efficiency and competitive advantage that means supply chain NRS strategies have a positive influence on organisational performance.

AlumCo_11 is one of the best examples that supports most of the relationships between the key three themes and the table shows that most of the propositions are supported. Competitive advantage also emerged as well in this case study as a new theme (see Table 5.45).

Table 5-45 The Research Propositions for AlumCo_11 (together with newly emerged theme) (Source: Derived from empirical data, Sales and Marketing Manager)

| **Sub-Propositions supported and Newly Emerged Themes** | **Level of support** | **Propositions** |
|---|---|---|
| P1.a: The importance of the scarce natural resource has a positive impact on has a positive impact on the adoption of buffering strategies. | Supported | P1, P2, P3 (Natural Resource Dependence Level and Supply Chain NRS Strategies ) |
| P1.b: The importance of the scarce natural resource has a positive impact on the adoption of bridging strategies. | Not supported | |
| P2.a: Supplier substitutability has an impact on the adoption of buffering strategies. | Not supported | |
| P2.b: Supplier substitutability has a positive impact on the adoption of bridging strategies. | Supported | |
| P3.a: Discretion over the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | |
| P3.b: Discretion over the scarce natural resource has a positive impact on the adoption of bridging strategies. | Supported | |
| P4: The adoption of buffering strategies has a positive impact on resource efficiency. | Supported | P4, P5(Supply chain NRS strategies and Organisational Performance) |
| P5: The adoption of bridging strategies has a positive impact on resource efficiency. | Supported | |
| Competitive Advantage<br>The vertical integration secured access to aluminium and also the use of recycling aluminium:<br>• leveraged access to resource | | Newly Emerged theme (Organisational Performance) |

## 5.13 Case study AlumCo_12

AlumCo_12 is a world leading aluminium rolling and recycling firm. AlumCo_12 uses aluminium, energy and water in its operations.

### Natural Resource Dependence Level and Supply Chain NRS Strategies

The price of energy, the large quantities of aluminium and legislation are the main contingency factors that the company considers (see Table 5.46). Their clients are in the automotive industry, the switching costs are also taken into consideration.

> *"It's a little bit different where we make a specific sheet with a specific quality level, a specific alloy to suit their body panel" (Plant Manager)*

*Table 5-46 Themes, Concepts, and Quotations for the Natural Resource Dependence Level dimension (AlumCo_12)* (Source: Derived from empirical data)

| Representative quotations | First-order themes | Second-order themes | Aggregate dimension |
|---|---|---|---|
| *"For our energy its mainly cost"* *(*Environmental Manager) | Price of the natural resource | Importance of the scarce natural resource | Natural Resource Dependence Level |
| *"Primary aluminium it's really energy intensive."* *(*Environmental Manager) | Quantity of natural resource | | |
| *"The thing with the automotive industry is the aluminium stays within a small circle"* (Plant Manager) | Switching costs | Supplier substitutability of the scarce natural resource | |
| *"We also comply with the EU ETS European Emission Trading Scheme so we are allocated an amount of carbon that we can use, obviously natural gas"* (Environmental Manager) | Legislation | Discretion over the scarce natural resource | |

There are some strategies such as recycling of scrap metal that have started to be implemented but they still do not focus on the implementation of comprehensive strategies to handle the issue of scarcity (see Table 5.47).

Table 5-47 Themes, Concepts, and Quotations for the Supply Chain NRS strategies dimension (AlumCo_12) (Source: Derived from empirical data)

| **Representative quotations** | **First-order themes** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *"It has been made from 90% recycled content"* (Senior Purchasing Manager) | New technologies or process to minimise resource usage | Product and process (re-) configuration (Buffering Strategies) | Supply NRS Strategies |
| *"Water tends to be used in our cooling towers , casting process and then it is recycled"* (Environmental Manager) | Recycling | | |
| *"Long term supply chain relationships where we have interdependencies, we work closely with some bigger players, strategic partners"* (Senior Purchasing Manager) | Relational Mechanisms | Relational Mechanisms And Transactional mechanisms (Bridging Strategies) | |
| *"We tend to have medium term agreements"* (Plant Manager) | Transactional mechanisms | | |

The main strategy followed by the company is the recycling of aluminium scrap. It has built a recycling processing facility for scrap cans and other aluminium waste produced into sheet and rolls and this leads to an effective closed-loop system. AlumCo_12 aims to expand the scrap capacity of aluminium and increase the purchased quantities of it. AlumCo_12 has also significantly increased the purchase of non-can post-consumer scrap. AlumCo_12 collaborates with its customers in order to establish closed loop practices. Contracts with their customers include an agreement that the company will buy any aluminium scrap generated by the customers production phase. New equipment has been invested in for recycling at one critical customer and this could help achieve a more cooperative, long-term relationship with customers. In order not to rely on primary aluminium they try to develop new scrap-friendly alloys. AlumCo_12 is able to offer a can body sheet with a minimum of 90% recycled content.

> *"We have got a vision for the can to be made from 90% recyclable content to 100%" (Senior Purchasing Manager).*

Most of the energy is used in the recycling casting centres. Renewable sources of energy (30%) and nuclear power (23%) are utilised in their manufacturing operations. One of its plants in America has its own hydroelectric facilities to provide power. Besides using new energy resources, AlumCo_12 also tries to make existing equipment more efficient. In its factories in the UK the lighting system has been upgraded to LEDs and two older compressors have been replaced with energy efficient ones.

Changes have also been made in melting and producing processes. For example, the furnace burner technology was upgraded and burners were replaced. Another example is that standard efficiency motors were changed with high-efficiency models. Brazil was closed due to high energy usage in Brazil five years ago and concerns over the energy and water usage have also been highlighted by AlumCo_12 for the current year (2015).

Although AlumCo_12 is not using a lot of water, water scarcity has been identified as a significant issue and as a result some strategies were implemented. For instance, water use in the casting of ingots after re-melting recycled materials has been optimised and monitors have been installed in order to control the water usage in the cooling operations. Water usage is tried to be reduced by repairing leaking water pipes, installing temperature monitoring in order to control cooling operations. Water is reused and recycled for example water is recycled through cooling towers in one of its UK factories.

The case study highlights that there are a few suppliers for the same resource. For the cans medium term agreements or volume pricing agreements are signed. In the automotive industry long term agreements are preferred in order to achieve a closed loop system. Specifically, a number of discussions and close collaboration with the car makers or other suppliers about car design are taking place in order to get the best utilisation of aluminium through the closed loop model.

With regards to accessibility, the plant manager believes that relocation of plants will not be considered but an expansion of their company in other locations might be followed as practice in order to produce more volume and meet the growing demand. However, the Environmental Manager believes that EU ETS (European Emission Trading Scheme) can lead companies to relocate. This scheme allocates a certain amount of carbon to use and this makes it less likely companies from the aluminium industry will invest in Europe and they will have to move to China or India. For example big aluminium factories such as the Anglesey aluminium plant have been shut down because of these environmental legislations.

**Supply Chain NRS Strategies and Organisational Performance**

AlumCo_12 has benefited from its practices of using renewable and recyclable resources (see Table 5.48).

Table 5-48 Themes, Concepts, and Quotations for the Organisational Performance Dimension (AlumCo_12) (Source: Derived from empirical data)

| **Representative quotations** | **First-order themes** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *"We are concerned or focused on water reduction"*<br>(Environmental Manager) | Reduction of the usage of resources | Resource Efficiency | Organisational Performance |
| *"We are looking on the planet and the $CO_2$ footprints for the products that we make […] the number of the emissions that we generate while we are producing our products"*<br>(Senior Purchasing Manager) | Minimisation of $CO_2$ | | |
| *"Corporate organisation has set a target of zero landfill"*<br>(Environmental Manager) | Waste minimisation | | |
| *"We have a target by 2020 to have 80% of all of our products sold made from recyclable inputs"*<br>(Senior Purchasing Manager) | Increased the recycling rate of resource | | |
| *"We would like to become like a household brand rather than just something that provides a sustainable product"*<br>(Senior Purchasing Manager) | Provide new or/and improved products to markets | Competitive Advantage<br>**(Newly Emerged Theme)** | |

Thus, AlumCo_12 improved the design of cans to markets as a result of the efficient use of resource and through the collaboration with the suppliers got leveraged access to scrap aluminium. The company has invested $2 billion since 2011 to expand its recycling and production capacity in order to cope with demand surge. AlumCo_12 aims to use at least 80% recycled material in its products by 2020.

The target is based on the fact that aluminium has a long life in many products such as cars which means that they will still be dependent on primary aluminium and also added to some recycled scrap to achieve the standards that are appropriate for alloy composition. By the end of 2014 about 46% recycled inputs exist in the final products and this number will increase to 50% by 2015. Since 2009 a reduction of 17% in GHG emissions, 24% in energy usage, 20% in water usage and 2% in waste were achieved. They also try to reduce $CO_2$ emissions as the Senior Purchasing Manager says:

> *"We are also working with them, we are trying to minimise the $CO_2$ emissions footprint"*

The goal for 2020 is to decrease energy usage by 39% (year 2007 and 2009 are the average baseline) and water usage by 25%. The Environmental Manager states that with regard to energy:

> *"We have to reduce the corporate energy footprint by 2020 by 39%. That cascades down to what each plant needs to do […] and we have to achieve 2% reduction in energy efficiency as a main KPI which is really hard to achieve as in the beginning of the project it's easy to save but after years it becomes more difficult"*

AlumCo_12 targets zero landfill by 2020 but this is questioned by the Environmental Manager as it very difficult to get technically zero landfill *"even if you send it through recycling there is going to be something that cannot be recycled".*

The theme of competitive advantage emerged as well with AlumCo_12. They are producing cans or parts of car bodies from recyclable resources. So they introduce new products in the market as the following quote supports:

> *"In terms of advantages the more you can reduce your cost base the more you can turn a product from being a commodity to a niche product or give you a cost advantage from a cost point of view" (Plant Manager)*

The production of these products requires new production equipment and specific technique skills, thus entry barriers will be high that makes it difficult for their customers to switch to other suppliers.

Thus, the implementation of buffering and bridging strategies have a positive impact on organisational performance. AlumCo_12 is a good supporter of most of the propositions and the possible association between the key themes. Table 5.49 below shows which propositions are supported positively.

Table 5-49 The Research Propositions for AlumCo_12 (together with newly emerged theme) (Source: Derived from empirical data)

| **Sub-Propositions supported and Newly Emerged Themes** | **Level of support** | **Propositions** |
|---|---|---|
| P1.a: The importance of the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | P1, P2, P3 (Natural Resource Dependence Level and Supply Chain NRS Strategies ) |
| P1.b: The importance of the scarce natural resource has an impact on the adoption of bridging strategies. | Not supported | |
| P2.a: Supplier substitutability has an impact on the adoption of buffering strategies. | Not supported | |
| P2.b: Supplier substitutability has a positive impact on the adoption of bridging strategies. | Supported | |
| P3.a: Discretion over the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | |
| P3.b: Discretion over the scarce natural resource has a positive impact on the adoption of bridging strategies. | Supported | |
| P4: The adoption of buffering strategies has a positive impact on resource efficiency. | Supported | P4, P5(Supply chain NRS strategies and Organisational Performance) |
| P5: The adoption of bridging strategies has a positive impact on resource efficiency. | Supported | |
| Competitive Advantage<br>The new aluminium-bodied car and the use of recycled materials to make cans and body panels led the company to:<br>• Differentiation from rivals<br>• Enhanced technical skills, knowledge making replication difficult | | Newly Emerged theme (Organisational Performance) |

## 5.14 Case study PlastCo_13

PlastCo_13 provides rotational moulding and assembly services and makes a range of large hollow products across a number of sectors including automotive in the UK. PlastCo_13 mainly uses natural resources polymers, polyethylene but also some small amounts of nylon and polypropylene.

**Natural Resource Dependence Level and Supply Chain NRS Strategies**

The Director of the company identified three main factors (see Table 5.50) namely the cost of the natural resource, legislation and any geopolitical risk that can lead their company to think about the scarcity of the natural resources such as oil and gas in the future. The Director of the company states that:

> *"Customers try to redesign and minimise the usage of resources because of prices."*

Table 5-50 Themes, Concepts, and Quotations for the Natural Resource Dependence Level dimension (PlastCo_13) (Source: Derived from empirical data, Director of the company)

| **Representative quotations** | **First-order themes** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *"Prices can fluctuate a lot"*<br><br>*"A big impact on the price of material"* | Price of the natural resource | Importance of the scarce natural resource | Natural Resource Dependence Level |
| *"The amount of volume of polymer has also an impact"* | Quantity of natural resource | | |
| *"Energy will become restricted"* | Legislation | Discretion over the scarce natural resource | |
| *"Political unrest in another country"* | Geopolitical risk | | |

PlastCo_13 do not face any issue to get polymer and gas, thus the company is not being so proactive at the moment. But they are reactive and any costs will be added to the final product price.

*"When the prices go up we have to react to that and we are passing that cost to our customers or adjusting what we do on site" says the company's director.*

Table 5.51 shows the main strategies that are used.

Table 5-51 Themes, Concepts, and Quotations for the Supply Chain NRS strategies dimension (PlastCo_13) (Source: Derived from empirical data, Director of the company)

| **Representative quotations** | **First-order themes** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *"We can use recycled polymer"* | New technologies to minimise the usage of resources in the product | Product and Process (re-) configuration (Buffering Strategies) | Supply NRS Strategies |
| *"If the gas becomes unavailable then we should have to look at switching to electric production"*<br><br>*"Finding alternative polymers"* | Substitution | | |
| *"If we create scrap items/any off cuts, we recycle them"* | Recycling | | |
| *"We have either a twelve month or 2 year contract. And that's the fixed price."*<br><br>*"We don't have contracts, we just place an order with whoever can provide us with the right price."* | Transactional mechanisms | (Transactional mechanisms) Bridging Strategies | |

Polymers are expensive material and in the future energy usage will become restricted it is believed by the director of the company. Supply of polymers is limited as it is derived from oil and gas. Looking at energy, there are some moulders using renewable sources of energy such as solar in some parts of America and electric power in Iceland. But their machines are gas driven so they will need a huge capital investment (e.g. new expensive machines). If they want to switch to electric they also need to purchase specific parts of tooling which may lead them to shutting down their business.

*So "until we get to the point where we can justify the cost then we can move to use electric machines" (Director of PlastCo_13)*

However, they used equaliser equipment (i.e. a machine that equalises the frequency of tasks to minimise the total energy consumption) to make more efficient use of energy. They also changed the lighting system within the factory. As far as polymers are concerned, there are alternative polymers such as bio-resins. The Director of the company explains that:

*"There is also research going on in the industry perhaps being able to reduce the amount of virgin material we use in our processes." (Director of PlastCo_13)*

They recently participated in a research project to verify how it is possible to produce high quality Post-Consumer Recycled (PCR) material in order to use it instead of Polyethylene. PCR is the resins recovered from the post-consumer (i.e. household) garbage stream such as blow moulded bottles for milk, water, but not oil products. They tested PCR in a variety of products and found that it can replace the virgin materials between 25% and in some cases even 100%. But bio-resins are very expensive and their customers do not use them to a great extent that kind of material.

*"We don't use bioresins that much at the moment because they are too expensive" (Director of PlastCo_13)*

Thus, their customers use bio-resins or recycled material in small amounts.

*"But as I said before I think the majority of it its price driven. And at the moment bio-resins are very expensive and our customers are letting you know that there are some driven by a green agenda and they do green marketing and that kind of thing that they would like to use bio-resins but when they actually come and look at the cost of it if your project is going to be 50% more from what it currently is they don't go to make that decision. Because they won't be able to sell these products. Whilst our customers do make these kind of decisions then we only use bio-resins or recycled material in lower amounts." (Director of PlastCo_13)*

They also keep polymers for three weeks stock level and gas for two weeks as it is expensive to keep more inventory. They send the waste back to a supplier and they also use recycled materials thus they try to minimise the waste in their processes because there is a cost incentive for recycling (i.e. recycled material is cheaper). When they design new products, they try also to reduce the use of material. Customers also design products within the scrap area in order to more efficiently use this resource.

For the polymer there are five suppliers in the UK but all of those suppliers get their supply from a single source. In this case, once issues arise for the supply of polymer, all five suppliers will be affected. However, they do not collaborate or have long term contracts with those suppliers but they have arm's length relationships. For electricity they have either a twelve month or two year fixed price contract. They also sign contracts with suppliers for recycling of the materials and then suppliers usually sell it back to them.

> *"Our industry is well set up so the material can be recycled which will come back to us." supports the Director of PlastCo_13.*

**Supply Chain NRS Strategies and Organisational Performance**

PlastCo_13 does not consider the issue of NRS as a high risk. However, by implementing some buffering strategies the company's Director perceives improvements in environmental, economic operational performance thus they achieve resource efficiency. Thus, the quotes below demonstrate that recycling, reusing and minimisation of resources affected their organisational performance positively (see Table 5.52).

> *"We monitor energy usage and we also try to reduce energy and also waste minimisation. We don't do this because of scarcity of resources because misuse of resource costs you money which affects the profit you are making." (Director of PlastCo_13).*

As the following quote states that the company tries also to minimise the waste.

> *"And to become an efficient company you are trying to minimise that at all times […] so you are succeeding or working towards waste minimisation" (Director of PlastCo_13).*

The company was awarded ISO 14001 as they monitor and enhance their environmental impact. Apart from being environmentally friendly the company achieved cost savings by minimising the energy usage, waste reduction and using instead of virgin material a recycling material in order to decrease the overall cost.

Table 5-52 Themes, Concepts, and Quotations for the Organisational Performance Dimension (PlastCo_13) (Source: Derived from empirical data, Director of the company)

| **Representative quotations** | **First-order themes** | **Second-order themes** | **Aggregate dimension** |
|---|---|---|---|
| *"We have installed equaliser that makes more efficient the energy usage"* | Reduction of the usage of resources | Resource Efficiency | Organisational Performance |
| *"On waste minimisation we constantly looking during the process to eliminate the scrap"* | Waste reduction | | |

PlastCo_13 does not strongly support the research propositions as can be seen in Table 5.53 below.

Table 5-53 The Research Propositions for PlastCo_13 (Source: Derived from empirical data, Director of the company).

| **Sub-Propositions supported and Newly Emerged Themes** | **Level of support** | **Propositions** |
|---|---|---|
| P1.a: The importance of the scarce natural resource has a positive impact on the adoption of buffering strategies. | Supported | P1, P2, P3 (Natural Resource Dependence Level and Supply Chain NRS Strategies ) |
| P1.b: The importance of the scarce natural resource has an impact on the adoption of bridging strategies. | Not supported | |
| P2.a: Supplier substitutability has an impact on the adoption of buffering strategies. | Not supported | |
| P2.b: Supplier substitutability has a positive impact on the adoption of bridging strategies. | Supported | |
| P3.a: Discretion over the scarce natural resource has an impact on the adoption of buffering strategies. | Not Supported | |
| P3.b: Discretion over the scarce natural resource has an impact on the adoption of bridging strategies. | Not Supported | |
| P4: The adoption of buffering strategies has a positive impact on resource efficiency. | Supported | P4, P5(Supply chain NRS strategies and Organisational Performance) |
| P5: The adoption of bridging strategies has a positive impact on resource efficiency. | Supported | |

## 5.15 Conclusion

Chapter 5 explored 13 case studies focusing on the key themes (natural resource dependence level, supply chain NRS strategies and organisational performance) in order to verify the propositions provided in Chapter 3 and also new themes emerged. Thus, this chapter fulfilled the third objectives of this research that was to verify the proposed conceptual framework. Chapter 6 analyses the cross-case findings to formulate the hypotheses and to reach meaningful conclusions.

# Chapter 6 FINDINGS AND DISCUSSION FROM CROSS-CASE ANALYSIS AND HYPOTHESES DEVELOPMENT

## 6.1 Introduction

Chapter 6 presents the cross-case analysis from the 13 cases and highlights the associations between the original themes and the newly emerged themes. The cross-case analysis increases the applicability of the findings to similar settings (Miles and Huberman, 1994). Thus, the aim of this chapter is to identify the factors that influence the implementation of Supply Chain NRS Strategies. At the same time, the main strategies followed and their outcomes are highlighted in in this chapter. The key findings are explained in order to validate the conceptual framework.

Section 6.2 provides a comparison between the strategies adapted by the manufacturing companies for each natural resource. Section 6.3 discusses the relationship between the first aggregate dimension namely natural resource dependence level and the second aggregate dimension namely supply chain NRS strategies. Section 6.4 explains the relationship between the supply chain NRS strategies and the third aggregate dimension (organisational performance). Following that, a final model for the evaluation of the associations between the three key aggregate dimensions is outlined to provide the valid conceptual framework and the hypotheses in Section 6.5. The chapter ends with the conclusions in Section 6.6.

## 6.2 Comparison between the multiple case study and the natural resources

In Chapter 5, a preliminary set of themes was established (First-order themes, Second order themes, Aggregate dimension) prior to analysis, based on the conceptual framework presented in Chapter 4. These themes informed the interview guide and are used in the qualitative Data Analysis. The main themes were: the natural resource dependence level, the supply chain NRS strategies and the organisational performance and within each of these there are sub-themes (First-order themes, Second order themes) which were visualised in NVivo 10 software in the form of a model (see Figure 6.1).

NVivo 10 helps to store the data in categories and in themes. It also allows an easier visualisation of the data. The use of NVivo 10 as it was described in the methodology chapter facilitates the coding process by recording the codes and coding frequencies helping in the process of thematic analysis (Kuckartz, 2014). The themes resulting from the cross-case content analysis are examined below. The open coding process drew out ten categories based on the conceptual framework developed in Chapter 3 namely product and process (re-)configuration, relational mechanisms, supply chain configuration, hierarchy mechanism, transactional mechanism, supplier substitutability, discretion and importance of the scarce natural resource, competitive advantage and resource efficiency.

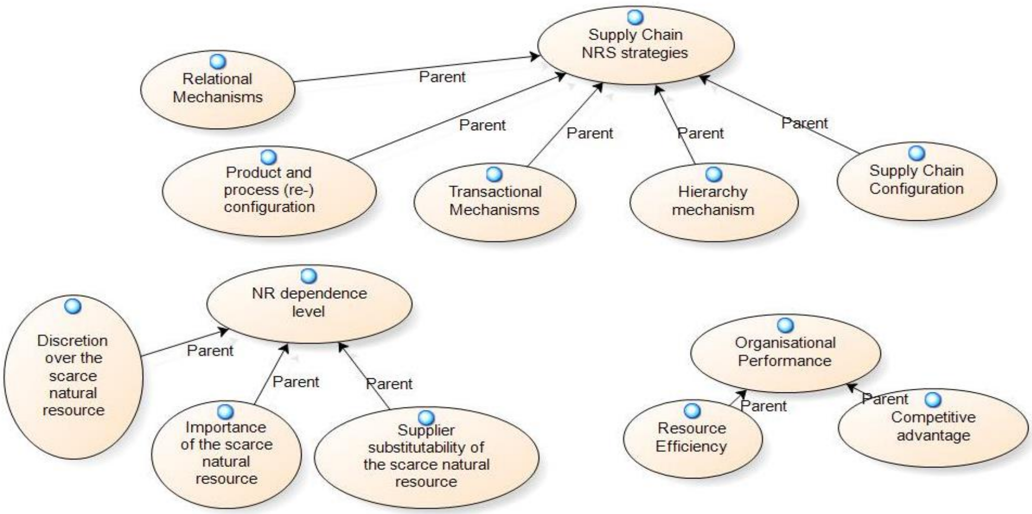


Figure 6.1 A model in NVivo 10 that shows the key themes and sub-themes

Before discussing the implications of the natural resource dependence level on supply chain NRS strategies further, it is important to have a clearer picture of the overall factors that define the dependence level. In Figure 6.2, seven factors are presented and explained below. The seven factors are: price of the natural resource, availability of alternative suppliers, social forces, legislation, switching costs and geopolitical risk.

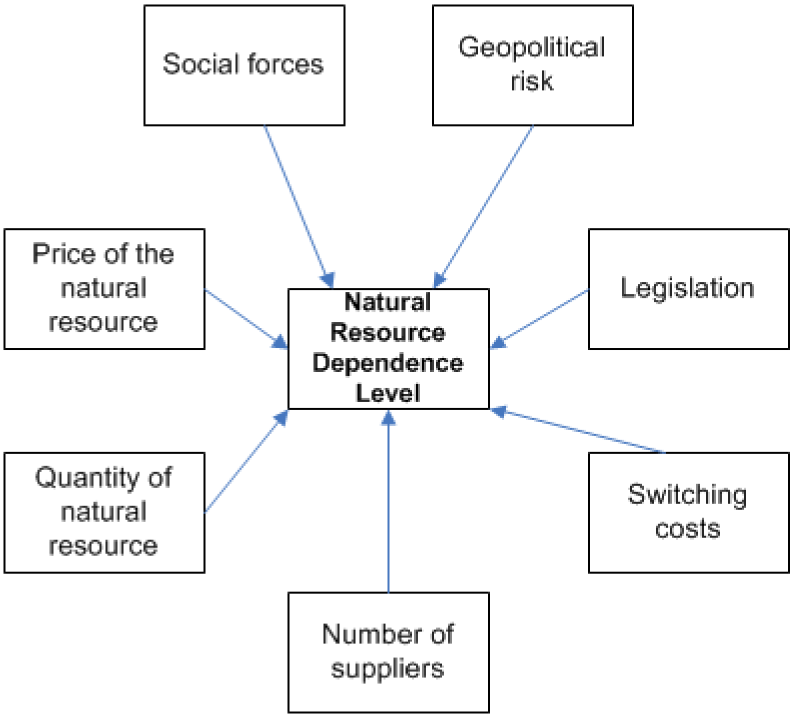


Figure 6.2 Thematic Network of the Natural Resource Dependence Level

In the Table 6.1 (it is the same for Table 6.3 and Table 6.9) the number of sources refers to the key informants that mentioned the theme. The coding frequency refers to the times that the specific theme was mentioned throughout the entire set of the 31 interviews. The price of the natural resource was the most frequently reported dimension (see Table 6.1) in all the interviews so it was indicated as a key driver to minimise the dependence on the natural resources, meaning their relative scarcity. Evidence from the data shows that all the 13 companies use in their operations scarce (price-sensitive) natural resources namely energy, water, steel, crude oil, rare earth metals and aluminium.

Apart from the price of the natural resource, the larger amount or quantities of a natural resource used by the companies makes the resource really critical for the company which is another driver mentioned in the transcripts. Another driver identified that led companies to specific strategies is the availability of suppliers and the switching costs. This is because companies cannot purchase their natural resource from another source because of the limited number of suppliers and the cost involved in changing suppliers.

Another, issue that emerged from the interview transcripts is legislation. Specifically operating in some countries can restrict the access to specific natural resources such as the carbon taxation that leads to high energy prices in Europe. Geopolitical risk can hinder an organisation's ability to procure natural resources such as energy from other nations. For instance, the risk of the rare-earth-metals supply stems from China's decision to reduce its export of those metals that has resulted in their price increasing. Thus, embargoes on exports and conflicts such as the conflict in the Democratic Republic of the Congo have an impact on resource availability. Social forces, especially for water resources, can act as a driver for companies to implement strategies and reduce water usage.

The comparison of the multiple case study (AutoCo_1, AutoCo_2, AutoCo_3, AutoCo_4, BrewCo_5, ChemCo_6, ChemCo_7, ElectCo_8, ElectCo_9, AlumCo_10, AlumCo_11, AlumCo_12, and PlastCo_13) is provided below in the case ordered-descriptive matrix in Table 6.2. The similarities and differences between the cases are presented. The research applies the case-ordered effect matrix in order to validate the framework and show the effect of each second-order theme of the natural resource dependence level on supply chain NRS strategies as an aggregate dimension.

Table 6-1 First Order Themes, Second Order Themes and Aggregate Dimension for Natural Resource Dependence Level

| Aggregate dimension | Second-order themes | Representative Quotations | First-order themes | Sources | Coding frequency | % of Total |
|---|---|---|---|---|---|---|
| Natural Resource Dependence Level | Importance of the scarce natural resource | *"The main reason that leads us to take some specific strategies is the cost. By referring to cost we mean the price of the raw materials."* | Price of the natural resource | 8 | 12 | 24% |
| | | *"The biggest by weight, the biggest amount of the material we use is drawn steels and they are used in the manufacturing of seat frames and seat suspension systems."* | Quantity of natural resource | 2 | 2 | 4% |
| | Supplier substitutability of the scarce natural resource | *"It's limited where you can go and buy"* | Number of suppliers | 6 | 6 | 12% |
| | | *"So let's say for example our supplier […] has to take the business risk building a new manufacturing facility for this situation or perhaps they have to modify an existing facility"* | Switching costs | 4 | 7 | 14% |
| | Discretion over the scarce natural resource | *"If the plant is located in a water scarce area then I think the company will face more pressure from the government to save water"* | Legislation | 8 | 10 | 19% |
| | | *"We have import duties in Europe for example on aluminium so definitely effect on how we source it"* | Geopolitical risk | 8 | 10 | 19% |
| | | *"It has a lot of pressure from the society and media"* | Social forces | 4 | 4 | 8% |
| | | | | Total | 51 | 100% |

Table 6-2 Case-Ordered Effect Matrix: Importance of the scarce natural resource, Supplier substitutability of the scarce natural resource Discretion over the scarce natural resource contributing to specific supply chain NRS strategies across the 13 cases.

| Aggregate dimension | First-order themes | Second-order themes | Auto Co_1 | Auto Co_2 | Auto Co_3 | Auto Co_4 | Brew Co_5 | Chem Co_6 | Chem Co_7 | Elect Co_8 | Elect Co_9 | Alum Co_10 | Alum Co_11 | Alum Co_12 | Plast Co_13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Natural resource dependence level | Price of the natural resource<br>Quantity of natural resource | Importance of the scarce natural resource | √√ | √ | √√ | √√ | √√ | √√ | √ | √√ | √ | √√ | √√ | √√ | √ |
| | Number of suppliers<br>Switching costs | Supplier substitutability of the scarce natural resource | √√ | — | √√ | √ | √√ | √√ | √ | √ | — | √√ | √√ | √√ | — |
| | Legislation<br>Geopolitical risk<br>Social forces | Discretion over the scarce natural resource | √√ | √ | √√ | √ | √√ | √√ | √ | √ | √ | √√ | √√ | √√ | √ |

(√√): case strongly presents (Second-order theme has a positive impact on supply chain NRS strategies as an overarching theme).
(√): case partly presents (Second-order theme has a positive impact on supply chain NRS strategies as an overarching theme).
(—): case presents negative impacts (there is no available information from the informants or no comments).

**Case strongly understands the impacts of NRS** **Case partly understands the impacts of NRS** **Case weakly understands the impacts of NRS**

In general, most of the cases support the idea that the second-order themes (e.g. switching costs) have positive impacts on the overarching theme (AutoCo_1, AutoCo_3, BrewCo_5, AlumCo_10, AlumCo_11 and AlumCo_12). 3 out of the 13 manufacturing companies (AutoCo_2, PlastCo_13, ChemCo_7) claim that most of the factors of the second-order themes of the natural resource dependence level have no impacts on the adoption of buffering or/and bridging strategies. AutoCo_4, ElectCo_8 and ElectCo_9 recognise the three dimensions but only partially support that they have utilised specific strategies thus they do not show strongly the implications of these factors on supply chain NRS strategies.

From Table 6.3 it can be seen from the interviews that most of the companies try to recycle or use new technologies to reduce the usage of resources in the product (23%). Thus, mainly buffering strategies are used, but also companies have long term relationships with their suppliers to access scarce natural resources (19%). Safety stock, relocation, and vertical integration are not strategies that these 13 manufacturing companies are widely following.

In Table 6.4 we can see the cross case matrix that shows the strategies that each company follows to respond to the dependence level that derives from the scarcity of natural resources.

Table 6-3 First Order Themes, Second Order Themes and Aggregate Dimension for Supply Chain NRS Strategies

| Aggregate dimension | Second-order themes | Representative quotations | First-order themes | Sources | Coding frequency | % of Total |
|---|---|---|---|---|---|---|
| **Supply NRS Strategies** | Product and process (re-) configuration | *"We used a new lighting system with LEDs and this will help us achieve cost savings"* | New technologies to minimise the usage of resources in the product | 14 | 28 | 23% |
| | | *"Looking at installing a pipeline that is a couple of km from here where a supplier is producing power from biomass and we are looking at taking gas from them"* | Substitution | 12 | 20 | 16% |
| | | *"So that's interesting because you are not only trying to recycle water for irrigation but actually sometimes you can offer water with a higher quality (upcycling)"* | Recycling | 18 | 29 | 23% |
| | Supply chain (re-) configuration | *"We are going to manufacture cars in Saudi Arabia. The driver for that is because the Saudis have a huge quantity of aluminium bauxite and they just built a massive refinery in Saudi Arabia."* | Relocation | 2 | 2 | 1% |
| | | *"So if you are looking at water in a critical situation we do sometimes own and maintain reservoirs"* | Safety stock | 4 | 4 | 3% |
| | Relational mechanisms | *"Most of our metal come from the long term strategic suppliers"* | Relational Mechanisms | 14 | 23 | 19% |
| | Transactional mechanisms | *"So we have short-term contracts in place where standard terms and conditions are on the back of our purchase orders "* | Transactional Mechanisms | 11 | 17 | 14% |
| | Hierarchy mechanism | *"We built a new cast house that was a big investment to process commodity ingots that you can buy on the world market and that means we have a wider portfolio of suppliers"* | Hierarchy Mechanism | 2 | 2 | 1% |
| | | | | Total | 125 | 100% |

Table 6-4 supply chain NRS strategies across the 13 cases.

| Aggregate dimension | Second-order themes (First-order themes) | Auto Co_1 | Auto Co_2 | Auto Co_3 | Auto Co_4 | Brew Co_5 | Chem Co_6 | Chem Co_7 | Elect Co_8 | Elect Co_9 | Alum Co_10 | Alum Co_11 | Alum Co_12 | Plast Co_13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Buffering Strategies** | Product and Process reconfiguration | | | | | | | | | | | | | |
| | Recycling | | | | | | | | | | | | | |
| | Water | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| | Rare earth metals | | | | | | | | ✓ | | | | | |
| | Metals | ✓ | ✓ | ✓ | | | | | | | ✓ | | ✓ | |
| | Oil (polymers) | ✓ | | | ✓ | | ✓ | | ✓ | | | | | ✓ |
| | Energy | | | | | | | | | | | | ✓ | |
| | Substitution | | | | | | | | | | | | | |
| | Rare earth metals | ✓ | | ✓ | | | | | | ✓ | | | | |
| | Metals | ✓ | ✓ | ✓ | ✓ | | | | | | | | | |
| | Energy | ✓ | | | | | ✓ | ✓ | ✓ | | | ✓ | ✓ | |
| | Oil (polymers) | ✓ | | ✓ | | | ✓ | | | ✓ | | | | ✓ |
| | New technologies to minimise the usage of resources | | | | | | | | | | | | | |
| | Energy | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Water | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| | Metals | ✓ | ✓ | ✓ | | | | | ✓ | | ✓ | ✓ | ✓ | |
| | Rare earth metals | ✓ | | ✓ | | | | | ✓ | | | | | |
| | Supply chain reconfiguration | | | | | | | | | | | | | |
| | Plant relocation | | | | | | | | | | | | | |
| | Close loop supply chain | | | | | | | | | | | | | |
| | Safety stock | | | | | | | | | | | | | |
| | Water | | | | | ✓ | | ✓ | | ✓ | | | | |
| | Oil | ✓ | | | | | | | ✓ | ✓ | | | | |
| **Bridging Strategies** | Transactional Mechanisms | | | | | | | | | | | | | |
| | Water | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Energy | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| | Oil (polymers) | ✓ | | | | | | | | | | | | ✓ |
| | Relational Mechanisms | | | | | | | | | | | | | |
| | Metals | ✓ | ✓ | ✓ | ✓ | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | |
| | Water | | | | | ✓ | | | | | | | | |
| | Energy | | | | | ✓ | ✓ | | | | | | | |
| | Hierarchy mechanisms | | | | | | | | | | | | | |

Exploration of the data within NVivo was done by creating tree maps and clusters. Cluster analysis was used to identify themes that contain similar concepts.

As can be seen in Figure 6.3 the themes appear on the same branch which means that they are similar, such as buffering strategies (i.e. substitution) and bridging strategies (i.e. short term contracts) than those that are far apart. We can see also that the strategies of safety stock, relocation of plants and ownership over scarce natural resource are close together that are the least widely used strategies.


Figure 6.3 Cluster analysis based on the first order themes of the Supply Chain NRS strategies based on NVivo

In order to explore the most widely used strategies for each natural resource Tree Maps were created within the Explore tab in Figure 6.4. Tree Maps are derived from NVivo that show the buffering (e.g. recycling) and bridging strategies (e.g. relational mechanisms) contained in a rectangle with the size of the rectangle indicating its relative frequency (the frequency can be seen in the relative tables below for each natural resource). The tree-map shows the distribution of data coded and the box sizes for each category correspond to the number of references made by the 31 interviewees.

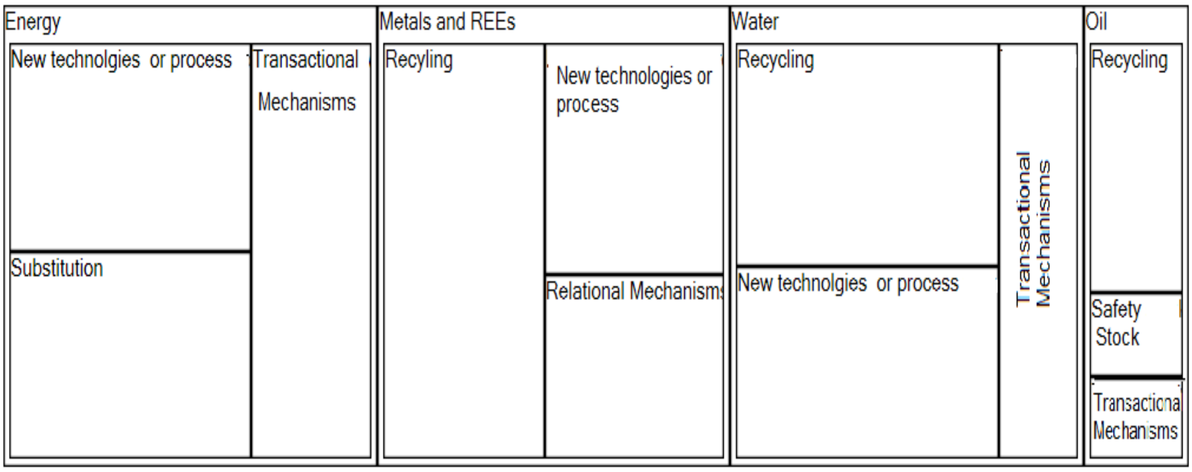


Figure 6.4 A tree map created for nodes compared by number of items coded in NVivo.

Below the strategies utilised for each natural resource, namely metals and rare earth metals, energy and crude oil, and water, are presented.

### Metals (Alluminium, Steel, Copper and Gold) and Rare earth metals

The main contingency factors for the metals and rare earth metals industries that lead to buffering and bridging strategies are price of the natural resource, number of suppliers, switching costs, geopolitical risk and social forces. Table 6.5 shows that for metals such as aluminium the most widely used strategy is recycling whereas for rare earth metals companies try to substitute these resources. Companies, in order to secure accessibility to metals such as aluminium and steel sign long term contracts with suppliers.

The next most widely used strategy is the recycling of these materials. This is due to the physical aspects of those resources (i.e. it can be recycled without quality loss). Another advantage of secondary metals in comparison with primary metals such as aluminium is lower energy consumption. Product and process redesign, substitution and vertical integration are implemented as strategies, but not to a great extent. Rare earth metals are non-renewable resources. The automotive companies and electronic companies use them in small quantities and they try to recycle or substitute rare earth metals for example in their engines in order to minimise their dependence on rare earth metals.

Table 6-5 Frequency of the strategies for metals and rare earth metals.

| First-order themes | Sources(Number of key informants mentioning item) | Coding frequency | % of Total |
|---|---|---|---|
| Relational mechanisms | 4 | 6 | 19% |
| Recycling | 11 | 15 | 47% |
| New technologies or process to minimise resource usage | 6 | 6 | 19% |
| Substitution | 3 | 3 | 9% |
| Vertical Integration | 1 | 2 | 6% |
| | Total | 32 | 100% |

### Energy and Crude Oil (Polymers)

The price of the natural resource, legislation and geopolitical risk are the main factors that lead to specific buffering and bridging strategies. There are renewable and non-renewable energy resources. All (13) companies are investing in new technologies to reduce energy usage. For instance, they tend to replace the existing lighting with highly energy efficient LED (Light Emitting Diode) bulbs to reduce the overall electricity consumption. Renewable sources of energy such as solar energy and wind power are preferred by companies in order to reduce carbon emissions.

Despite the fact that in most of the cases there are not many suppliers that can provide energy to companies they sign short term contracts with the suppliers. The interviewees (ElectCo_9 and AlumCo_10) stated that in some regions, such as India, in which power cuts cause disruption in many manufacturing companies, diesel generators or safety stocks of oil (Crude oil is a non-renewable resource) are used to handle the issue of scarcity. Recycling is also currently used by companies of polymers to reduce the oil usage and the $CO_2$ emissions. Substitution of virgin polymers with bio-resins or recycled polymer is also followed to a lesser extent. The frequency of these strategies can be seen in Tables 6.6 and 6.7.

Table 6-6 Frequency of the energy.

| First-order themes | Sources(Number of key informants mentioning item) | Coding frequency | % of Total |
|---|---|---|---|
| Transactional Mechanisms | 7 | 9 | 30% |
| Substitution | 8 | 10 | 33% |
| New technologies or process to minimise resource usage | 8 | 11 | 37% |
| | Total | 30 | 100% |

Table 6-7 Frequency for oil strategies.

| First-order themes | Sources(Number of key informants mentioning item) | Coding frequency | % of Total |
|---|---|---|---|
| Transactional Mechanisms | 2 | 2 | 22% |
| Substitution | 1 | 1 | 12% |
| Safety stock | 2 | 2 | 22% |
| Recycling | 4 | 4 | 44% |
| | Total | 9 | 100% |

### Water

Water is an important natural resource also from a social aspect. Companies, due to social forces, need to use it wisely in order to maintain their reputation in the community. Water is a renewable natural resource, but it can be scarce in specific regions. Most of the companies (except Auto_Co2 and PlastCo_13) try to secure water through recycling (Figure 6.7 and Table 6.8). For instance, the brewery industry reuses and recycles water in its cooling systems. Short-term contracts seem to be preferred by companies, despite the fact that there are only a few water suppliers. Companies, namely AutoCo_1, AutoCo_3, BrewCo_5, ChemCo_6, ChemCo_7, ElectCo_8 and ElectCo_9, redesign their products or processes (e.g. change the painting process in the automotive industry) in order to use water more efficiently. A few companies such as BrewCo_5, ChemCo_6, ElectCo_9 and AlumCo_10) have water system reservoirs for water storage e.g. rain water and wastewater storage.

Table 6-8 Frequency for water strategies.

| **First-order themes** | **Sources(Number of key informants mentioning item)** | **Coding frequency** | **% of Total** |
|---|---|---|---|
| Transactional Mechanisms | 5 | 5 | 19% |
| Safety stock | 2 | 2 | 8% |
| Recycling | 10 | 12 | 46% |
| New technologies or process to minimise resource usage | 7 | 7 | 27% |
| | Total | 26 | 100% |

All of these strategies lead to resource efficiency and/or better organisational performance. However, most of the interviewees supported (12/15) that their companies focus on cost reduction as can be seen in Table 6.9 but they also try to measure the efficient use of resources such as water. The interviewees also supported that companies through implementing strategies such as process reconfiguration have gained competitive advantage. This theme mainly emerged through the secondary data but also a few companies also supported that the implementation of these strategies and the achievement of resource efficiency enable them to gain a competitive advantage.

Table 6-9 First Order Themes, Second Order Themes and Aggregate Dimension for Organisational Performance

| Aggregate dimension | Second-order themes | Representative quotations | First-order themes | Sources | Coding frequency | % of Total |
|---|---|---|---|---|---|---|
| **Organisational Performance** | Resource Efficiency | *"So at one large facility we saved about 10% of our water consumption"* | Waste reduction | 10 | 13 | 17% |
| | | *"We set targets for each site and benchmark our reductions: energy, water, waste"* | Reduction of the usage of resources | 13 | 24 | 31% |
| | | *"Renewable sources which help to reduce further the* $CO_2$ *emissions"* | Minimisation of $CO_2$ | 9 | 11 | 14% |
| | | *"By reducing natural resource usage, the cost applied to each product also reduced"* | Decrease of the purchasing cost | 12 | 15 | 19% |
| | Competitive advantage | *"In terms of advantages the more you reduce your cost, the more you can turn a product from being a commodity to a niche product or you can have a cost advantage"* | Provide new improved products to markets | 2 | 2 | 2% |
| | | *"This joint venture is key to our company for our future, having the kind of plentiful and inexpensive raw materials in order to serve the growing Asian markets"* | Leveraged access to resource | 6 | 7 | 9% |
| | | *"If you have an integrated facility that is essentially vertically integrated within the company so you are taking advantage of the economies of scale in that situation"* | Enhanced technical skills, knowledge making replication difficult | 6 | 7 | 10% |
| | | | | Total | 78 | 100% |

All 13 manufacturing companies can be seen to try to recycle their natural resources such as water, aluminium, polymer, rare earth metals. "*It's all about recyclability. Isn't it?"* says the Production and Tooling Purchase Manager of one automotive company. However, differences exist on how the recycled materials are used.

Resources such as aluminium and steel do not decrease in quality and can be recycled endlessly whereas water and plastic (its production requires the use of oil, a finite resource) suffer from quality loss and cannot be recycled endlessly. However, *"no one really recycles steel scrap because of its low value"* (Purchasing and Logistics Director, automotive company) and also water is so undervalued in terms of price.

The brewery's Company Sustainability Manager believes that what companies *"pay for each gallon of water is really low [...] and they don't realise how expensive is to treat waste water"*. Thus, there a lot of difference between the price of different natural resources such as water and metal (i.e. economic scarcity). As BrewCo_5 are using large quantities of water so they try to reduce the dependence on this resource mainly due to the social aspect of the resource and also because they have realised as their companies are using large quantities of water its price will be increased in the future.

> *As the Sustainability Manager of ChemCo_6 states "recognise that […] increases in value for the ecosystem services in which we are depending and in many cases they are undervalued today and they will valued differently in the future".*

Companies adding reused or recycled resource in their products, for example, the water can be recycled but is reused in the production process but not as an element of the products.

> *The Sustainability Manager (BrewCo_5) in the brewery company stated that "we don't recover for the purposes of making more products but for other uses such as cooling".*
>
> *The water in the automotive industry is reused also in their production. "We are using wastewater in our production plants" (Purchasing Manager B of AutoCo_1).*

However, for natural resources such as aluminium, the automotive industry is reusing waste from aluminium in their products.

> *The Sustainability Manager says, "We set up a system where scrap aluminium goes back to our supplier who after processing it they sent it to us; so it stays at our products".*

In their sustainability report, it was highlighted that one specific car is using almost 40% recycled aluminium. In the aluminium industry, the automotive industry and electronics industry, companies (AutoCo_3, ElectCo_8 and AlumCo_12) closely collaborate with their suppliers to develop new products and process innovations.

AlumCo_11 and AlumCo_12 have had to make adjustments to reflect market conditions by, for example, closing facilities, creating a close loop supply chain to face the increasing price of virgin aluminium. This stems from the high price of energy and the Chinese decision to impose export duties on aluminium which has led to waste being reused in the manufacturing process. We can see that companies (BrewCo_5, ChemCo_6, ElectCo_8, AlumCo_10, AlumCo_11 and AlumCo_12) are vertically integrated or there are subsidiaries in order to access scarce natural resources (i.e. controlling rights). Chihara (2011) concluded, especially for the mining companies, that the holding company has the benefit of controlling mined resources.

AutoCo_1 and PlastCo_13 are trying to reduce their dependence on oil by using soy-based polyurethane foams, bio-resins or by using recyclable polymers e.g. post-consumer plastic. PlastCo_13 director believes that recycled polymer "*it's not so much available to the extent that we will need it to be"* as it is going overseas or it is used in other processes. Thus, dependence is created also in recycled resources from the manufacturing companies. AutoCo_1 and AutoCo_4 are sending their waste to a supplier that sources this waste to other manufacturing companies and AutoCo_1 and AlumCo_12 utilise waste from another industry. ElectCo_8 has found that it needs to try to remanufacture its products. As Ferguson (2010) found that manufacturing companies do not have the infrastructure and expertise (i.e. to collect used products and remanufacture).

An issue that came to light, particularly relating to the automotive industry, is long life cycle of the products such aluminium that is used in the production of cars. This influences the time when the used product can be recovered. The life cycle of a car is around *"15-20 years so there will be aluminium body panels out for many years…"* that cannot be recycled says the Product Environment Manager, Vehicle Engineering.

AutoCo_1, AutoCo_3 and AlumCo_12 have discussions with their customers in order to implement systems that will enable them to have access to end of life vehicles which means that they can recover valuable resources such as aluminium and gold. However, recycling of rare earth metals (that also demands less energy than primary mining activities) is not used as a mechanism to secure those resources from the companies. According to UNEP (2011c), rare earths are currently being recycled less than 1% because of the inefficient collection systems, technological issues and lack of incentives.

AutoCo_1, AutoCo_3, ElectCo_9 and ChemCo_7 that are making use of rare earth metals do not understand immediately the implications of scarcity as the quote below shows:

> *"We don't actually buy rare earth minerals […] Concerning the banned exports from China we didn't see any impact yet. We don't buy rare earth metals we buy finished components" (Purchasing and Logistics Director, automotive company)*

The cases highlight that there is a high lack of transparency for certain materials in the automotive sector and electronic industry, e.g. where rare earth metals are sourced from as their suppliers do not transfer the information of other tier suppliers. *"So often we are the last to hear"* says the Manager of Materials Engineering of AutoCo_3, as the automotive company is not directly affected as these metals are used in small quantities, in a large number of components further up the supply chain. This is not the case for the brewing industry, BrewCo_5 confirms that there is a high transparency in their supply chain as they do not have second or third tier suppliers that leads them to develop personal relationships with each one of those farming families. However, most of the companies have a low number of suppliers while there is an increasing number of manufacturing companies that try to develop relational mechanisms with their suppliers.

Companies (i.e. AutoCo_1, AutoCo_2, AutoCo3, and AutoCo_4) keep small quantities of safety stock of resources such as palladium and aluminium as these resources are expensive and/or the price volatility of those resources make them too risky to be stockpiled. However, the brewery company have large quantities of water in reservoirs.

It appears also that legislation sets different targets for different natural resources. For instance, the end-of-life vehicle directive set targets for the automotive companies for the reuse and recycling of materials in end-of-life vehicles. However, ElectCo_8 stated that there is no regulation to make them follow any strategy for plastics, but they recycle plastic. Also, none of the legislation has influenced product design to make recovery or remanufacturing easier. The regulation forces all companies to try to reduce their $CO_2$ emissions, thus using less energy. Companies in the aluminium industry in the EU highlight that stricter regulations can damage their competitiveness and two indicated the issues for other companies which has led them to close down factories and relocate elsewhere.

The introduction of new technologies is also a common strategy in order to minimise resources such as water and energy. For instance, the Director of Sustainability Programs and Enterprise Risk for one chemical companies stated that *"we just want to reduce the line of reverse osmosis elements that produce 30% better water purification with 40% less energy"*. In the automotive company a Purchasing Manager says "*We change the cooling system and we will move from metal-halide to LED lighting in order to reduce annual energy consumption"*. Most companies are also trying to use alternative sources of energy such as wind turbines, solar energy or to substitute polymers with bio based polymers.

As can be seen large organisations are more likely to implement strategies to minimise the issue of NRS. The first reason is the large investment that may be needed, for example LED lighting, and the second reason might be that larger organisations have plants in many regions around the world so they face issues such as local legislation that can lead them to apply specific strategies. For example, in the case of PlastCo_13 the company would like to move to renewable sources of energy but new expensive machines must be purchased that makes this change difficult.

The electronic company ElectCo_8, as a leader in the field, has already implemented the practice of reclaimed and refurbished products whereas ElectCo_9 (also a company in the electronics industry) is seeing it as an opportunity in the future as they have just started to grow and think about these issues. RDT also supports that a larger organisation utilises more resources that can help them to avoid dependence. According to Pfeffer and Salancik (1978, p. 131) size "*provides organizations with additional control over their environments and enhances their likelihood of survival*".

The issue of NRS is a strategic decision but small firms are often described as being reactive in strategic decision making and are also short-term oriented towards operational rather than long-term strategic issues (Bergman et *al.*, 2006). PlastCo_13 and ElectCo_9 try to reach the ISO standards but they do not have comprehensive KPIs. Thus, large companies mostly react to resource scarcity by introducing products and resource efficient processes On the other hand, most of the small and medium manufacturing companies hardly pursue measures to decrease their material and energy demand. Small companies often take on formal quality systems as there is external pressure and there is usually a minimalist approach to achieve these standards (Sturkenboom et *al.*, 2001).

Several studies (Arend and Wisner, 2005; Ford, 2009; Koufteros et *al.*, 2007; Vaaland and Heide, 2007) have supported that it is difficult for small companies to change their supply chain management practices due to their organisational structure. Other studies have found that specific SCM practices are more adequate for certain industrial sectors than for others (de Sousa Jabbour.et al., 2011). Big automotive companies such as AutoCo_1 and AutoCo_4 indicated that the greater the size of the company, the greater the level of supply chain NRS strategies whereas AutoCo_3 and AutoCo_4 SMEs are not freely choosing to pursue supply chain NRS strategies as they are client driven (i.e. they follow the decision of the strong tier in the chain such as AutoCo_4). It is observed from the study that on many issues auto sector has some similarities with the electronic industry. These similarities may be attributed due to the common pattern of manufacturing and common natural resource such as REEs. Many of the raw materials and components are purchased from a few number of suppliers in the automotive and electronic industry. Moreover, in these industries in most cases there are a small number of suppliers for a single component and raw material.

The following sections evaluate the relationship between natural dependence levels, supply chain NRS strategies and organisational performance. More specifically, the propositions (statements that associate two or more constructs) developed in Chapter 3 are evaluated based on the case study data, and hypothesis (statements related to two or more variables) developed that will be tested in the following chapter. According to Babbie (1994), hypotheses are expectations about empirical reality that are derived from propositions. The measures that are used to conceptualise the independent and dependent variables of the conceptual framework are provided in Chapter 3.

## 6.3 Natural Resource Dependence level and Supply Chain NRS Strategies

The case studies support the idea that the importance of the scarce natural resource, supplier substitutability of the scarce natural resource and discretion over the scarce natural resource are the key antecedents of the buffering and bridging strategies. These strategies enable companies to use natural resources in an efficient way and reduce its purchasing costs while the companies can gain a competitive advantage. In general, the key findings suggest that these three factors have a high impact on buffering and bringing strategies.

The 13 companies are cross-examined to show the support for propositions 1a, 1b, 2a, 2b, 3a and 3b. This is in order to provide the possible causal link between Theme 1 (second-order themes: importance of the scarce natural resource, supplier substitutability of the scarce natural resource and discretion over the scarce natural resource and Theme 2 (second-order themes: buffering and bridging strategies) across all the cases. A concern in case study research is the internal validity of the proposed relationships, that is, whether the right cause-and-effect relationships have been established (Yin, 1994). Internal validity issues are relevant in explanatory studies where the aim is to establish causal relationships. In the interview questionnaire, I usually need to ask exploratory questions, as my attempt was to understand the novel phenomenon, and identify useful distinctions that clarify my understanding. However, in order to understand the causality between two different phenomena, and specifically whether occurrence of one is related to occurrence of the other I had formulated specific questions for example: "When a natural resource is scarce and cannot be substituted what kind of strategy do you consider more appropriate, what benefits can you identify in your organisational performance (e.g. cost minimisation,) by redesigning your product or processes?)". Another example is the answers that the interviewees provided for instance when I was asking "Is there any legal responsibility to recover the material?" a reply was that "I don't think there is...but there is financial implication, because is very valuable." The causality was understood better by the use of pattern-matching analysis. Thus, I was comparing each case study to see if the variables were repeated.

Yin (2003, p. 116) suggests comparing patterns of cases to predicted ones. Pattern matching is relevant, to predict patterns of the specific variables that defined prior to the data collection (Yin, 2009, p.136) in order to test theoretical propositions rather than developing new theory. The type of pattern matching applied in this study helps to develop explanations for observed causal linkages. These explanations are compiled in an iterative process as suggested by Yin (2003, p. 122). The first stage was to develop the initial propositions based on RDT. These proposition and the conceptual framework used to compare each case studies. Thus, when a proposition was supported in within case analysis means that the data for each company were compared and match with a pattern defined prior to data collection namely the conceptual framework and propositions developed (Yin, 2014, p. 240). The rich narrative from the data was most conducive for the analytical pattern matching technique known as explanation building (Yin, 2014). This technique facilitated detailed explanations of the phenomenon to stipulate the presumed set of causal links about how or why situations occurred (Yin, 2014). This mean when the formulated and predicted propositions from the theory matched to the empirical findings of this thesis, the causal relationship between variables can be confirmed (Yin, 2014). The findings from the cross case studies led to a revision of the propositions namely creating sub propositions. In the cross case analysis, the more the case and the prediction coincides in the 13 case studies, the more the theoretical propositions on which the prediction is based are supported and the internal validity further strengthened. Thus, data was analysed using pattern matching and though the cross case analysis. Thus, while the phase one is exploratory in nature and was not intended to establish causal linkages, a goal, nevertheless was to provide a basis for helping to establish possible causality and develop the hypotheses. The causality will be tested and established in the quantitative phase.

### 6.3.1 Importance of the scarce natural resource

In general, the key findings suggest that importance of the scarce natural resource has a high impact on buffering strategies and bridging strategies, which provides positive support for proposition P1a and P1b below.

**Proposition 1a:** The importance of the scarce natural resource has an impact on the adoption of buffering strategies (product and processes (re-) configuration and supply chain configuration).

**Proposition 1b:** The importance of the scarce natural resource has an impact on the adoption of bridging strategies (transactional mechanisms, relational mechanism, and hierarchy mechanism).

**Buffering Strategies**

According to the findings, the association between importance of the scarce natural resource and buffering strategies is positively supported.

Resource importance is the key determinant of buffering strategies as found in the prior literature (Meznar and Nigh, 1995), the interviewees have supported that the price of the scarce natural resource, but also the quantities of a given resource to some extent lead companies mainly to buffering strategies namely product and process reconfiguration (e.g. recycling and substitution).

This is in line with the RDT that supports that companies with high dependence on the supply of a particular resource (in this case natural resource), will try to make it less important. The buffering strategy emerged from the cross case analysis as a main strategy. This strategy is used mainly to reduce the importance of specific natural resources by enhancing resource efficiency and cutting cost and by having the focus on either existing natural resources (e.g. minimise the usage of resources) and/or adding other kinds of natural resources (e.g. use of another natural resource or substitution).

Companies are also adding reused or recycled resources in their products. For example, AutoCo_1, AutoCo_3, AutoCo_4, PlastCo_13 try to reduce the dependence on oil by using soy-based polyurethane foams, bio-resins or by using recyclable polymers e.g. post-consumer plastic. The introduction of new technologies is also a common strategy in order to minimise resources such as water and energy. In the case studies described in the previous chapter, some commonalities in the supply chain strategies deployed by companies can be observed, for example all the 13 companies moved to LED lighting or changed their cooling systems. AutoCo_1, AutoCo_4, BrewCo_5, ChemCo_6, ChemCo_7, ElectCo_9, AlumCo_10, AlumCo_11 AlumCo_12 use alternative sources of energy such as wind turbines and solar energy. With the agreement from all interviewees in this research, two hypotheses are made below:

H1a: The importance of the scarce natural resource positively affects the adoption of product and processes (re-) configuration.

H1b: The importance of the scarce natural resource positively affects the adoption of supply chain (re-) configuration.

As was seen above when the resource is critical companies try to make it less important, however, the findings revealed that a few companies follow bridging strategies. Relational mechanisms such as joint venture are also used by ChemCo_6 in order to secure *"plentiful and inexpensive raw materials"* says the Director of Sustainability Programs. In order to secure large quantities of water (which is the main ingredient for beer, but it is also used for the crops) BrewCo_5 started working collaboratively with the growers and others within its agricultural supply chain to become efficient. On the other hand, in ChemCo_7 company's annual reports it was stated that they use medium-term contracts with key suppliers despite the fact that it is exposed to commodity price risk in respect of oil-related products. Interestingly, the data supported proposition P1b which means that in the case of important scarce natural resources, companies follow bridging strategies, such as transactional mechanisms and relational mechanisms but the adoption of vertical integration is not verified.

H1c: The importance of the scarce natural resource positively affects the adoption of transactional mechanisms.

H1d: The importance of the scarce natural resource positively affects the adoption of relational mechanisms.

H1e: The importance of the scarce natural resource positively affects the adoption of hierarchy mechanisms.

### 6.3.2 Supplier substitutability of scarce natural resource

The findings from the cross analysis demonstrate that supplier substitutability of scarce natural resource is a highly important contingency factor that determines the resource dependence level. In line with the RDT, when companies do not have many suppliers (there are a few organisations that control the resource) or the switching costs are high bridging strategies are preferred. Thus, the proposition 2b below is verified; whereas there is no evidence that the small number of suppliers will lead to buffering strategies (P2a).

**Proposition 2a:** Supplier substitutability of scarce natural resource has an impact on the adoption of buffering strategies.

**Proposition 2b:** Supplier substitutability of scarce natural resource has an impact on the adoption of bridging strategies.

According to RDT, high dependency on specific suppliers motivates companies to collaborate and exchange information with existing suppliers. Bridging strategies include transactional mechanisms (long-term contracts that establish supply and price), relational mechanisms (partnerships or a joint venture) and hierarchy mechanism (vertical integration).

**Bridging Strategies**

In all cases it was found that for water and energy suppliers, transactional mechanisms are mainly adopted. The suppliers of water and energy are non-substitutable as they have monopoly control on those natural resources needed by the manufacturing companies.

> *"Consumable contracts for water, gas, power, they will be reviewed normally under 2-3 years fixed contracts for the utilities dependant on the best deal we can get and later we will check the open market and may be change the supplier" (Purchasing and Logistics Director of an automotive company).*

According to Pfeffer and Salancik (1978) integration is a strategy to overcome the dependence generated from the little number of suppliers and competition. ChemCo_6, ElectCo_8, AlumCo_11, AlumCo_12 are vertically integrated with the suppliers for critical resources. This gives the companies the opportunity to control and possess more resources. Companies that use aluminium as the most critical natural resource in their production pursue vertical integration due to the low number of aluminium suppliers.

Some of them understand the need to move to long term agreements. For example, one automotive company's Purchasing Director states *"We didn't have a supply strategy here before, now we have the global strategy and the global strategy will feature long term agreements with the key suppliers"* and the Director of Global Strategic Sourcing from one electronic company says *"we have to engage much more closely as a partnership"*.

For example AlumCo_10 in the aluminium industry follows a relational mechanism approach. Specifically in the aluminium production *"there are not really many alternatives [...] most of our metal is coming from the long term strategic partner"* says the Vice President of Strategic Sourcing.

The Director Global Strategic Sourcing of metal for an aluminium company supports that there *are "8-9 largest primary suppliers for metals, they are not easily replaced"* and they have "*done business with them for 20 years but usually contracts are for a year or three years"*. Apart from the number of suppliers switching costs are important. The Sustainability Manager of one automotive company highlights that *"it's not an easy* *process we have to go through various steps to do that including you need to a lot of verification test work to ensure particularly if it is a safety feature in the vehicle you need to make sure that a new supplier or a different supplier is able to meet all our company's requirements around of the material standards."*

Another first tier supplier in the automotive industry stated that there are two aluminium suppliers in Europe and one steel supplier in the UK and maybe another three steel suppliers on the continent. Thus, the company established long-term contracts that usually are equal to the general life cycle of a vehicle that is about seven years.

Most of the companies will try to closely collaborate with suppliers. Strategic partnership or collaboration that entails a high level of operational integration exists in the case of wiring connectors in AutoCo_1. AutoCo_3 collaborates with AlumCo_12 as the aluminium company is the only company that can provide the recycled aluminium quantities that will be used in the productions of cars.

With the above interesting findings regarding the implications of supplier substitutability of scarce natural resource to the bridging strategies and deep explanation gathered from the cases, the next hypotheses are developed:

H2a: Supplier substitutability positively affects the adoption of product and processes (re-) configuration.

H2b: Supplier substitutability of scarce natural resource positively affects the adoption of supply chain (re-) configuration.

H2c: Supplier substitutability of scarce natural resource positively affects the adoption of transactional mechanisms.

H2d: Supplier substitutability of scarce natural resource positively affects the adoption of relational mechanisms.

H2e: Supplier substitutability of scarce natural resource positively affects the adoption of hierarchy mechanism.

### 6.3.3 Discretion over the scarce natural resource

The key findings of the cases suggest that if the accessibility is disrupted for a given natural resource, companies are following a combination of buffering and bridging strategies namely recycling, substitution or close collaboration are followed which provides positive support to proposition P3a and P3b below.

**Proposition 3a:** Discretion over the scarce natural resource has an impact on the adoption of buffering strategies.

**Proposition 3b:** Discretion over the scarce natural resource has an impact on the adoption of bridging strategies.

**Buffering Strategies**

It is significant to highlight that all cases agree that product and processes (re-) configuration is the most cited strategy.

> *"If you are going to lose 3 million dollars a day for not having the part you need you will find a way" says a Purchasing Manager of one automotive company for rare earth metals.*
>
> *"Specifically we try to use the minimum of a scarce natural resource such as gold […] and we mix it with other resources that are not considered to be scarce" says another Purchasing Manager of the same company.*

BrewCo_5, ChemCo_6, ElectCo_8, AlumCo_10 recognise that water is abundant in some regions and scarce in others. Thus, the dependence on water resources is based on the availability per region. Thus, despite the strategies that try to reduce water usage, there is no regulation to prevent and remedy water scarcity impacts. However, BrewCo_5 recognises the social aspect of water scarcity that can have an impact on the accessibility of water (e.g. Coca Cola due to social forces shut down a factory in India). The strategy of safety stock is mainly preferred from companies such as the brewing industry. *"Depending of the site of the facility and the stress of a given community we can reduce or increase those reserves"* (Sustainability Manager of the brewery company). Water shortages also lead to recycling as an appropriate strategy in order to continue production by a few companies. Cases indicated (i.e. BrewCo_5, ChemCo_7 ElectCo_8 and AlumCo_10) that the discretion to natural resources can be hindered by local community concerns and/or reactions.

Companies (except ChemCo_6 and ChemCo_7) agreed that they will not reconfigure their supply chain due to scarcity. One reason for not relocating identified by BrewCo_5 is that a company that operates in one region for many years has more advantages in terms of water rights. Some industries such as the chemical and aluminium industry is really capital intensive thus make the strategy of relocation really difficult to be implemented.

One aluminium company faced energy shortages in India but *"we try to live with that and set buffers of energy to assure business continuity"* says the Vice President of Strategic Sourcing. However, it was found through secondary data (i.e. news website) that ChemCo_7 (chemical company) had to shut down their factory due to scarcity of water and power. Environmental legislation is also considered as a driver for shutting down plants. For instance, European Emission Trading Scheme led other aluminium companies to relocate their plants.

For example, smelters are facing high energy cost and carbon taxation in Europe. *"If you look at the aluminium industry the most efficient smelting capacity is being built where there is access to cheap power […] so that's in places like Scandinavia or Canada where there is hydroelectricity or places like the Middle East where oil is cheap"* (Sales & Marketing Manager).

Thus, the hypotheses below are supported by the findings:

H3a: Discretion over the scarce natural resource positively affects the adoption of product and processes (re-) configuration.

H3b: Discretion over the scarce natural resource positively affects the adoption of supply chain configuration.

However, buffering strategies might not always be possible which encourages companies to choose bridging strategies. Bridging strategies minimise the chances of a resource scarcity (e.g. increase of price) by strengthening the links between firms and its suppliers (Scott, 2003).

**Bridging Strategies**

According to Pfeffer and Salancik (1978) the first option to get more discretion over resources is possession, which can be achieved by vertical integration. For instance AlumCo_11 follow the strategy of vertical integration (e.g. they built a casting facility) in order to secure the supply of aluminium. However, vertical integration appeared not to take place in the other companies to secure resources but they use transactional and relational mechanisms.

Water is a critical resource for BrewCo_5 as it is used as the main ingredient in the beer production, but it is also used for agricultural purposes, such as crop irrigation. BrewCo_5 in order to secure water started to collaboratively work with their growers and others within the agricultural supply chain. Discretion over scarce natural resources also depends on who is the owner and who is in control of the resource. *'It is possible for a resource to be used by other than the owners, in which case the users have some measure of control over the resource'* (Pfeffer and Salancik, 1978, p.48). For example AlumCo_12 collects recycled aluminium which is consumed by the automotive AutoCo_3. This could give practically AlumCo_12 means of control over the recovered resource that AutoCo_3 needs, but they are following the relational mechanism of partnership.

Long-term contracts are another means to reduce the dependence and have access to scarce natural resources, for a mutually agreed period. These contracts have the advantage that enables companies to get discretion over the scarce natural resource. For ChemCo_7 (chemical company) it was found in their annual reports that despite the fact that they are exposed to commodity price risk related to raw materials (e.g. such as oil-related) they use medium-term contracts with key suppliers.

With that in mind, the following hypotheses are developed:

H3c: Discretion over the scarce natural resource positively affects the adoption of transactional mechanisms.

H3d: Discretion over the scarce natural resource positively affects the adoption of relational mechanisms.

H3e: Discretion over the scarce natural resource positively affects the adoption of hierarchy mechanisms.

## 6.4 Supply chain NRS strategies and Organisational performance

It was found from the case study analysis that by the implementation of the supply chain NRS strategies companies enjoy benefits such as a decrease in the purchasing cost of the scarce natural resource and competitive advantage.

Most of the outcomes especially the financial factors are based on secondary data. To summarise, there are two main outcomes (financial and non-financial outcomes) that derive from buffering and bridging strategies namely, resource efficiency and competitive advantage.

> *According to the European Purchasing Director of an automotive company they want to "cut actually more from a cost point of view to stay competitive".*

However, not all companies (e.g. BrewCo_5 and AutoCo_4) can give evidence in terms of numbers of reduction in purchasing cost, minimisation of resource usage and waste as some of them do not measure all of these improvements.

The level of support of the following propositions is investigated below.

**Proposition 4a:** The adoption of buffering strategies has an impact on resource efficiency.

**Proposition 4b:** The adoption of buffering strategies will lead companies to obtain a distinct competitive advantage.

**Proposition 5a:** The adoption of bridging strategies has an impact on resource efficiency.

**Proposition 5b:** The adoption of bridging strategies will lead companies to obtain a distinct competitive advantage.

The relationship between resource efficiency and the newly emerged theme namely competitive advantage was also investigated.

**Proposition 6:** Resource efficiency will lead companies to achieve a distinct competitive advantage.

### 6.4.1 Resource Efficiency

**Buffering Strategies**

The first outcome identified as a result of the buffering strategies is reduction of the usage of the natural resources. Specifically companies try to minimise the waste during the production phase so they reuse it or they sell it to other companies. The usage of the scarce natural resources is also reduced by substituting virgin natural resources such as aluminium with recycled materials that have been recovered through closed-loop systems. For natural resources such as aluminium and water the recycling rate increased. Companies that are using recycled scarce natural resources instead of virgin natural resources have reduced their dependency on them while cutting costs (e.g. ElectCo_8, AlumCo_11 and AlumCo_12).

Another benefit is the decrease of purchasing cost. Strategies that try to minimise the use of natural resources have been recognised with the potential for significant cost savings (Clinch and Healy, 2000; Schleich, 2009). By implementing these practices a reduction on cost can be achieved as fewer natural resources are wasted. Recycled waste reduced the cost of buying natural resources and cost of treating waste whereas cost and waste reduction goes hand in hand and, virgin natural resources are more expensive than recycled. AutoCo_1, AutoCo_2, AutoCo_3 ChemCo_6, AlumCo_12 highlighted that resource efficiency saved them money in dealing with waste but also saved natural resources from being wasted.

There are also some companies that make some profit by selling their waste such as AutoCo_1. For instance, AutoCo_1 achieved a reduction in dysprosium usage which reduced the cost and can save up to 500,000 pounds of rare earth metals annually. Concerning energy, another chemical company in 2020 wants *“to achieve a 35% reduction in energy consumption per unit of production”* and *“in 2013 we have already achieved something like a 5.6% reduction”* says the Supply Chain Manager. By optimising energy performance (e.g. heating/cooling, equipment efficiency, renewable sources of energy etc.) a 30% lower electricity usage has been reached.

Therefore, the results support that buffering strategies can enhance the organisational performance of an organisation. The researcher posits the next hypotheses as below:

H4a: The adoption of product and processes (re-) configuration positively affects resource efficiency.

H4c: The adoption of supply chain (re-) configuration positively affects resource efficiency.

**Bridging Strategies**

By collaborating with suppliers, companies can minimise the usage of resources. Manufacturing companies can minimise the dependence for example, by collaborating with other companies that can use their waste. Companies collaborate by exchanging technical information and mutual willingness is mandatory in order for the supplier to learn about each of the manufacturing company’s operations and achieve resource efficiency thus minimise *“the environmental impact associated with material flows in the supply chain”* (Vachon and Klassen, 2008, p.303). For example, companies that produce cars can ask from their suppliers to produce aluminium sheets with recycled aluminium.

AutoCo_3 and AlumCo_12 have a partnership in the automotive industry in order to produce a car that entails a high percentage of recycled aluminium of which 45% comes from a recycling strategy of scrap utilisation. Thus, these companies will face a reduction in the cost for aluminium raw materials, reduction of virgin material through the recycling process thus also the recycling rate is increased.

> *As the director of PlastCo_13 supported that "Recycled material is considered to be cheaper than virgin material so we are driven by the economics".*

The Purchasing and Logistics Director from an automotive company stated that they *"get about quarter a million a month"* from recycling. Specifically, by the blank reduction program they achieve savings of £660 million. Apart from cost reductions, $CO_2$ emissions are also reduced. This means the investment and the collaboration with these suppliers for new technologies pays off. Thus, suppliers can adapt to customer needs by developing and introducing technologies that minimise the usage of resources and emissions (Vachon and Klassen, 2008).

So all the above lead to the following hypotheses:

H5a: The adoption of transactional mechanisms positively affects resource efficiency.

H5c: The adoption of relational mechanisms positively affects resource efficiency.

H5e: The adoption of hierarchy mechanisms positively affects resource efficiency.

### 6.4.2 Competitive advantage (New emerged theme)

Another outcome identified by adapting either buffering strategies and/or bridging strategies is the achievement of competitive advantage. As explained by the interviewees in AutoCo_1, AutoCo_3, AutoCo_4, BrewCo_5, ChemCo_6, ChemCo_7, AlumCo_11, and AlumCo_12; competitive advantage is gained when companies follow the practices of product and processes (re-)configuration, supply chain (re-)configuration, relational mechanisms, hierarchy mechanism. All the above 8 companies that support that through supply chain NRS strategies have gained a competitive advantage are large companies as the introduction of a proactive strategies, as was explained in Chapter 6, tend to be problematic for SMEs. Bianchi and Noci (1998) supported that the majority of customers are unwilling to pay a premium price for an environmentally friendly product or process. For instance, PlastCo_13 said that they tend to pass the cost on to their customers. Thus, SMEs are not convinced that economic and competitive advantage will accrue from better utilisation of scarce natural resources thus better environmental performance (Kim, 2007).

A few companies (i.e. AutoCo_1 and BrewCo_5) show by achieving resource efficiency a competitive advantage can be gained.

**Buffering Strategies**

New technologies or innovation introduced by companies provide a competitive advantage. The new innovations imply changes in the production processes or in the product design that can enable companies to differentiate from rivals. Another advantage is that they can act as a barrier for rivals in the acquisition of scarce natural resources (Lieberman and Montgomery, 1988) such as recycled resources. AutoCo_1 achieved an advantage among rivals by introducing a new car that has aluminium panels. By introducing the new car, the company distinguished itself from the competitors and targeted new customer groups.

Other companies adapted their supply chain reconfiguration such as facility relocation. By having access to those resources a firm can outperform its competitors. This is supported by the Product Environment Manager of AutoCo_3 that will open a new facility in Saudi Arabia to access aluminium and also in Brazil for accessing copper non-ferrous metals and the petrochemicals. Thus, companies try to find locations that provide them with superior or less costly access to the natural resources for production. When companies move to countries with different regulations for accessing scarce natural resources a competitive advantage can be gained as it stated by the manager of AlumCo_11. With that, the next hypotheses are developed:

H4b: The adoption of product and processes (re-) configuration positively affects competitive advantage.

H4d: The adoption of supply chain (re-)configuration positively affects competitive advantage.

**Bridging Strategies**

Companies can also achieve a competitive advantage by following relational mechanisms. Companies that collaborate closely with suppliers e.g. AutoCo_3 collaborates with the aluminium supplier so the automotive company can access this resource more easily than competitors. Another, example is the close collaboration of AutoCo_3 and AlumCo_12 in order to recycle aluminium that used is by AutoCo_3.

AlumCo_12 by using more efficient aluminium was the first company that produced a car that used recycled aluminium for its body components. *"Natural resource scarcity drives some of our investment decisions"* for example a joint venture made recently enabled ChemCo_6 *"in the future having the kind of plentiful and inexpensive raw materials that is needed to serve growing Asian markets"* (Director Sustainability Programs). Thus, ChemCo_6 through this joint venture will gain a competitive advantage. It was found in the secondary data (a book that provides a guidance for business investments) that this joint venture will enable ChemCo_6 to access energy easily and with less cost (i.e. access to low cost feedstock, vast crude oil and natural gas resources).

AlumCo_11 used the strategy of vertical integration in order to secure the production block of aluminium through in-house production. This strategy can give the advantage of having a steady supply of raw material at a competitive price. Vertical integration also offered the company to gain control over aluminium, improve costs, and increase recycling capacity by reducing the purchases of third party aluminium slabs. Firms controlling their critical scarce natural resources are supposed to gain a competitive advantage in the market.

H5b: The adoption of transactional mechanisms positively affects competitive advantage.

H5d: The adoption of relational mechanisms positively affects competitive advantage.

H5f: The adoption of hierarchy mechanisms positively affects competitive advantage.

**Resource efficiency**

The efficient use of scarce natural resources shows that manufacturing companies can gain a competitive advantage. Companies that have lower manufacturing costs have been shown to exhibit better performance than their competitors (Gimenez and Ventura, 2002; Morgan et *al.*, 2004). Competitive advantage is the unique position of an organisation against rivals due to the efficient usage of natural resources (Shahmansouri et *al.*, 2013).

For example, BrewCo_5 have a competitive advantage in the brewing industry by achieving resource efficiency. BrewCo_5 significantly reduced the water usage by achieving water to-beer ratio to 4.07:1 that is significantly below industry standards (5:1). By using the water more efficiently BrewCo_5 face lower risks associated with the issue of water scarcity especially in water scarce regions (i.e. safeguarding their license to operate). AutoCo_1 reduced petroleum usage and $CO_2$ emissions by 30,000 pounds annually and reduction of dysprosium usage saved up to 500,000 pounds of rare earth metals annually. So reactive players will face a competitive disadvantage that stems from the increased costs, higher intensity and emissions (van Someren, 1995). Thus, having the scarce natural resources is not enough, but companies have to use them efficiently in order to obtain a competitive advantage.

Hence, the following hypothesis is suggested:

**H6:** Resource efficiency positively affects competitive advantage.

## 6.5 Revised Framework and Hypotheses

Based on the discussion of cross-case analysis within the cases, and the propositions developed in this section, a new framework, the Proposition 6 was added and hypotheses were developed. As emphasised in Chapter 2, past research did not provide a framework to analyse the dependence that derives from the scarce natural resources and its implications for the supply chain strategies of manufacturing companies.

The updated model and the propositions are presented in the Figure 6.5 below. Based on the discussion in Chapter 5, a list of propositions was developed to see the effect of the findings of each case, and to establish the relationship between each construct in the framework. Table 6.10 illustrates the propositions that are accepted or rejected based on the empirical findings (case studies). The propositions that were not supported from the multiple case studies are highlighted in grey. Table 6.11 below shows the causality of the propositions developed above concerning the linkage of the Natural resource dependence level and Supply chain NRS strategies. The hypotheses are listed that were developed based on the propositions presented in Chapter 3 and the empirical data from the case studies. The research model that includes the sub-constructs under the main constructs as well as their proposed relationships (hypotheses) is depicted in Figure 6.6.

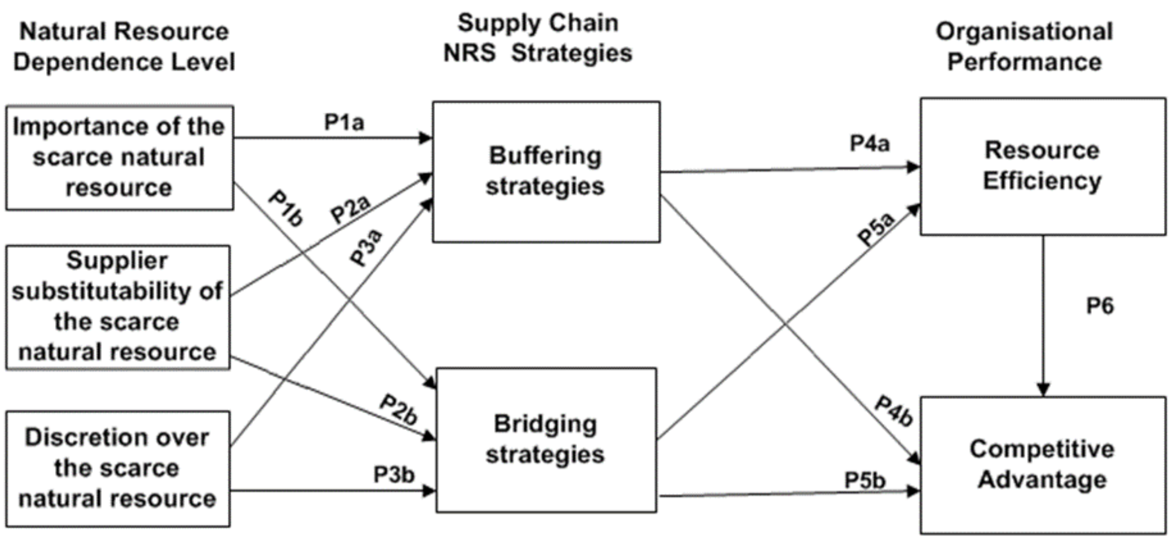


Figure 6.5 Updated Framework

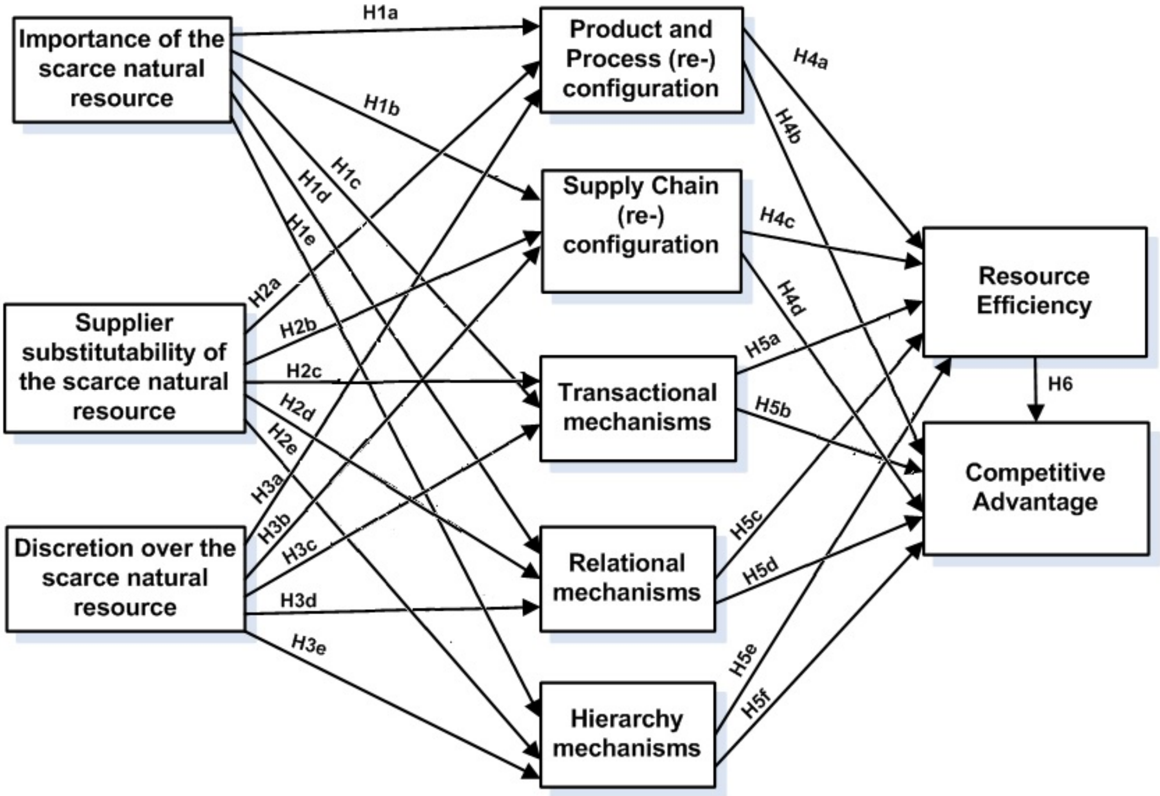


Figure 6.6 Research Framework and Hypotheses

Table 6-10 Propositions and Hypotheses

| Propositions | Sub-propositions Verified by the interviewees | Verified by the interviewees | Developed Hypotheses | Section |
|---|---|---|---|---|
| Proposition 1a: The importance of the scarce natural resource has an impact on the adoption of buffering strategies. | P1a.a: The importance of the scarce natural resource has an impact on the adoption of product and processes (re-) configuration. | Partially Supported | H1a: The importance of the scarce natural resource positively affects the adoption of product and processes (re-) configuration. | Section 6.3.1 |
| | P1a.b: The importance of the scarce natural resource has an impact on the adoption of supply chain (re-) configuration. | | H1b: The importance of the scarce natural resource positively affects the adoption of supply chain (re-) configuration. | |
| Proposition 1b: The importance of the scarce natural resource has an impact on the adoption of bridging strategies. | P1b.a: The importance of the scarce natural resource has an impact on the adoption of transactional mechanisms. | Partially Supported | H1c: The importance of the scarce natural resource positively affects the adoption of transactional mechanisms. | |
| | P1b.b: The importance of the scarce natural resource has an impact on the adoption of relational mechanisms. | | H1d: The importance of the scarce natural resource positively affects the adoption of relational mechanisms. | |
| | P1b.c: The importance of the scarce natural resource has an impact on the adoption of hierarchy mechanism. | | H1e: The importance of the scarce natural resource (critical resource and high purchase importance) positively affects the adoption of hierarchy mechanisms. | |
| Proposition 2a: Supplier substitutability has an impact on the adoption of buffering strategies. | P1a.a: Supplier substitutability has an impact on the adoption of product and processes (re-) configuration. | Partially Supported | H2a: Supplier substitutability positively affects the adoption of product and processes (re-) configuration. | Section 6.3.2 |

| | | | | |
|---|---|---|---|---|
| | P1a.b: Supplier substitutability has an impact on the adoption of supply chain (re-) configuration. | | H2b: Supplier substitutability of scarce natural resource positively affects the adoption of supply chain (re-) configuration. | |
| Proposition 2b: Supplier substitutability has an impact on the adoption of bridging strategies. | P2b.a: Supplier substitutability has an impact on the adoption of transactional mechanisms.<br><br>P2b.b: Supplier substitutability has an impact on the adoption of relational mechanisms.<br><br>P2b.c: Supplier substitutability of scarce natural resource has an impact on the adoption of hierarchy mechanism. | | H2c: Supplier substitutability of scarce natural resource positively affects the adoption of transactional mechanisms.<br><br>H2d: Supplier substitutability of scarce natural resource positively affects the adoption of relational mechanisms.<br><br>H2e: Supplier substitutability of scarce natural resource positively affects the adoption of hierarchy mechanism. | |
| Proposition 3a: Discretion over the scarce natural resource has an impact on the adoption of buffering strategies. | P3a.a: Discretion over the scarce natural resource has an impact on the adoption of product and processes (re-) configuration.<br><br>P3a.b: Discretion over the scarce natural resource has an impact on the adoption of supply chain configuration. | Partially Supported | H3a: Discretion over the scarce natural resource positively affects the adoption of product and processes (re-) configuration.<br><br>H3b: Discretion over the scarce natural resource positively affects the adoption of supply chain (re-) configuration. | Section 6.3.3 |
| Proposition 3b: Discretion over the scarce natural resource natural resource has an impact on the adoption of bridging strategies. | P3b.a: Discretion over the scarce natural resource has an impact on the adoption of transactional mechanisms. | | H3c: Discretion over the scarce natural resource positively affects the adoption of transactional mechanisms. | |

| | | | | |
|---|---|---|---|---|
| | P3b.b: Discretion over the scarce natural resource has an impact on the adoption of relational mechanism.<br><br>P3b.c: Discretion over the scarce natural resource has an impact on the adoption of hierarchy mechanism. | | H3d: Discretion over the scarce natural resource positively affects the adoption of relational mechanisms.<br><br>H3e: Discretion over the scarce natural resource positively affects the adoption of hierarchy mechanisms. | |
| Proposition 4a: The adoption of buffering strategies has an impact on resource efficiency. | P4a.a: Product and processes (re-) configuration has an impact on resource efficiency.<br><br>P4a.b: Supply chain configuration has an impact on resource efficiency. | Supported | H4a: The adoption of product and processes (re-) configuration positively affects resource efficiency.<br><br>H4c: The adoption of supply chain (re-) configuration positively affects resource efficiency. | Section 6.4.1 |
| Proposition 5a: The adoption of bridging strategies has an impact on resource efficiency. | P5a.a: The adoption of transactional mechanisms has an impact on resource efficiency. | Partially Supported | H5a: The adoption of transactional mechanisms positively affects resource efficiency. | |
| | P5a.b: The adoption of relational mechanism has an impact on resource efficiency. | | H5c: The adoption of relational mechanisms positively affects resource efficiency. | |
| | P5a.c: The adoption of hierarchy mechanism has an impact on resource efficiency. | | H5e: The adoption of hierarchy mechanisms positively affects resource efficiency. | |
| Proposition 4b: The adoption of buffering strategies will lead companies to obtain a distinct competitive advantage. | P4b.a: Product and processes (re-) configuration will lead companies to obtain a distinct competitive advantage. | Supported | H4b: The adoption of product and processes (re-) configuration positively affects a distinct competitive advantage. | Section 6.4.2 |

| | | | | |
|---|---|---|---|---|
| | P4b.b: Supply chain configuration will lead companies to obtain a distinct competitive advantage. | | H4d: The adoption of supply chain (re-) configuration positively affects competitive advantage. | |
| Proposition 5b: The adoption of bridging strategies will lead companies to obtain a distinct competitive advantage. | P5a.a: The adoption of transactional mechanisms has an impact on competitive advantage. | Partially Supported | H5b: The adoption of transactional mechanisms positively affects competitive advantage. | |
| | P5a.b: The adoption of relational mechanism has an impact on competitive advantage. | | H5d: The adoption of relational mechanisms positively affects competitive advantage. | |
| | P5a.c: The adoption of hierarchy mechanism has an impact on competitive advantage. | | H5f: The adoption of hierarchy mechanisms positively affects competitive advantage. | |
| Proposition 6: Resource efficiency will lead companies to obtain a distinct competitive advantage. | Partially Supported | | H6: Resource efficiency positively affects competitive advantage. | Section 6.4.2 |

Table 6-11 Representative Quotations of the Impact of Natural Resource Dependence Level on Supply Chain NRS Strategies

| **Representative quotations** | **Causality** | **Company** | **Proposition Support** |
|---|---|---|---|
| *" Aluminum is an expensive material, the more we can recycle it the better we will be from a cost base"* | Purchasing importance leads to recycling. | AlumCo_12 | P1a (Importance of the scarce natural resource and buffering strategies) |
| *"We used a new lighting system, LED system, that will help us to achieve cost savings"* | Purchasing importance leads to new technologies. | ChemCo_7 | |
| *"We are going to manufacture cars in Saudi Arabia. The driver for that is because the Saudis have a huge quantity of aluminum bauxite"* | Criticality leads to supply chain reconfiguration. | AutoCo_3 | |
| *"There will be in some cases long term type of contracts. In other situations we will have short term contracts based on commodity types of materials where we know that the prices are going to be fluctuating and we think we can get a better price at some point in the future"* | Purchasing importance leads to transactional mechanisms. | ChemCo_6 | P1b (Importance of the scarce natural resource and bridging strategies) |
| *"It doesn't mean that there is always an alternative, the supplier may exist who does something different but it may be not always possible to supply from them "so "We will have a given contract with the supplier that supplies that parts and depending on the commodity either will be for the life of the vehicle or the life of that platform or alternatively for a year"* | The low number of alternative suppliers leads to transactional mechanisms or relational mechanisms. | AutoCo_3 | P2b (Supplier substitutability and bridging |

| | | | |
|---|---|---|---|
| *“We have identified the largest suppliers the strategic suppliers* and *most of our metals come from the long term strategic suppliers”* | The low number of alternative suppliers leads to relational mechanisms. | AllumC0_10 | strategies) |
| *“So if we change the supplier, the testing has to be redone. So we can’t just switch. “so “We have with our production suppliers … few long term agreements”* | The low number of alternative suppliers leads to relational mechanisms. | AutoCo_4 | |
| *“It’s not a supplier that you could change every year or you could change every quarter it’s a really long term relationship”* | The low number of alternative suppliers leads to relational mechanisms. | BrewCo_5 | |
| *“Water has a particular link with the community” so we apply several strategies for example “we use dry lubricants* | Social forces for water usage leads to new technologies. | BrewCo_5 | (Discretion of the scarce natural resource and buffering strategies) |
| *“You have to prove to the government that you are proactively reducing your impact on the environment.” And thus they have “a process for low energy lighting across the factory and the offices”* | Legislation leads to new technologies to minimize. | AutoCo_4 | |
| *“In the future there are likely to be severe restrictions and this not only depends on the acquisition mining availability but also it depends on political objectives. We starting recognize the issue … where the materials coming from, is from China, Russia so these countries are politically sensitive areas on specific materials “so “Create a close loop system (by close collaborating with our aluminum supplier) where basically aluminum is coming from the production line”* | Geopolitical risk leads to:<br>-Supply chain configuration (recycling)<br>-Relational mechanisms | AutoCo_3 | P3b<br>(Discretion of the scarce natural resource and bridging strategies) |

| | | | |
|---|---|---|---|
| *“Due to energy pricing and carbon taxation, Europe is becoming less interesting for companies to smelt and cast aluminum. So we are facing potentially a shortage and the cost will increase” and “So we build our own casting facility that we can buy the aluminum ingot … and we can melt it and we produce the rolling block”* | Legislation leads to hierarchy mechanism. | AlumCo_11 | |

## 6.6 Conclusion

This chapter has presented the interpretation of the key findings in order to test the propositions and to validate the framework (three main constructs natural resource dependence level, buffering and bridging strategies and organisational performance). It is interesting to highlight that the case studies show that the dependence level consists of seven factors namely price of the natural resource, availability of alternative suppliers, social forces, legislation, switching costs and geopolitical risk. AutoCo_1, AutoCo_3, BrewCo_5, AlumCo_10, AlumCo_11 and AlumCo_12 strongly supported the relationship between these factors and buffering and bridging strategies. For each different natural resource e.g. energy, water different factors identified and consequently different strategies utilised by the manufacturing companies. Regarding buffering strategies, recycling or the use of new technologies are widely adopted used. Concerning bridging strategies, long term relationships are preferred whereas safety stock, relocation, and vertical integration are not strategies that are widely used. For instance, most of the companies (except Auto_Co2 and PlastCo_13) try to secure water through recycling. Large organisations are more likely to implement strategies to minimise the issue of NRS and the lack of transparency is reason also not to take any action or the right action to mitigate the risk of natural resource scarcity. The findings suggest that there is a positive relationship among natural resource dependence level, supply chain NRS strategies and organisational performance. Specifically, it is found that seven factors (i.e. price of the natural resource, availability of alternative suppliers, legislation, switching costs and geopolitical risk) representing the natural resource dependence level. The high prices of the natural resource and the high quantities used of a particular resource lead a company to employ the following buffering and bridging strategies: product and process (re) configuration, transactional and relational mechanisms. The low substitutability of certain suppliers and the high switching costs lead companies mainly to bridging strategies (i.e. transactional, relational and hierarchy mechanisms). Social forces, legislation for certain natural resources and geopolitical risk lead companies to product and process (re) configuration and supply chain (re) configuration (buffering strategies) and relational and hierarchy mechanisms (bridging strategies). By adopting these strategies companies achieved resource efficiency and a competitive advantage. A series of hypotheses proposed based on the propositions and the interviews that will be subject to rigorous testing (to determine whether or not statistically supported) in the following chapter.

# Chapter 7 QUANTITATIVE DATA ANALYSIS AND DISCUSSION

## 7.1 Introduction

This chapter presents the results of the quantitative analysis of the study. Section 7.2 provides the descriptive analysis (i.e. profile of the survey participants and companies) and section 7.3 contains the assessment of the measurement scales in order to establish the reliability and validity of the survey instruments. The final part provides the PLS analysis namely builds the structural equation model and tests the proposed hypotheses for this research.

## 7.2 Descriptive Analysis

After removing 3 invalid responses, a total of 183 questionnaires were used. The first part includes an overview of the natural resources that were identified as scarce by the interviewees in their companies. This section next provides general information on respondents and participant companies. It presents sample characteristics in terms of respondents (job title, years worked in the organisation etc.) and the companies.

**Scarce natural resources**

Energy (32%) and water (27%) have both been identified as the scarcest natural resources by the interviewees (see Figure 7.1).

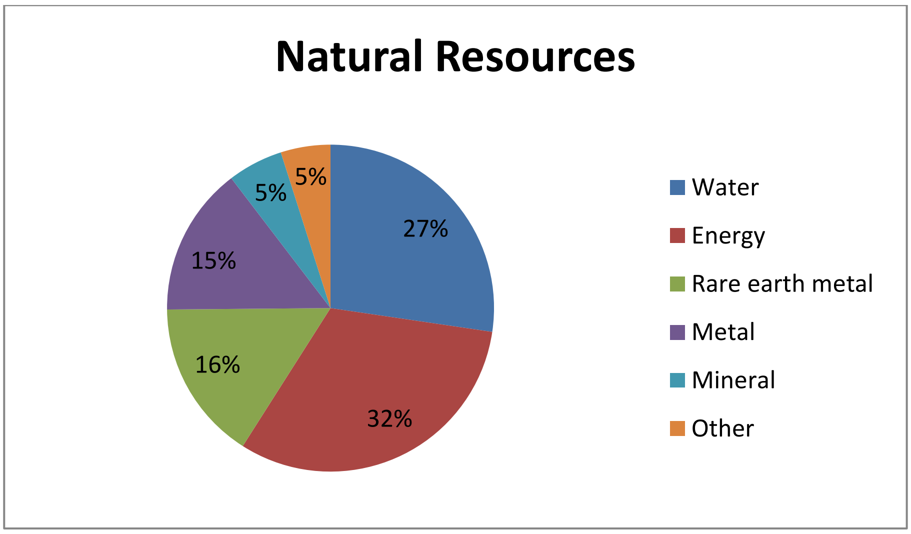


Figure 7.1 Natural resources indicated as scarce companies' resources by the interviewees

**Profile of respondents and participating companies**

The profile of the responding firms in Table 7.1 shows a broad spectrum of manufacturers. The sample composition has the largest representation in food and kindred products (23%), chemical and allied products (13%), and the rest of the respondents where from various industries. The Transportation Equipment industry (i.e. automotive, aviation and rail industry) but also electronic and other electrical equipment industries rely on REEs to develop their products.

Table 7-1 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 | 11% |
| **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 of the respondents are managers (19%), while 15% stated that they are supply chain managers, 10% are sustainability managers and 10% purchasing managers (see Figure 7.2). The rest of the respondents are mainly high-level executives, thus that means the responses received have a high reliability as these executives have a higher job responsibility and administrative knowledge on the issue of natural resource scarcity. Thus, most of the qualified informants (as was discussed in the Methodology chapter) are active in a middle management to director level position.

Table 7-2 Respondents by job title

| Industry | Frequency | Percent |
|---|---|---|
| **Manager** | 34 | 19% |
| **Supply Chain Manager** | 27 | 15% |
| **Purchasing Manager** | 18 | 10% |
| **Sustainability Manager** | 17 | 10% |
| **Supply Chain Director** | 11 | 6% |
| **Head of Procurement** | 10 | 6% |
| **Director** | 10 | 6% |

| | | |
|---|---|---|
| **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% |

**Years Stayed with the Organisation**

The majority of the respondents (32%) have been working in their organisation for between 6-10 years while 8% account for less than 1 year of the sample (see Table 7.3).

Table 7-3 Years worked with the organisation

| Years worked with the organisation | Frequency | Percent |
|---|---|---|
| **<= 1 year** | 15 | 8% |
| **2-5 years** | 47 | 26% |
| **6-10 years** | 58 | 32% |
| **11-15 years** | 31 | 17% |
| **16-20 years** | 10 | 5% |
| **>=21** | 22 | 12% |
| **Total** | 183 | 100% |

With regard to years in their current position, the majority of them (45%) are experienced as they having been in their current position for about 2-5 years and only 22% of the respondents have been in the current role for less than a year (see Figure 7.4). This reflects positively on the reliability of the data obtained given that the respondents have familiarity with the subject area.

Table 7-4 Years worked in the current position

| Years worked in the current position | Frequency | Percent |
|---|---|---|
| **<= 1 year** | 36 | 19% |
| **2-5 years** | 82 | 45% |
| **6-10 years** | 41 | 22% |
| **11-15 years** | 16 | 9% |
| **16-20 years** | 3 | 2% |
| **>=21** | 5 | 3% |
| **Total** | 183 | 100% |

**Number of Employees**

The respondents worked primarily for medium and large firms with nearly 23% working for firms employing between 1,000-4,999 employees. 21% of the organisations have between 100-499 employees and only 4% of the companies have less than 25 employees (see Table 7.5).

Table 7-5 Number of Employees

| Number of Employees | Frequency | Percent |
|---|---|---|
| **Less than 25** | 8 | 4% |
| **25– 99** | 15 | 8% |
| **100 – 499** | 38 | 21% |
| **500 – 999** | 31 | 17% |
| **1,000 – 4,999** | 42 | 23% |
| **5,000–9,999** | 16 | 9% |
| **10,000 and more** | 33 | 18% |
| **Total** | 183 | 100% |

The annual sales in the UK questionnaires are measured in £ whereas the rest of the responses are measured in $ for the amount of total sales.

**Amount of total sales £**

Most of the organisations have total sales of more than £10 billion (see Table 7.6). Looking at the below table only 3% of the organisations have annual sales of less than £1 million. This suggests that the majority of companies in the UK are large in size with respect to their annual sales.

Table 7-6 Total sales £

| Total sales £ | Frequency | Percent |
|---|---|---|
| **Less than £1 million** | 2 | 3% |
| **£1million– under £10 million** | 3 | 5% |
| **£10 million–under £50 million** | 5 | 8% |
| **£50 million–under £100 million** | 5 | 8% |
| **£100 million–under £250 million** | 10 | 16% |
| **£250 million–under £500 million** | 3 | 5% |
| **£500 million–under £1 billion** | 8 | 12% |
| **£1 billion–under £10 billion** | 13 | 20% |
| **£10 billion and more** | 15 | 23% |
| **Total** | 64 | 100% |

**Amount of total sales $USD**

18% are employed by companies or organisations with an annual sales turnover greater than 50 million USD but under $100 million and just 4% of companies have total sales of less than $1 million (see Table 7.7).

Table 7-7 Total sales $US

| Total sales $ | Frequency | Percent |
|---|---|---|
| **Less than $1 million** | 4 | 4% |
| **$1 million – under $10 million** | 12 | 10% |
| **$10 million–under $50 million** | 17 | 14% |
| **$50 million–under $100 million** | 22 | 18% |
| **$100 million–under $250 million** | 18 | 15% |
| **$250 million–under$500 million** | 18 | 15% |
| **$500 million–under $1 billion** | 7 | 6% |
| **$1 billion–under $10 billion** | 7 | 6% |
| **$10 billion and more** | 14 | 12% |
| **Total** | 119 | 100% |

Size is correlating it to employees and/or annual turnover/sales (Donaldson, 1996). Thus, size is measured based on these two attributes. Based on RDT, size is one important organisational factor that has implications on a firms' behaviour in response to changes in market environments. The above tables suggest that the majority of companies both in the UK and the USA are medium and large firms with respect to their annual sales. So by having both medium and large firms a wide range of strategies can be identified, both buffering and bridging.

## 7.3 Reliability

The validation of the measurement model is required prior to the investigation of the relationships between constructs. In order to ensure that the measures are representing the constructs in the framework, reliability and validity of the items measured are examined (Chin, 1988; Hair et *al.*, 2011).

Scale reliability refers to the internal consistency reliability (Melewar and Saunders, 1999). The internal consistency implies that items of the scale share a common core and measure the same concept (Netemeyer et *al.*, 2003). Internal consistency of scales assessed by measuring their coefficient alphas which measure the interrelatedness among a set of items designed to measure a construct (Netemeyer et *al.*, 2003).

SPSS software is used to calculate the scores of reliability coefficient. It is generally considered a value of 0.7 or higher to indicate adequate reliability (Nunnally, 1978). Cronbach's alpha can be described as follows (George and Mallery, 2003; Kline, 1999): $\alpha \geq 0.9$ Excellent; $0.8 \leq \alpha < 0.9$ Good; $0.7 \leq \alpha < 0.8$ Acceptable; $0.6 \leq \alpha < 0.7$ Questionable; $0.5 \leq \alpha < 0.6$ Poor; $\alpha < 0.5$ Unacceptable.

A value of greater than 0.6 is also considered acceptable (Hair et *al.*, 2010). A reliability coefficient value of 0.5-0.6 has also been reported as sufficient for preliminary research (exploratory work) that involves use of newly developed scales (Nunnally, 1978). An alpha coefficient of 0.5 is quite sufficient for a three item scale but inadequate for a ten scale item (Bradley, 1994). Thus, the items were considered to represent an acceptable level of internal consistency if the Cronbach's alpha value was within 0.5 to 0.7 and a good level if the Cronbach's alpha value was more than 0.7 (see appendix 4). All item-to-total correlations must be above 0.35 which is the value that would indicate that an item should be deleted from the scale (Saxe and Weitz, 1982; Bearden et *al.*, 2001).

Almost all Cronbach's alpha values are between $0.7 \leq \alpha < 0.8$ exhibiting acceptable reliability others are between $0.6 \leq \alpha < 0.7$ exhibiting questionable reliability and there is one item that the alpha value is 0.547 meaning there is a poor reliability (see Table 7.8). As can be seen the Cronbach's alpha coefficient for all the items is close to 1.0 that means there is a great internal consistency of the items in the scale.

Table 7-8 Cronbach alpha for all constructs

| Group | Construct | Items Retained after Purification | Cronbach alpha (a) |
|---|---|---|---|
| **Natural Resource Dependence** | Criticality (CR) | 1. Compared to other natural resources, resource X is not easily replaced.<br>2. Compared to other natural resources, we do not have (an | 0.547 |

| | | | |
|---|---|---|---|
| **Level (28 items)** | | acceptable) alternative for resource X. | |
| | Purchase Importance (PURCH) | 1. The purchase of resource X is important for business continuity.<br>2. Resource X involves a significant financial commitment.<br>3. The purchased quantities of resource X are significant.<br>4. The cost of resource X is significant. | 0.673 |
| | Availability (AVAIL) | 1. There are only a few suppliers that can provide your organization with resource X.<br>2. Resource X is purchased from a limited pool of capable suppliers (e.g. technical expertise, specifications).<br>3. When it comes to selecting suppliers for resource X, there are not many options available.<br>4. Only a few suppliers of resource X are geographically positioned close to your company. | 0.812 |
| | Switching costs (SWITCH) | 1. We have made significant investments to strengthen our relationship with the supplier (-s) of resource X.<br>2. If we switched to another supplier (for resource X), we would lose the investments committed to the current supplier of resource X.<br>3. Switching supplier (s) of resource X would result in the loss of specific capabilities.<br>4. Switching supplier(s) of resource X would result in decreased capacity.<br>5. Our production systems (e.g. tooling, equipment) have been adapted to align with the practices of the supplier of resource X. | 0.870 |
| | Ownership (OWN) | Ownership of resource X provides a competitive advantage because of increased barriers to entry for competitors.<br>By owning resource X we gain greater control over costs and supply.<br>By owning resource X we can react quickly to changes in availability.<br>By owning resource X we can manage price volatility.<br>By owning resource X we can avoid government price controls and increased tariffs and taxes. | 0.882 |
| | Accessibility (ACCESS) | 1. My company can easily obtain the quantities of resource X needed to manufacture products. | 0.816 |

| | | | |
|---|---|---|---|
| | | 2. Resource X is abundant in the regions where our factories are located providing easy access.<br>3. Additional quantities of resource X are easily obtained.<br>4. The competition for resource X is low.<br>5. My company has no issues in accessing resource X (e.g. due to local community concerns and/or reactions). | |
| | Usage (USAGE) | 1. In using resource X, my company is penalized by lack of compliance with government regulations (e.g. fines imposed for non-compliance with waste legislation).<br>2. In using resource X, my company is required to do business with suppliers in specific countries that control resource X (e.g. China's export quotas for rare earth metals).<br>3. In using resource X, my company is subject to severe penalties if we fail to safeguard the interests of the local community. | 0.753 |
| **Supply Chain NRS Strategies (24 items)** | Product and Process configuration (PPCONF) | 1. We work closely with suppliers of resource X in product (re-) design to minimize or avoid the use of resource X.<br>2. We work closely with suppliers of resource X in developing innovative practices (e.g. new technologies) to minimize use of resource X.<br>3. We work closely with suppliers of resource X in process (re)-design in order to minimize or avoid the use of resource X.<br>4. We work closely with suppliers of resource X in order to produce products or design production processes that include recycled resource X.<br>5. Our company returns the waste generated by the use of resource X to suppliers for reuse. | 0.871 |
| | Supply chain configuration (SCCONF) | 1. Our facilities are close to where suppliers of resource X are located.<br>2. We have designed a closed-loop supply chain (e.g. collection/acquisition centers, inspection/sorting centers and disposal facilities) to be able to recycle resource X.<br>3. Our facilities are in a place where competition cannot act as a barrier to obtaining resource X.<br>4. Our facilities are located in a place where political pressures cannot act as a barrier to acquiring resource X. | 0.712 |

| | | | |
|---|---|---|---|
| | Transactional Mechanisms (TRANS) | 1. We have formal agreements with the suppliers of resource X that detail the obligations and rights of both parties.<br>2. We have formal agreements that explicitly state the legal remedies for failure to perform.<br>3. We spend much time and effort in developing processes to meet the practices of the suppliers of resource X.<br>4. We have programs to help improve performance of the resource X (i.e training).<br>5. Our formal agreements outline warranty policies. | 0.845 |
| | Relational Mechanisms (RELAT) | 1. In the relationship with the suppliers of resource X, information is shared bi-directionally.<br>2. In the relationship with the suppliers of resource X, ideas or initiatives are widely shared and welcomed via open communication.<br>3. In the relationship with the suppliers of resource X, problems or conflicts are remedied through joint consultations and discussions.<br>4. The suppliers of resource X will be ready and willing to offer assistance and support in case of unexpected events.<br>5. When making important decisions, the interests of the suppliers of resource X are taken into consideration | 0.906 |
| | Hierarchy Mechanisms (HIER) | 1. We are considering vertical integration with the supplier of resource X because there are few options available.<br>2. We are considering vertical integration with the supplier of resource X because of fluctuations in price.<br>3. We are considering vertical integration with the supplier of resource X because of government regulations.<br>4. We are considering vertical integration with the supplier of resource X to reduce the cost.<br>5. 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). | 0.962 |
| **Organisational Performance (10 items)** | Resource Efficiency (REF) | 1. My company has achieved reduction of the usage of resource X.<br>2. My company has reduced the waste of resource X. | 0.767 |

| | | | |
|---|---|---|---|
| | | 3. My company has decreased the purchasing cost of resource X.<br>4. My company has decreased the cost of processing of resource X.<br>5. My company has increased the recycling rate of resource X. | |
| | Competitive Advantage (COMAD) | 1. My company has leveraged access to resource X to which competitors may be restricted.<br>2. My company has secured resource X at a lower price than my competitors.<br>3. My company has enhanced the intangible internal resources (technical skills, knowledge etc.) making replication difficult.<br>4. My company has leveraged access to resource X when other competitors face shortages or spiking prices.<br>5. 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). | 0.868 |
| | | | **Cronbach's Alpha score for all items** |
| | | | 0.937 |

## 7.4 Assessment of the measurement model (Convergent and discriminant validity)

The results obtained from the reliability analysis using the software SPSS were then submitted to SMART PLS software to apply Partial Least Square (PLS) analysis. The convergent (the similarity between the individual items measuring the same construct) and discriminant validity (if the individual items do not measure any other constructs) were measured (Henseler et *al.*, 2009). The item reliability, internal consistency, Average Variance Extracted (AVE) measure the convergent validity (Fornell and Larcker, 1981) and the square-root of AVE and cross loadings measure the discriminant validity (Barclay et *al.*, 1995).

### 7.4.1 Evaluation of the measurement model: first-order model

According to Bollen (1989) reliability and validity should be assessed for reflective measurement models. The model consists of all first order dimensions associated with the relevant constructs. Cronbach's alpha measures the internal consistency. All constructs revealed satisfactory levels as was found in the previous section. However, this measure *"tends to provide a severe underestimation of the internal consistency reliability of latent variables in PLS path models"* (Henseler et *al.*, 2009, p.299). Thus, the measurement of composite reliability that measures how well a construct is measured by its assigned indicators is more appropriate.

The data indicated that the measures are robust in terms of their internal consistency reliability as indexed by the composite reliability (Table 7.23). The composite reliabilities exceeded the recommended threshold value of 0.7 (Nunnally and Bernstein, 1994), it even exceeds 0.8 for all constructs. The next measure reported is the Average Variance (AVE) that shows the variance between a construct and its items. AVE must be higher than 0.5 that indicates that convergent validity measures contain less than 50% error variance (Chin, 1998). Results revealed that the AVE for all constructs exceeded the minimum threshold value of 0.5, see Table 7.43, indicating that all latent variables have explained more than 50% of the variance in their observable measures (Götz et *al.*, 2009).

Table 7-9 Composite Reliability and Average Variance Extracted

| 1st order constructs | Average Variance Extracted (AVE) | Composite Reliability |
|---|---|---|
| **Accessibility** | 0.578 | 0.873 |
| **Availability** | 0.648 | 0.880 |
| **Competitive Advantage** | 0.660 | 0.906 |
| **Criticality** | 0.677 | 0.805 |
| **Hierarchy** | 0.867 | 0.970 |
| **Ownership** | 0.686 | 0.916 |
| **Product_Process_Configuration** | 0.628 | 0.910 |
| **Purchase** | 0.604 | 0.819 |
| **Relational** | 0.728 | 0.930 |
| **Resource Efficiency** | 0.522 | 0.844 |
| **SCConfiguration** | 0.537 | 0.822 |
| **Switching costs** | 0.661 | 0.906 |
| **Transactional** | 0.660 | 0.886 |
| **Usage** | 0.670 | 0.859 |

The next step was to measure the discriminant validity that shows if a concept is unique and is not related with the measures of other concepts (Bagozzi *et al.*, 1991). Discriminant validity can be evaluated using the Fornell-Larcker criterion and the cross-loadings. The Fornell-

Larcker criterion postulates that the correlation of a construct with its indicators (i.e. the square root of AVE) must be higher than the correlation between the construct and any other construct (Fornell and Lacker, 1981). The results show in Table 7.24 that for all constructs the root AVE values were greater than the corresponding off-diagonal correlations, indicating adequate discriminant validity (Barclay *et al.*, 1995).

Concerning the cross-loadings, the loading of each indicator is expected to be greater than all of its cross-loadings (Götz *et al.*, 2009). Although acceptable reliability is 0.707 (Fornell and Larcker, 1981), some argue that a value of 0.5 might be regarded as an acceptable factor loading as long as there are some other factors in the same construct that load highly (Chin, 1998). Items with loadings of less than 0.4 – 0.5 should be excluded (Hulland, 1999). Thus, when the item reliability is at least 0.50 there can be evidence of convergent validity. Table 7.25 provides an overview of the constructs and their indicators with loadings. According to this assessment of the indicator reliability, all of the indicators have loadings above 0.6. Thus, the indicators in the measurement model show satisfactory reliability levels

### 7.4.2 Evaluation of the measurement model: second-order model

This model includes 7 first order factors and 3 second order factors. The constructs product and process (re-) configuration, supply chain configuration, transaction mechanisms, relational mechanisms, hierarchy mechanisms, resource efficiency and competitive advantage were pondered as first-order constructs, whilst importance of the scarce natural resource, substitutability of the scarce natural resource and discretion over the scarce natural resource were conceptualised as second-order factors reflective-formative constructs in which each of its dimensions (criticality, purchase importance, availability, switching costs, usage, accessibility and ownership) were treated as reflective first-order constructs.

The reflective first order constructs were assessed in the previous sub-section. The method of repeated indicators (hierarchical component model) was applied to the second order factors. The first order factors are used to measure directly the second order factors. Latent variables scores were obtained and used as the indicators of the second order constructs in a sequential second stage (Ringle et *al.*, 2012). The latent variable scores were computed by PLS. The items ACCESS_1 and ACCESS_5 have loadings lower that 0.5, AVE is 0.419 thus it was decided to be deleted. In the evaluation of the second order reflective-formative constructs, the only criterion is to examine the variance inflation factor (VIF) that confirms that there is no multicollinearity between the formative indicators that form the construct (Moreno and Casillas, 2008). VIF for all indicators (see Tables 7.26, 7.27 and 7.28) are less than the suggested threshold of 10 (e.g. Hair et *al.*, 2011), 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. Item weights are also above the value of 0.1 (Hassan et *al.*, 2015), thus are significant formative indicators for their latent variable construct (i.e. importance, substitutability and discretion). So it can be seen that multicollinearity does not pose a problem for the formative measurement model operationalisation.

The two-stage approach that includes all the hypothesised relationships for the structural model is visualised in Figure 7.2. From this operationalisation, hypothesis testing is performed.

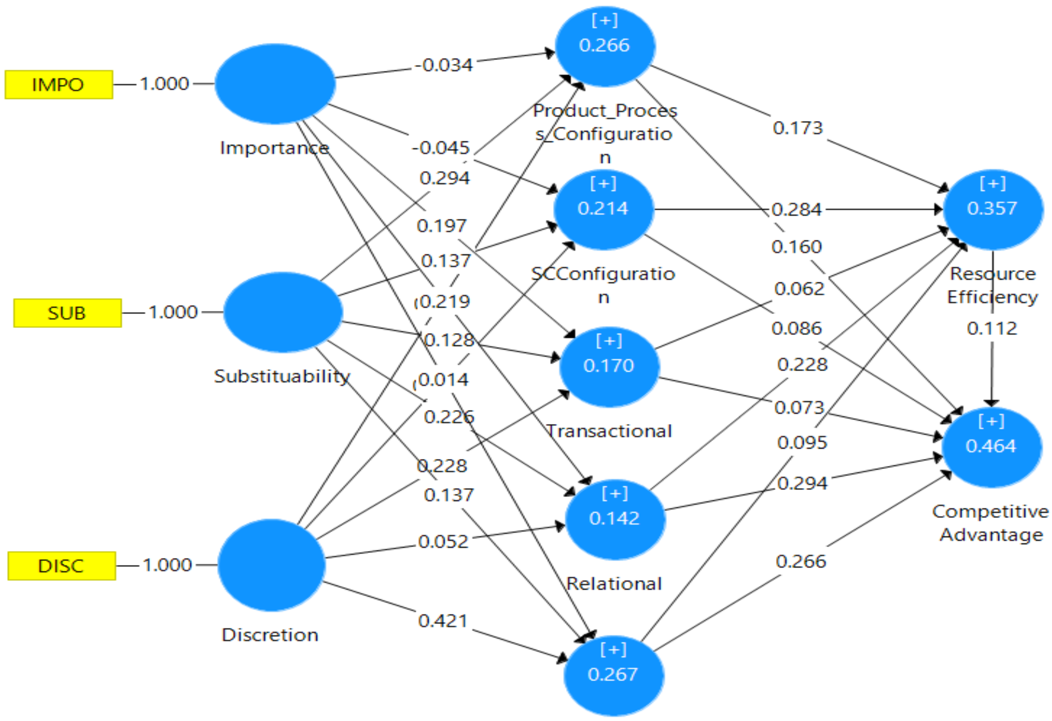


Figure 7.2 PLS path model

## 7.5 Structural model evaluation

The previous sub-section examined the model via PLS analysis (i.e. internal consistency reliability, convergent validity and discriminant validity). This section evaluates the structural model based on the variance explanation of the endogenous (dependent) construct and the significance of path coefficients.

### 7.5.1 Variance explained

The first criterion to assess the structural model is to determine the variance explained by inspecting $R^2$ value of the endogenous construct. According to Backhaus et *al.* (2003) $R^2$ measures the goodness of fit and is a measure of the relative importance of the exogenous latent variables for an endogenous latent variable. The value of $R^2$ ranges from 0 to 1; the higher the value; the greater the explanatory power on the structural model (Hair et *al.*, 2011). There is no consensus on the minimum level that this index should reach. $R^2$ value's effect degree can be high (above 0.26), medium (0.13-0.26), and low (0.02-0.13) (Cohen, 1988). Others (Falk and Miller, 1992) recommend a minimum value of 0.1 that ensures that at least 10% of the construct variability is due to the model. Table 7.29 illustrates the $R^2$ and it can be seen from the table that 46.4% and 35.7 of the variance in performance is explained by the supply chain NRS strategies constructs. The $R^2$ values of the endogenous constructs used greatly exceed this recommended minimum value, thus the model has an adequate predictive power.

To evaluate the predictive relevance of the model, the Stone-Geisser test was used to examine the predictive relevance of the latent endogenous variable. Values ≥0 can verify the predictive relevance of the model (Fornell and Bookstein, 1982). Thus, as $Q^2$ values in the Table 7.48 exceed the threshold it can be said that the dependent variables can be predicted by the independent variables.

The effect size $f^2$ is also examined (Cohen's $f^2 = R^2 / (1 - R^2)$) that shows how the $R^2$ of an endogenous variable changes, when an exogenous latent variable is excluded. $f^2$ can be classified as small ($f^2 \geq 0.02$), as medium-sized ($f^2 \geq 0.15$) and as large ($f^2 \geq 0.35$) (Cohen,1988).

Effect size was medium for relational mechanisms ($f^2 = 0.165$), SCConfiguration ($f^2 = 0.272$) and Transactional mechanisms ($f^2 = 0.204$). Large amounts of variance were explained in competitive advantage ($f^2 = 0.865$), Resource Efficiency ($f^2 = 0.555$), hierarchy mechanisms (f2=0.364), Product_Process_Configuration ($f^2=0.362$) as can be seen in Table 7.49.

Additionally, the goodness of fit (GoF) proposed by Tenenhaus et *al.* (2005) was calculated (see Table 7.49). This index is bounded between 0 and 1. The model analysed showed a value of 0.46, which can be considered a high value according to Cohen (1988). Wetzels et *al.* (2009) and indicates three cut-off values for the validation of the PLS model (GoFsmall = 0.1, GoFmedium = 0.25, GoFlarge = 0.36). GoF measured by multiplying the SQRT Average Communality with the Average $R^2$. In this study, GoF value of 0.352 was obtained for the complete (main effects) model, which exceeds to a great extent the medium cut off as it is more close to the large cut off value. Thus, the model has substantial explaining power.

Table 7-10 $R^2$, $Q^2$, $f^2$ and communality value of the endogenous construct

| | **$R^2$** | **$Q^2$** | **$f^2$** | **Communality** |
|---|---|---|---|---|
| **Competitive Advantage** | 0.464 | 0.293 | 0.865 | 0.480 |
| **Hierarchy** | 0.267 | 0.228 | 0.364 | 0.794 |
| **Product_Process_Configuration** | 0.266 | 0.156 | 0.362 | 0.466 |
| **Relational** | 0.142 | 0.098 | 0.165 | 0.586 |
| **Resource Efficiency** | 0.357 | 0.167 | 0.555 | 0.274 |
| **SCConfiguration** | 0.214 | 0.097 | 0.272 | 0.221 |
| **Transactional** | 0.170 | 0.103 | 0.204 | 0.415 |

### 7.5.2 Analysis of path coefficients/Test of hypotheses

After the evaluation of variance explained or $R^2$ values the assessment of the second criterion tried to be assessed in order to determine the significance of the path coefficients based on t-statistics based on the bootstrapping technique. Since the study's hypotheses are one-directional, one tailed t-tests were used to identify the significance level. Table 7.30 illustrates the path coefficients, t-values, significance. Conclusions on whether the hypotheses are accepted or rejected by the data are made. The path coefficients show the direction and strength of the relationship (Chin, 1998) and should be greater than 0.1 (Sellin and Keeves, 1994). While 12 hypotheses supported (H1c, H1d, H2a, H2d, H3a, H3b, H3c, H3e, H4c, H5c, H5d, and H5f) from the empirical test, 14 hypotheses are not supported (highlighted in grey).

Table 7-11 Path coefficient, t-value and significance

| Hypothesis | Relationship | Path Coefficient ($\beta$-value) | T Value | Sig (P-value) | Outcomes of the hypothesis |
|---|---|---|---|---|---|
| H1a | Importance→ PP_configuration | -0.034 | 0.572 | 0.567 | Rejected |
| H1b | Importance→SC_configuration | -0.045 | 0.569 | 0.569 | Rejected |
| H1c | Importance→Transactional | 0.197 | 2.227 | 0.026* | Accepted |

| | | | | | |
|---|---|---|---|---|---|
| H1d | Importance→Relational | 0.219 | 3.331 | 0.001*** | Accepted |
| H1e | Importance→Hierarchy | 0.014 | 0.245 | 0.807 | Rejected |
| H2a | Substitutability → PP_configuration | 0.294 | 3.124 | 0.002** | Accepted |
| H2b | Substitutability → SC_configuration | 0.137 | 1.607 | 0.109 | Rejected |
| H2c | Substitutability → Transactional | 0.128 | 1.655 | 0.098 | Rejected |
| H2d | Substitutability → Relational | 0.226 | 2.588 | 0.010** | Accepted |
| H2e | Substitutability → Hierarchy | 0.137 | 1.682 | 0.093 | Rejected |
| H3a | Discretion → PP_configuration | 0.293 | 3.122 | 0.002** | Accepted |
| H3b | Discretion → SC_configuration | 0.377 | 4.562 | 0.000*** | Accepted |
| H3c | Discretion → Transactional | 0.228 | 2.696 | 0.007** | Accepted |
| H3d | Discretion → Relational | 0.052 | 0.565 | 0.572 | Rejected |
| H3e | Discretion → Hierarchy | 0.421 | 5.502 | 0.000*** | Accepted |
| H4a | PP_configuration→ Resource Efficiency | 0.173 | 1.651 | 0.099 | Rejected |
| H4c | SC_configuration→ Resource Efficiency | 0.284 | 3.772 | 0.000*** | Accepted |
| H5a | Transactional→ Resource Efficiency | 0.062 | 0.600 | 0.549 | Rejected |
| H5c | Relational→ Resource Efficiency | 0.228 | 2.880 | 0.004** | Accepted |
| H5e | Hierarchy→ Resource Efficiency | 0.095 | 1.316 | 0.189 | Rejected |
| H4b | PP_configuration→ Competitive Advantage | 0.160 | 1.851 | 0.065 | Rejected |
| H4d | SC_configuration→ Competitive Advantage | 0.086 | 0.600 | 0.549 | Rejected |
| H5b | Transactional→ Competitive Advantage | 0.073 | 0.951 | 0.342 | Rejected |
| H5d | Relational→ Competitive Advantage | 0.294 | 4.451 | 0.000*** | Accepted |
| H5f | Hierarchy→ Competitive Advantage | 0.266 | 3.997 | 0.000*** | Accepted |
| H6 | Resource Efficiency→ Competitive Advantage | 0.112 | 1.246 | 0.213 | Rejected |

* $p < 0.05$ ($t = 1.96$). The hypothesis is confirmed with a significance of 95%.

** $p < 0.01$ ($t = 2.58$). The hypothesis is confirmed with a significance of 99%.

*** $p < 0.001$ ($t = 3.31$). The hypothesis is confirmed with a significance of 99.9%.

### Natural Resource Dependence level and Supply Chain NRS Strategies

*H1a: The importance of the scarce natural resource positively affects the adoption of product and processes (re-) configuration.*

*H1b: The importance of the scarce natural resource positively affects the adoption of supply chain (re-) configuration.*

*H1c: The importance of the scarce natural resource positively affects the adoption of transactional mechanisms.*

*H1d: The importance of the scarce natural resource positively affects the adoption of relational mechanisms.*

*H1e: The importance of the scarce natural resource positively affects the adoption of hierarchy mechanisms.*

Hypotheses H1a and H1b are not supported as the coefficient are not significant. Contrary to the expectations based on RDT and the empirical data, the higher the importance of the scarce natural resource the more companies will implement buffering strategies (i.e. product and processes (re-) configuration and supply chain (re-) configuration). Of interest here, is that in spite of not being significant the path coefficient also has a negative sign. This contradictory result needs further investigation. One explanation for this non-finding could be that the measurement items used for the sub-constructs criticality of the scarce natural resource and purchase importance of the scarce natural resource might not be sufficient, as indicated by the relatively low Cronbach's alpha for these constructs.

The relationship between the importance of the scarce natural resource and the bridging strategies was also mixed. The relationship between high importance and transactional mechanisms ($\beta = 0.197$, $p < .05$) and the relationship between high importance and relational mechanisms ($\beta = 0.219$, $p < .001$) is significant, whereas the relationship between high importance and hierarchy mechanisms is not significant. Therefore, H1c, H1d is supported but H1e is not. This is in line with the empirical data from the case studies.

RDT and previous studies (e.g. Meznar and Nigh, 1995) support that resource importance is the key driver of buffering strategies. However, both qualitative and quantitative stages show the bridging strategies utilisation as well. According to Caniëls and Gelderman (2007), key suppliers represent significant value to one organisation in terms of a high impact on profit and a high risk of supply. However, with natural resources such as water and energy it is not easy to be substituted and companies can access these important natural resources mainly through transactional and/or relational mechanisms. The size of the companies may also influence the result. According to Pfeffer and Salancik (1978) larger firms can resist to environmental pressures whereas smaller firms will adapt their behaviour. Smaller firms may be more inclined to develop formal types of collaborative activities to gain better access to critical resources (Guo and Acar, 2005). Large firms have sufficient resources with which they can *"alter their contexts in a significant fashion"* (Pfeffer and Salancik, 1978, pp. 267). Thus it is supported that large firms controlling important resources engage in more buffering activities (Meznar and Nigh, 1995). Consistent with the literature (Fennell and Alexander, 1987; Meznar and Nigh, 1995), buffering and bridging strategies are not mutually exclusive.

*H2a: Supplier substitutability positively affects the adoption of product and processes (re-) configuration.*

*H2b: Supplier substitutability of scarce natural resource positively affects the adoption of supply chain (re-) configuration.*

*H2c: Supplier substitutability of scarce natural resource positively affects the adoption of transactional mechanisms.*

*H2d: Supplier substitutability of scarce natural resource positively affects the adoption of relational mechanisms.*

*H2e: Supplier substitutability of scarce natural resource positively affects the adoption of hierarchy mechanism.*

With respect to the relationship between substitutability (low number of suppliers and switching costs) and supply chain NRS strategies, it is found that the relationship for both buffering (i.e.

product and processes (re-) configuration) - $\beta = 0.294$, $p < 0.01$- and bridging strategies is significant (i.e. relational mechanisms) - $\beta = 0.226$, $p < 0.01$-, while the effect of substitutability on supply chain (re-) configuration, transactional mechanisms and hierarchy mechanisms is not significant. Therefore, H2a and H2d are supported but H2b, H2c and H2e are rejected. The findings are partially in line with RDT theory and the perceptions of the interviewees in the multiple case studies. The theory supports that low substitutability leads mainly to bridging strategies which is also verified by the case studies (i.e. transactional mechanisms, relational mechanisms and hierarchy mechanism). However, the quantitative analysis supports just the use of relational mechanisms which matches with the results of other studies. Cannon et *al.* (2010) supports that when buyers are dependent on a few suppliers for essential resources then long-term collaborative relationships are preferred. Previous studies show there is a positive relationship between buyer dependence and the choice of bridging strategies (Bode et *al.*, 2011; Su et *al.*, 2014; Wu et *al.*, 2004). The findings of the survey support that there is a positive relationship between substitutability and product and process reconfiguration. This is a very interesting finding. Companies collaborate with a few carefully selected key suppliers (Daft, 2006). Demeter et *al.* (2006) supported that suppliers are involved and enable the product development at an earlier stage. These suppliers comply with buyers' requirements and are not capacity focused nor product focused as they adapt themselves to the buyers' expectations (Demeter et *al.*, 2006).

*H3a: Discretion over the scarce natural resource positively affects the adoption of product and processes (re-) configuration.*

*H3b: Discretion over the scarce natural resource positively affects the adoption of supply chain (re)configuration.*

*H3c: Discretion over the scarce natural resource positively affects the adoption of transactional mechanisms.*

*H3d: Discretion over the scarce natural resource positively affects the adoption of relational mechanisms.*

*H3e: Discretion over the scarce natural resource positively affects the adoption of hierarchy mechanisms.*

Next, the relationship between discretion and the buffering and bridging strategies is investigated. The relationship between low discretion and buffering strategies is significant (product and processes (re-) configuration-$\beta = 0.248$, $p < .01$- and supply chain (re)configuration ($\beta = .248$, $p < .01$). The relationship between low discretion and bridging strategies is partially supported. Low discretion has a positive relationship with transactional and hierarchy mechanisms whereas has no impact on relational mechanisms. Therefore, H3a, H3b, H3c and H3e are supported but not H3d.

This is almost in line with the case studies. In the case studies interviewees supported that low discretion also leads companies to relational mechanisms. Van Leeuwen (2007) found that companies use relational mechanisms or vertical integration by acquiring firms that own the recovered resources they need, or firms that control the access to recovered resources. The results of the quantitative part may be attributed to the scarce natural resources of the surveyed companies; specifically, 32% and 27% of the respondents have identified water and energy, as was previously stated, as scarce natural resources. Companies tend to have a contract with the suppliers of water and energy (which in many cases is the government of each country) which specifies the transactions: the price, quantity, quality, and duration. This transactional mechanism increases partners' interdependence on each other (Bellouma, 2011). Vertical integration is chosen when contracts cannot provide the necessary safeguards (Yu et *al.*, 2006).

REEs that are used mainly by the automotive and electronics industry (11% and 12% respectively) establish short term contracts with their suppliers as they do not purchase them directly for their production. For example, catalyst manufacturers have long term contracts with the REE suppliers and then they provide the catalyst to the car manufacturers. Ford Motor company identified the REEs used in its cars after 18 months as they do not purchase them directly (Sheffi, 2015).

***Supply chain NRS strategies and Organisational performance***

> *H4a: The adoption of product and processes (re-) configuration positively affects resource efficiency.*
>
> *H4c: The adoption of supply chain (re-) configuration positively affects resource efficiency.*
>
> *H5a: The adoption of transactional mechanisms positively affects resource efficiency.*
>
> *H5c: The adoption of relational mechanisms positively affects resource efficiency.*
>
> *H5e: The adoption of hierarchy mechanisms positively affects resource efficiency.*

H4a, H4c, H5a, H5c and H5e state that product and processes (re-) configuration, supply chain (re-) configuration, transactional mechanisms, relational mechanisms and hierarchy mechanisms are positively related to resource efficiency respectively. The PLS model results for these relationships shows that the relationship between supply chain (re-) configuration and resource efficiency is strong and positive ($\beta = 0.284$, $p < 0.001$) and there is also a positive relationship between relational mechanisms and resource efficiency. Thus H4c and H5c are supported whereas H4a, H5a and H5e are not demonstrated as having a significant positive association with resource efficiency.

The specific result is in accordance with previous works that supported that collaborative buyer-supplier relationships create efficient resource utilisation (e.g. waste minimisation) (Lee et *al.*, 2000; Schliephake et *al.*, 2009). However, it was found in the qualitative study that product and process reconfiguration and hierarchy mechanisms can also lead to resource efficiency. Vertical integration is also found that can help companies to minimise costs and improve resource efficiency (Delmas and Pecovic, 2015).

*H4b: The adoption of product and processes (re-) configuration positively affects a distinct competitive advantage.*

*H4d: The adoption of supply chain (re-)configuration positively affects competitive advantage.*

*H5b: The adoption of transactional mechanisms positively affects competitive advantage.*

*H5d: The adoption of relational mechanisms positively affects competitive advantage.*

*H5f: The adoption of hierarchy mechanisms positively affects competitive advantage.*

The relationship of product and processes (re-)configuration, supply chain (re-) configuration with the competitive advantage are not significant. However, it was identified in the case studies that product and process reconfiguration and supply chain reconfiguration can lead to competitive advantage. Previous studies (e.g. Delmas and Pecovic, 2015; Bell et *al.*, 2013) found a positive relationship between the adoption of resource efficiency strategies (i.e. minimise energy and resource usage) and competitive advantages (e.g. lower energy prices). Concerning the second relationship, supply chain reconfiguration entails cost that may lead to a competitive disadvantage. The preferable location may attract other competitors in order to achieve their own objectives that means competitive disadvantage (Ghosh and Craig, 1983). This sample includes SMEs that are not able to invest a lot of money for eco design practices and relocate their plants.

The relationship between relational mechanisms and competitive advantage is found to be significant ($\beta$=0.294, $p < 0.001$). It empirically confirms that the close collaboration with suppliers leads manufacturing companies to competitive advantage which is in line with the theory and empirical results from the qualitative study. This is line with other studies that show that close buyer–supplier relationships (e.g. open communication, frequent exchanges of information) build a strategic competitive advantage (Chen et *al.*, 2004; Matopoulos et *al.*, 2007; Takeishi, 2001). Cheng (2009) argues that companies establish close relationships with their suppliers to enable them to have access to resources and reduce purchasing costs. The supported hypothesis gives empirical proof in the arguments of past studies concerning the closed-loop supply chain as a means to creating competitive advantage (Bell et *al.*, 2013). Similarly, the relationship between hierarchy mechanisms and competitive advantage was determined to be positive as predicted ($\beta = 0.266$, $p < 0.001$). Hence H5d and H5f are supported. Companies through vertical integration can control its input, differentiate and thus increase the entry barrier (Grant, 2010). There is a great deal of empirical evidence that shows that hierarchy mechanism can lead to a competitive advantage (Fabbe-Costes and Jahre, 2008; Ragatz et *al.*, 1997; Singh and Power, 2009; Wiengarten et *al.*, 2010)

*H6: Resource efficiency positively affects competitive advantage.*

Finally, the relationship between resource efficiency and competitive advantage was investigated. This hypothesis does not find support based on the account of a non-significant t value. Therefore, this hypothesis is not supported by the data. This hypothesis tried to give empirical proof in the arguments (i.e. Matopoulos et *al.*, 2015) concerning the link between resource efficiency and competitive advantage. Previous studies found that in some cases companies can gain competitive advantages through resource efficiency (Dalhammar et *al.*, 2014). Some of the cases (interviewees) connected resource efficiency with a competitive advantage. This may reflect low variation in our sample because most of the respondents were from the food and kindred products industry. Thus, the relationship could be more significant with a larger sample including more respondents from other industries such as the automotive industry.

## 7.6 Conclusion

The research instrument presented in Chapter 3 was tested in this chapter. Confirmatory factor analysis, reliability, and validity applied. Finally, hypothesis testing was performed through the Partial Least Squares (PLS) path modelling method based on a valid sample of

183 questionnaires. The results supported 12 out of 26 hypothesised paths. The hypothesis test has allowed us to test the influence of natural resource dependence level on the choice of supply chain NRS strategies. The results showed the following positive relationships: from the importance of the scarce natural resource to transactional and relational mechanisms; from supplier substitutability to product and process (re)configuration and relational mechanisms, from discretion over the scarce natural resource to product and process (re)configuration, supply chain (re) configuration, transactional mechanisms and hierarchy mechanisms. Moreover, we have also examined the relationship between supply chain NRS strategies and organisational performance. It is found and supported from other studies (e.g. Van Leeuwen, 2007) the use of relational mechanisms or vertical integration by acquiring firms that own the recovered resources they need, or firms that control the access to recovered resources. Another aspect that needs to be highlighted is that the respondents have identified water and energy as scarce natural resource in their companies, 32% and 27% respectively. Water and energy tends to be supplied based on contracts which specifies the transactions: the price, quantity, quality, and duration.

Resource efficiency was predominantly linked with the implementation of the following buffering and bridging strategies: product and process (re) configuration and relational mechanisms respectively. Similarly, relational and hierarchy mechanisms was predominantly linked to competitive advantage. All other direct paths examined were non-significant.

The next and final chapter summarises the key findings, details the theoretical and methodological contributions and suggests areas where future research may prove fruitful.

# Chapter 8 CONCLUSIONS AND CONTRIBUTIONS

## 8.1 Introduction

Chapter 8 summarises the interpretations made based on the findings presented in Chapters 5, 6 and 7. Next the link between the research questions identified in chapter 2 and in chapter 5 and chapter 6 will be discussed. The contributions, implications, limitations and future research opportunities are discussed.

## 8.2 Research Summary and Key Findings, Contributions and Future Research

In order to understand supply chain NRS strategies, both antecedents and consequences of them were investigated. A research overview and a summary of the key findings are provided in below subsections, related to the key associations between natural resource dependence levels, supply chain NRS strategies and organisational performance in the supply chain management field. The contributions and guidelines for future research have been outlined. The outcomes of this chapter are summarised in the table 8.1 below.

Table 8-1 Summary of the Key Findings, Contributions, and Future Research

| Summary level | Key issues |
|---|---|
| **Research title** | Supply chain NRS and their implications for organisational performance: an empirical study of manufacturing companies |
| **Research context** | Resource dependence theory |
| **Empirical context** | **Stage 1:** Case studies<br>31 interviews, 13 companies from different sectors (automotive, chemical, electrical/electronics, food and beverages, mining and metals, and plastics).<br><br>**Stage 2:** Survey<br>183 responses, sectors: food and beverages (23%), chemical (13%), electrical/electronics (12%), mining and metals (11%), automotive (11%) |
| **Research Methodology** | Mixed methods- Sequential exploratory research (case study and survey) |
| **Key Findings** | The findings support the central premise that importance of the scarce natural resource, supplier substitutability and discretion over the scarce natural resource dimensions are found to be key antecedents to buffering and bridging strategies which influences organisational performance as an outcome consequence. A novel framework associated with NRS is formulated. |

| | |
|---|---|
| **Key contributions** | **Theoretical Contributions:**<br>1. A conceptual framework for the implications of NRS scarcity on manufacturing companies is newly developed.<br>2. RDT applied to develop the framework.<br>3. NRS is empirically examined in detail, extending the theoretical link among contingency factors, supply chain NRS strategies and organisational performance.<br>4. A sequential exploratory strategy applied (mixed-method approach): qualitative and quantitative<br><br>**Policy and Managerial Implications:**<br>The research provides policy makers and managers with insights into how and why to specific supply chain NRS strategies based on the natural resource dependence level for better organisational performance. Different countries and industries may benefit from this study. |
| **Future Research Suggestions** | 1. Apply a longitudinal study or mapping tools, life cycle assessment and simulation modelling based on the current novel framework<br>2. Future studies can apply SEM technique by having larger sample thus providing more robust results.<br>3. Conduct comparative studies<br>4. Relationship between the content of the exchanged information and the risk of NRS<br>5. Examine response strategies more closely and their effect on organisational performance |

This research develops and empirically tests a framework that aims to understand the NRS implications for SCM. RDT was utilised to provide the theoretical underpinning of the conceptual framework associating in a meaningful and valid way the antecedents of NRS with specific strategies (buffering or bridging strategies). The thesis includes eight chapters. The research background and the key problem and gaps were addressed in Chapter 1 where it is argued that the risk of NRS although important in the field of SCM has only been explored by a limited number of studies (Alonso et *al.*, 2008; Alonso et *al.*, 2009; Alonso et *al.*, 2010; Alonso et *al.*, 2012; Autry et *al.*, 2012; Bell et *al.*, 2012, Bell et *al.*, 2013; de Winter, 2014). Several studies consider the risk of NRS, but lack sufficient awareness of the various antecedents, mitigation strategies and implications of NRS on organisational performance. Thus, there was a real need to improve our understanding of how NRS affects companies' supply chain strategies and the implications for organisational performance.

A review of the previous research was discussed in Chapter 2 in order to refine the research questions. The theoretical justification for using RDT as a foundation to develop the conceptual model and its propositions were also presented in this chapter. Drawing on RDT a conceptual model and a set of propositions are developed in Chapter 3, as well the operationalisation of the constructs is provided. In Chapter 4, the methodology was developed. Mixed methods were utilised in this study to achieve the research objectives and fill the research gaps by both qualitative and quantitative data.

The first stage provided the findings from the multiple case studies, which were used to refine the first generated framework. The results were also validated with the literature and with companies' documents. The replication logic among the cases was followed to achieve validity and to generalise the findings (analytical generalisation). The second stage was to examine and validate the final conceptual framework based on 183 survey responses. The PLS approach was conducted to test the research hypotheses. In Chapter 5, each case was discussed based on the initial conceptual framework whereas Chapter 6 entailed the key findings from the cross-cases analysis. In Chapter 7 the results from PLS analyses are presented.

### 8.2.1 Phase One-Multiply- case study

The research primarily follows the multiple-case strategy in order to collect and analyse data based on specific themes and the findings provided empirical examination of the proposed framework and a set of propositions. This step entails seeking evidence and replication across all the cases to examine the proposed associations. Table 8.2 shows that the suggested key propositions are mostly supported by the findings.

Table 8-2 Results of propositions of the multiply case study

| **Sub-propositions Verified by the interviewees** | **Verified by the interviewees** |
|---|---|
| P1a.a: The importance of the scarce natural resource has an impact on the adoption of product and processes (re-) configuration. | Supported |
| P1a.b: The importance of the scarce natural resource has an impact on the adoption of supply chain (re-) configuration. | Not supported |

| | |
|---|---|
| P1b.a: The importance of the scarce natural resource has an impact on the adoption of transactional mechanisms.<br>P1b.b: The importance of the scarce natural resource has a positive impact on the adoption of relational mechanisms. | Supported |
| P1b.c: The importance of the scarce natural resource has an impact on the adoption of hierarchy mechanism. | Not Supported |
| P1a.a: Supplier substitutability has an impact on the adoption of product and processes (re-) configuration.<br>P1a.b: Supplier substitutability has an impact on the adoption of supply chain (re-) configuration. | Not Supported |
| P2b.a: Supplier substitutability has an impact on the adoption of transactional mechanisms.<br>P2b.b: Supplier substitutability has an impact on the adoption of relational mechanisms.<br>P2b.c: Supplier substitutability of scarce natural resource has an impact on the adoption of hierarchy mechanism. | Supported |
| P3a.a: Discretion over the scarce natural resource has a negative impact on the adoption of product and processes (re-) configuration.<br>P3a.b: Discretion over the scarce natural resource has a negative impact on the adoption of supply chain configuration. | Supported |
| P3b.a: Discretion over the scarce natural resource has an impact on the adoption of transactional mechanisms. | Not Supported |
| P3b.b: Discretion over the scarce natural resource has an impact on the adoption of relational mechanism.<br>P3b.c: Discretion over the scarce natural resource has an impact on the adoption of hierarchy mechanism. | Supported |
| P4a.a: Product and processes (re-) configuration has an impact on resource efficiency.<br>P4a.b: Supply chain configuration has an impact on resource efficiency. | Supported |
| P5a.a: The adoption of transactional mechanisms has an impact on resource efficiency. | Not Supported |
| P5a.b: The adoption of relational mechanism has an impact on resource efficiency. | Supported |
| P5a.c: The adoption of hierarchy mechanism has an impact on resource efficiency. | Not Supported |
| P4b.a: Product and processes (re-) configuration will lead companies to obtain a distinct competitive advantage.<br>P4b.b: Supply chain configuration will lead companies to obtain a distinct competitive advantage. | Supported |

| | |
|---|---|
| P5a.a: The adoption of transactional mechanisms has an impact on competitive advantage. | Not Supported |
| P5a.b: The adoption of relational mechanism has an impact on competitive advantage.<br>P5a.c: The adoption of hierarchy mechanism has an impact on competitive advantage. | Supported |
| Proposition 6: Resource efficiency will lead companies to obtain a distinct competitive advantage. | Partially Supported |

It is found that all companies are reacting to pressure of the natural resource scarcity, but some companies are more proactive than others. Companies have some form of strategies in response to pressures such as high cost and the volatility of raw material prices and legislation. The qualitative results support that there are three main contingent factors namely the importance of the scarce natural resource (e.g. the price of the natural resources), the supplier substitutability of the scarce natural resource (e.g. number of suppliers) and the discretion over the scarce natural resource (e.g. legislation and geopolitical risk) leading companies to natural resource dependencies and thus to specific supply chain NRS strategies. Studies in the past (Bode et *al.*, 2011; Bell et *al.*, 2013) identified several strategies, but have either treated them in isolation or fell short in identifying when to employ each strategy. The present research extends the existing literature by empirically demonstrating that buffering and bridging strategies are not mutually exclusive and also how their implementation can be influenced by three main factors (i.e. the importance of the scarce natural resource, supplier substitutability and discretion over the scarce natural resource).

The qualitative findings show that the importance of a resource will mainly lead to buffering strategies (i.e. product and process reconfiguration such as recycling, substitution) and to some extent to bridging strategies. Recycling as a practice is also supported as the most favoured practice in the case of paper and plastics. RDT and other studies until now supported that the importance of resources was just related to buffering strategies (Meznar and Nigh, 1995).

When the number of suppliers is limited, manufacturing companies employ bridging strategies namely relational mechanisms and to some extent hierarchy mechanisms. Apart from the bridging strategies, a few companies have also utilised buffering strategies such as product and process reconfiguration, and supply chain reconfiguration. Close relationship with suppliers can help also companies to implement best and innovative practices. For example, the automotive company collaborates with the aluminium company and this strong relationship with the material supplier gives an opportunity to revert back waste to the supplier, and promises that they will get a steady raw materials supply. A focal firm is often unable to detect the root cause of disruptions e.g. the automotive companies regarding REEs so it is difficult for them to mitigate the effect of NRS, and resume business operations by reconfiguring supply chain resources alone. Thus, collaboration is required.

RDT and other studies until now supported that the importance of resources was just related to buffering strategies (Meznar and Nigh, 1995). Previous studies have also found that the importance of resource interdependence was positively associated with strategies such as joint ventures (e.g. Park and Mezias, 2005). When the number of suppliers is limited bridging strategies are employed namely transactional mechanisms, relational mechanisms and hierarchy mechanism. Bode et *al.* (2011) and Su et *al.* (2014) focused only on this contingent factor and confirm as well only the relationship between supplier substitutability and bridging strategies. When companies face difficulties in owning, accessing, or using scarce natural resources then both buffering and bridging strategies are adopted. Concerning organizational performance, this research supported that through the implementation of supply chain NRS strategies, resource efficiency was improved. Previous studies supported that these kinds of strategies can lead to resource efficiency through resource reductions and competitive advantage through closed-loop supply chain resources and new marketable products (Bell et *al.*, 2013; Delmas and Pekovic, 2013; Stafford and Hartman, 1998).

The results from the qualitative study shows that both strategies can improve organisational performance in terms of resource efficiency and to some extent help companies to gain a competitive advantage. For example, closed loop supply chain configuration can minimise the extraction of natural resources such as metals and oil that means but also the resource usage of other resources (Bell et *al.*, 2013). For instance, recycled aluminium uses 90% less energy. Reverse logistics network help companies to recycle materials, wastes, and reuse them thus improve their operational system eco-efficiency (Stock, 1998). However, it is supported that there is a need for concurrent product and process reconfiguration and supply chain reconfiguration in the close loop supply chains to achieve resource efficiency (Metta and Badurdeen, 2011; Tsoulfas and Pappis, 2006).

### 8.2.2 Phase Two-Survey

Data for this study were collected by means of a questionnaire and a sample of 183 managers working on manufacturing companies of different sizes operating in various industries. In our research there were no missing values and our measuring instrument contained three main constructs of this research: Natural Resource Dependence Level, Supply Chain NRS strategies and Organisational Performance. PLS technique applied to find the statistical relationship between each dependent and independent factor. Table 8.3 presents the outcome of the statistical results.

Table 8-3 Results of hypotheses of the survey stage

| **Developed Hypotheses** | **Outcomes of the hypothesis** |
|---|---|
| H1a: The importance of the scarce natural resource positively affects the adoption of product and processes (re-) configuration. | Rejected |
| H1b: The importance of the scarce natural resource positively affects the adoption of supply chain (re-) configuration. | |
| H1c: The importance of the scarce natural resource positively affects the adoption of transactional mechanisms.<br><br>H1d: The importance of the scarce natural resource positively affects the adoption of relational mechanisms. | Accepted |

| | |
|---|---|
| H1e: The importance of the scarce natural resource positively affects the adoption of hierarchy mechanisms. | Rejected |
| H2a: Supplier substitutability positively affects the adoption of product and processes (re-) configuration. | Accepted |
| H2b: Supplier substitutability of scarce natural resource positively affects the adoption of supply chain (re-) configuration. | Rejected |
| H2c: Supplier substitutability of scarce natural resource positively affects the adoption of transactional mechanisms. | Rejected |
| H2d: Supplier substitutability of scarce natural resource positively affects the adoption of relational mechanisms. | Accepted |
| H2e: Supplier substitutability of scarce natural resource positively affects the adoption of hierarchy mechanism. | Rejected |
| H3a: Discretion over the scarce natural resource positively affects the adoption of product and processes (re-) configuration. | Accepted |
| H3b: Discretion over the scarce natural resource positively affects the adoption of supply chain (re-) configuration. | |
| H3c: Discretion over the scarce natural resource positively affects the adoption of transactional mechanisms. | Accepted |
| H3d: Discretion over the scarce natural resource positively affects the adoption of relational mechanisms | Rejected |
| H3e: Discretion over the scarce natural resource positively affects the adoption of hierarchy mechanisms. | Accepted |
| H4a: The adoption of product and processes (re-) configuration positively affects resource efficiency. | Rejected |
| H4c: The adoption of supply chain (re-) configuration positively affects resource efficiency. | Accepted |
| H5a: The adoption of transactional mechanisms negatively affects resource efficiency. | Rejected |
| H5c: The adoption of relational mechanisms positively affects resource efficiency. | Accepted |
| H5e: The adoption of hierarchy mechanisms negatively affects resource efficiency. | Rejected |
| H4b: The adoption of product and processes (re-) configuration positively affects a distinct competitive advantage.<br>H4d: The adoption of supply chain (re-)configuration positively affects competitive advantage. | Rejected |
| H5b: The adoption of transactional mechanisms positively affects competitive advantage. | Rejected |
| H5d: The adoption of relational mechanisms positively affects competitive advantage.<br>H5f: The adoption of hierarchy mechanisms positively affects competitive advantage. | Accepted |
| H6: Resource efficiency positively affects competitive advantage. | Rejected |

The quantitative results as well support that there are three main contingent factors namely the importance of the scarce natural resource (e.g. the price of the natural resources), the supplier substitutability of the scarce natural resource (e.g. number of suppliers) and the discretion over the scarce natural resource (e.g. legislation and geopolitical risk) leading companies to natural resource dependencies and thus to specific supply chain NRS strategies.

Interestingly, the data supported that in the case of important scarce natural resources, companies follow bridging strategies (H1c and H1d) such as transactional mechanisms and relational mechanisms, but not vertical integration (H1e). This shows that buffering strategies alone are not an effective approach as they do not remove the basic vulnerability of the source (Pfeffer and Salancik, 2003). Thus, to overcome the primary resource issue, companies bridge towards other organisations.

An unexpected finding was made in the quantitative stage. Despite that RDT and the qualitative findings support the positive relationship of the importance of resource and buffering strategies, the path coefficient was not strong thus no relationship was found (H1a and H1b). This may be due to the relatively low Cronbach's alpha for the sub-constructs criticality of the scarce natural resource and purchase importance of the scarce natural resource (Cronbach alpha=0.547). Adequate reliability coefficients are 0.70 or higher (Cronbach, 1951; Nunnally, 1978). Past studies e.g. Chen et *al.* (2004) could not support specific hypothesis (limited number of suppliers and customer responsiveness) due to low Cronbach. On the contrary, the importance of the scarce natural resource was only found to be positively related with the transactional and relational mechanisms as the qualitative study supported (H1c and H1d). Previous studies have also found that the importance of resource interdependence was positively associated with strategies such as joint ventures (e.g. Park and Mezias, 2005).

When the number of suppliers is limited bridging strategies namely transactional mechanisms, relational mechanisms and hierarchy mechanism (H2c, H2d and H2e). Bode et *al.* (2011) and Su et *al.* (2014) focused only on this contingent factor and confirm as well only the relationship between supplier substitutability and bridging strategies. This is in line with the qualitative study and RDT that support when companies do not have many suppliers or the switching costs are high, bridging strategies are preferred.

Contrary to what has been suggested by the qualitative findings and RDT, this survey revealed also a positive relationship between substitutability of suppliers and product and process reconfiguration (buffering strategies) (H2a). This very interesting finding implies that companies collaborate with a few key suppliers that are involved in the product development at an earlier stage. This is also supported by other studies (e.g. Demeter et *al.*, 2006). In the phase two it is found a positive relationship of supplier substitutability (i.e. high switching costs and low number of suppliers) with the relational mechanisms. When companies face difficulties in owning, accessing, or using scarce natural resources then both buffering (i.e. product and process reconfiguration and supply chain reconfiguration) and buffering strategies (i.e. hierarchy mechanisms) are adopted. Thus, companies, as a precaution, make collaborations with its suppliers to get an easy access to the sources anytime they need. (Hessels, and Terjesen, 2010; Yilmaz, 2014).

The results support hypothesis H3d but not hypothesis H3c, thus when manufacturing companies have issue with the discretion over the scarce natural resources transactional mechanisms are preferred as a bridging strategy. Liu et *al.* (2010) supported that transactional mechanisms are more effective than relational mechanisms. Transaction specific investments are more efficient in governing repeated exchange (Williamson, 1983). This result may be influenced by participants that identified water (27%) and energy (37%) as scarce natural resources and also the majority of the companies where from the food and beverage and chemical industries that are using mostly these kind of resources. Specifically, water and energy resources are mainly provided to companies through contracts that specify the terms and conditions. The suppliers of water and energy are non-substitutable as they have monopoly control over those natural resources needed by the manufacturing companies. Thus, buyer dependency is high and supplier dependence is low, thus opportunistic behaviour can exist. However, transaction investments create interdependences and serve as incentives to act non-opportunistically as the cost to terminate the relationship is increased for both buyer and suppliers (Murray and Kotabe 2005; Elbert et *al.*, 2011). Transactional mechanisms are also adopted by the automotive and electronics companies for REEs as they do not purchase them directly.

The results from the quantitative stage shows that buffering (e.g. product and processes (re-) configuration) and bridging strategies (e.g. hierarchy mechanism) can improve organisational performance in terms of resource efficiency and to some extent help companies to gain a competitive advantage. Specifically, there is a relationship between supply chain (re-) configuration and resource efficiency. Resource efficiency can also be achieved through relational mechanisms but there is no relationship between the adoption of product and processes (re-) configuration and competitive advantage (H4b). Concerning the H4d, there is no relationship also between supply chain (re-) configuration and competitive disadvantage. However, this study shows that relational mechanisms and vertical integration lead to a competitive advantage which is in line with the literature (Li et al., 2006; Moberg et al., 2002) regarding the the relationships between SCM practices and competitive advantage. This sample includes many SMEs that are not able to invest money thus redesign their products. For example, Veshagh and Li (2006) found also that the main barriers that SMEs face to implement eco-design practices is the lack of financial incentives and no justification for investment.

The relationship between resource efficiency and competitive advantage was not strongly supported. Previous studies also supported that strategies can lead to resource efficiency through resource reductions and competitive advantage through closed-loop supply chain resources and new marketable products (Bell et *al.*, 2013; Delmas and Pekovic, 2013; Stafford et *al.*, 1998).

## 8.3 Theoretical Contributions and Policy and Managerial Implications

### 8.3.1 Theoretical Contributions

The study contributes to existing research in multiple ways. Firstly, it employs an RDT lens with the aim of gaining an in-depth understanding of natural resource dependencies and associated supply chain strategies in the manufacturing sector. The lack of theoretical development in logistics research has been highlighted numerous times (Kovács and Spens, 2005; Mollenkopf et *al.*, 2010) and identified as a key gap also in this study. There is a call for supply chain management academics to use current resource theories (Esper and Crook, 2014) to develop propositions related to NRS (Bell et *al.,* 2012).

Uncertainty that arises from NRS has not been studied to a great extent. Bell et *al.* (2013) proposed a model based on the Resource Advantage theory that explores how closed loop supply chains enable competitive advantage. Despite the fact that RDT is a leading theory for understanding organisation-environmental relationships, it is not explored and tested in ways that consider NRS (Stock, 2006; Drees and Heugens, 2013). This study has contributed to this lacuna by providing empirical data in the context of dependent firms on scarce natural resources. A cross-industry analysis was done on different sectors (automotive, chemical, electrical/electronics, food and beverages, mining and metals, and plastics).

Research in the field of SCM has focused on green strategies and sustainability (e.g. Pagell and Shevchenko, 2014), but does not touch upon issues related to NRS or to the dependence of companies on specific natural resources. More specifically, there are studies that focus on sustainable strategies, motivations, constraints and outcomes (e.g. Côté et *al.*, 2006; Finnveden et *al,* 2005; Vernon et *al.*, 2003; Yu et *al.*, 2009). This study responds to the researchers who suggested the need to examine NRS in the field of supply chain management in detail (Bell et *al.*, 2012; Matopoulos et *al.*, 2015). To the best of the Author's knowledge this is the first study that also applies a theoretical perspective in this context. It is argued that this perspective is useful as resource scarcity results in power relations between the company and its external environment.

Previous studies do not also implement a grounded theoretical conceptual framework except Bell et *al.* (2013). Drawing upon RDT, this study developed a conceptual framework in order to address the implications of NRS on supply chain NRS strategies and on performance. This research draws attention to the strategies available for managing the issue of NRS, establishing possible credible links between natural resource dependence levels, supply chain strategies and organisational performance. Studies in the past (Bode et *al.*, 2011; Bell et *al.*, 2013) identified several strategies, but have either treated them in isolation or they fell short in identifying when to employ each strategy.

The present research extends the existing literature by empirically demonstrating that buffering and bridging strategies are not mutually exclusive and also how their implementation can be influenced by three main factors (i.e. the importance of the scarce natural resource, supplier substitutability and discretion over the scarce natural resource). This research followed the concurrent engineering approach proposed by Fine (1998) regarding the buffering strategies. Thus, buffering strategies entail product and process configuration and supply configuration as the main practices. None of the three papers take into consideration the contingent factors that can change the natural resource dependence level and thus the adoption of the proper supply chain strategy. Future studies in the supply chain field must include contingent factors that shape supply chain strategies (Esper and Crook, 2014). Dependence on scarce natural resources has a number of causes and may take a number of forms.

The thesis contributes to the existing body of knowledge by taking a novel perspective on the relationships among and between different operational performance dimensions namely resource efficiency and competitive advantage. Other studies till now support the ability of green SCM practices to impact organisational performance (Sarkis and Talluri 2004; Srivastava, 2007). Matopoulos et *al.* (2015) highlighted a need for further research on understanding the link between NRS, resource efficiency and competitive advantage in the SCM field. Concerning organisational performance, this research supported that through the implementation of supply chain NRS strategies (e.g. recycling), resource efficiency was improved (e.g. cost reduction, waste minimisation) and collaboration was leveraged to some extent as companies gained access to resources that are even more difficult to be accessed by other competitors. Despite that most of the framework constructs are not new, this is the first study to synthesise them especially in the risk of NRS. Another contribution of this study is the development of new constructs through a rigorous two-stage process. These scales will be useful for future studies on the topic of NRS.

Thirdly, this research is one of the first empirical studies addressing NRS and the impact on manufacturing supply chains. The research context is upstream product-based suppliers and manufacturers. Manufacturing firms are more likely to be affected by materials uncertainty than service firms (Brouthers et *al.*, 2002). Although there are some papers in the field of supply chain management that have considered the issue of scarcity, their research is not empirically tested. Bell et *al.* (2012) highlighted the need for industry case studies to recognise and implement creative supply chain strategies to alter natural resource availabilities. The manufacturing sector is a resource intensive sector (e.g. resources account for 40% of the manufacturer's cost), but one that has not received attention on how resources might affect their profitability and the operational challenges for risk management (EEF, 2014).

This research contributed in addressing this gap. The empirical evidence collected in different manufacturing sub-sectors (e.g. automotive, chemical) indicates that the conceptual framework can be applied to other sectors as well. The multiple-case study method has been adopted in order to discover contingent issues and supply chain strategies, and their influence on organisational performance that are specific to each case (Yin, 2003). A sequential exploratory strategy (mixed-method approach) was employed in this research. The research provides support for the literature that proposes applying this research design when investigating a new phenomenon (e.g. Creswell, 2009). Previous studies ended up providing a vague understanding of NRS as they did not explore it empirically.

Qualitative (inductive) interviews and quantitative (deductive) questionnaires were employed in this research to collect the primary data, enhancing the research validity. In the first stage, the multiple case study was conducted from different sectors (automotive, chemical, electrical/electronics, food and beverages, mining and metals, and plastics). The interviews analysed through content analysis to understand and revise the conceptual framework. The use of NVivo 9 software can increase the robustness of the research (James, 2009; Jones, 2007). Based on the final conceptual framework, quantitative data were collected and analysed through the PLS technique. 183 questionnaires were received from the sectors of food and beverages (23%), chemical (13%), electrical/electronics (12%), mining and metals (11%), automotive (11%). The respondents in both stages where mainly purchasing managers, supply chain managers, sustainability managers and logistics managers. By applying mixed methods in data collection, there is a contribution regarding the enrichment of the research methods in logistics and supply chain management which is a field where positivism dominates.

### 8.3.2 Managerial and Policy Implications

Regarding the managerial implications, this study provides a useful framework, which could help determining the appropriate supply chain strategies for overcoming the issue of NRS. Managers can understand the advantages and disadvantages of those strategies in order to incorporate them into the strategic planning, and also to identify the specific conditions that influence the selection regarding the appropriateness of these strategies. It provides an insight into other companies' strategies, contingent factors and benefits.

Managers can learn good practices, overcome difficulties based on other companies' experiences and eventually build better strategies themselves to handle the issue of NRS. Managers should gather information and collaborate closely with suppliers in order to find where scarce natural resources appear in their products and operations. Based on this analysis, they can adopt buffering strategies (e.g. increase the rates of recycling or investing in substitutions or different processes) and/or bridging strategies (e.g. long term contracts with the suppliers to secure the scarce natural resource). Partnerships with key suppliers is a key strategy for companies (buyers) as partnership can empower suppliers and induce cost, sharing visions includes a similar understanding about the importance of improvements and changes in order to minimise the risk of natural resource scarcity. This study shows also that suppliers play a more proactive role and without this the supply chain cannot function smoothly.

Regarding policy implications, there are laws and regulations in the USA and the EU (e.g. EU's Raw Materials Initiative, National Strategic and Critical Minerals Production Act of 2013, H.R. 761) that are setting standards on how to deal with the scarcity mainly of the following resources: minerals, rare earth elements, construction materials and wood. For example, EU is largely dependent on imports from other countries; however, there are variations by country and resource (Damen, 2012). Recently the Members of the European Parliament stressed the importance of resource efficiency by setting a target of increasing it by 30% by 2030 (e.g. 70% waste reduction) that leads to costs savings of about €600 billion (European Parliament, 2015).

Policy makers are worried about the impact of resource scarcity on their country's growth, but also the ability of manufacturing companies to compete in global markets. However, these initiatives are lacking in concrete actions and guidelines. It appears that legislation sets different targets for different natural resources. For example, the end-of-life vehicle directive led automotive companies to recycling of materials in end-of-life vehicles, however there is no legislation that incentivises companies to recycle water. Some legislation prevents companies from applying other legislation. For instance, the Waste Electrical and Electronic Equipment Directive (WEEE) is contradictory to the Restriction of the Use of Certain Hazardous Substances directive (RoHS) as the latter restricts manufacturing companies from effectively recycling electronic products. Also, the WEEE does not give incentives to manufacturing companies to design product for easy reuse or recycling. There is no concrete directive that substantially influences product design to make recovery or remanufacturing easier.

Another issue is the European Emission Trading Scheme that resulted in aluminium companies having to relocate their plants. This research provides a unique framework with more consistent strategies that can assist policy makers in assessing scarcity issues thus informing their decisions. Policy makers could use the empirical findings of the study for better understanding and managing the challenges of a resource constrained world. They must be more aware of the available supply chain NRS strategies and its antecedents in order to provide concrete targets and indicators to manufacturing companies for improving the efficiency of resource usage. For example, recycling can enable a more resource efficient economy giving countries or continents such as Europe a competitive advantage and minimise its dependency on foreign sources. Recycling opportunities are not used to their full potential. The United Nations Environment Program (2011c) study found that less than 1% of REEs are recycled. Low recycling rates means a missed economic opportunity, for example non-recycling of copper means annually $52 billion are lost (Ellen MacArthur Foundation, 2011). Scarcity issues must be integrated into policies and policy makers have to monitor how this is progressing.

## 8.4 Limitations of the Research and Opportunities for Future Research

Even though this exploratory study makes academic and practical contributions, there is a rich opportunity for future research. NRS research is at a very initial stage and this is only an exploratory research thus there are many opportunities for conducting further research in this field. The study is cross sectional which means the results are based on a specific point in time and data collection at another period could result in different findings (e.g. during the summer of 2015 the USA faces California's water crisis). Mapping tools, life cycle assessment and simulation modelling can be used to enable efficient use of scarce natural resources and how to design products, processes and the supply chain configuration. Future studies can focus on specific industries (e.g. automotive supply chain i.e. mapping all tiers of the supply chain) and conduct risk assessment of critical natural resources (i.e. water, energy, metals, REEs). By using these tools, the researcher can:

- Identify which of the operations may be exposed to NRS risk and understand the degree of dependency on these resources (sub-tier suppliers).
- Examine how different strategies perform in order to avoid disruptions and enhance resource efficiency: substitution (use of new materials and processes), reduction of resource usage, recycling (e.g. collection systems).
- Capture resource status changes (i.e. market price of the resource).

Semi-structured interviews were used to collect the data in the phase one in order to collect rich information. But it has a disadvantage known as the problem of anecdotalism which is explained in Bryman (2001) and Silverman (2004). This happens when the researcher tends to draw findings from clear or apparent phenomenon and less attention is given to less clear (or even contradictory) data.

This research has investigated supply chain NRS strategies at 13 companies without selecting the attributes of the companies other than choosing manufacturing companies which practice any related strategies. As found in this study there are various resource scarcity issues, that are mainly understood through factors such as the price of the resource or low accessibility to the use of the resource , experienced by manufacturers, influenced by factors such as company's size, scarce natural resources used, legislation, and type of products. Future research can investigate the issues that are faced by smaller companies versus type bigger companies. Moreover, a future study can focus on a specific sector in order to identify the similarities and differences between competitors in a specific industry e.g. automotive industry. It was not done in this research due to time limitation and would probably need more case studies in order to include for example more SMEs. Concerning company size, companies which participated in this study were mixed, a few are small size companies and some of them are large international companies. After the above studies, supply chain management research should go deeper to include first tier suppliers and even to second-tier suppliers. This may bring more values to supply chain research. It was found through the case studies automotive companies and the brewing company develop their products through active collaboration among the company's design, engineering, production and other divisions with major automotive Tier 1 Suppliers. Future studies can evaluate how interactions between supply chain partners and certain bridging strategies such as relational mechanisms can influence NRS conflicts, thus to explore whether and how collaboration affect NRS issues in product design and its effect on organisational performance. The lack of visibility to natural resources such as REEs can be also minimised through supplier participation in this research. Chunxing et al. (2013) support that companies should focus on obtaining visibility to lower tier suppliers, especially if critical components are involved. By involving other tiers certain NRS issues can be understood in more depth.

While the response rate was adequate, the sample size was low (183 responses) which put constraints on the statistical analysis. Past studies show that the response rate in operations management range from 10-15% (Griffs et *al.*, 2003) or 10-20% (Flynn et *al.*, 1990; Malhotra and Grover, 1998). Klassen and Jacobs (2001) supported that the response rate in the field of in operations and supply chain management is low ranging from 5-10%. This can be explained by the nature of the sample that mainly consists of senior level managers, who are considered to be difficult to approach (Inman et *al.*, 2011). PLS is flexible concerning sample size (Chin, 1998) but in order to test a model using SEM a sample size of 200 at least is required (Hair et *al.*, 2014) for valid results. Some constructs also experienced problematic issues related to measurement such as the importance of the scarce natural resource. Thus, future quantitative studies are needed to further validate the proposed framework. In this study the PLS tool was used, future studies can apply the Structural Equation Modelling (SEM) technique by having a larger sample thus providing more robust results. With regard to the structural model presented here, it would be worthwhile to analyse potential moderating effects such as type of industry and number of years of operation of the company could be taken into account to determine whether they influence the implications of supply chain NRS strategies on organisational performance.

Another issue with the current study is that the unit of analysis is the focal firm rather than a specific supply chain. The unit of analysis enabled the study to focus on organisation patterns whereas further studies can collect data from different members from a specific supply chain (e.g. automotive industry) thus more informative results might be obtained. In addition, this study in the qualitative part did not look at a particular firm's competitive advantage of using scarce natural resources such as water leaving out of scope competition between companies (competitors). Thus, the data collection in the multiple case studies did not include these organisations (i.e. competitors in the same industry) or questions that try to identify the specific issues in an industry and it can be addressed in a future comparative study for a specific industry. As was shown through the qualitative studies and quantitative analysis several relationships were not verified. For example, the relationship between the importance of the scarce natural resources and buffering strategies were not supported in the quantitative study which were contrary to the qualitative findings, theory and the researcher's expectations. Thus, maybe a better construct definition and measurement items could have been developed for the importance of the scarce natural resource that may change the above findings. It was found in Chapter 7 that this construct has measurement issues, the items used for tapping this construct might not be sufficient (i.e. Cronbach's alpha was low). In order to conduct international and comparative studies, additional data collection can be implemented from more respondents in different industries (i.e. companies that will identify REEs and metals as scarce natural resources). Concerning company size, companies which participated in this research were mixed, but mainly large international companies. Future research can therefore conduct group case studies into sets of large companies versus sets of smaller companies.

The patterns of findings can offer deeper insights into new knowledge as these variables may yield different results. Future research needs to examine response strategies more closely and their effect on organisational performance. For example, relational mechanisms may lead to increasing a buyer's dependence on the supplier, but others such as hierarchy mechanism might not. In this research, the information that is transferred in the buyer–supplier relationship was not addressed. Future research could determine the relationship between the content of the exchanged information and the risk of NRS.

## 8.5 Final Remarks

This study is novel as it develops and empirical test a theoretical framework that tries to understand the NRS implications. Specifically, RDT was utilised to develop a conceptual framework that provides reliable and valid antecedents associated with specific strategies (buffering or bridging strategies). The first objective was to identify the various factors that determine the natural resource dependence level. There are three main contingent factors namely the importance of the scarce natural resource (e.g. the price of the natural resources), the supplier substitutability of the scarce natural resource (e.g. number of suppliers) and the discretion over the scarce natural resource (e.g. legislation and geopolitical risk) leading companies to natural resource dependencies thus to specific supply chain NRS strategies. The findings are in line with the RDT showing that the importance of a resource will mainly lead to buffering strategies such as product and process redesign (i.e. recycling, substitution). When there will not be a high number of suppliers bridging strategies such as transactional mechanisms, relational mechanisms will be employed. Concerning the third dimension, when companies face a difficulty to own, access, use scarce natural resources then they will follow either buffering strategies such as safety stock, relocation or/and bridging strategies such as vertical integration. This in line with the RDT that supports that buffering and bridging strategies are not mutually exclusive strategies. By applying these strategies, organisational performance can be improved such as minimising water and energy use, and gaining competitive advantage.

Supply chain NRS strategies is of utmost importance to ensure that the scarce natural resources, is available for the manufacturing industry to continue operating now and in the future. Manufacturers need to change their way of doing business, the way their products are designed and how they manufacture their products. From the study, it can be seen that manufacturing companies are aware of the issue of natural resource scarcity and they try to use their scarce resources more efficiently, mostly due to factors such as cost and legislation.

In terms of manufacturing strategy, manufacturers should concentrate on employing tactics and using technology to promote efficient use of materials to increase manufacturing and machine efficiency. Although there are challenges in changing manufacturing process, but we can see for example energy efficient materials and resources are quickly becoming as important as manufacturing efficiency in the future.

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# APPENDICES

Appendix 1: Key Previous Research Related to RDT in supply chain management.

| Sources | Research Objective | Research Stance | Description of how theoretical perspectives used to support SCM | Description for future research |
|---|---|---|---|---|
| Bode et *al.* (2011) | Identify the different strategic responses to supply chain disruptions and test a model that explains the reasons for different responses | Build and test an empirical model | Bridging or buffering responses | Replication across other industries<br><br>Did not study motivations to act to disruptions<br><br>Longitudinal data |
| Cai and Yang (2008) | Identify antecedents of the decision to develop cooperative norms | Build and test an empirical model | Supply importance and alternatives are the two major indicators of resource dependence. | Explore cooperative norms from both sides between buyers and suppliers to confirm the findings of this study |
| Carr et *al.* (2008) | To analyse the supplier dependence on supplier participation in buyer supported training and supplier involvement | Empirically tested model | Suppliers that are dependent upon the buyer for a high level of its sales volume are more committed to the buyer-supplier relationship. | Try to generalise the findings why some firms do not participate in supplier training<br><br>How buyers can affect suppliers who are not dependent on them? |
| Carters and Rogers (2008) | Move the concept of sustainability towards new theory in supply chain management. | Build a model and propositions | Resource dependence and vertical coordination under conditions of uncertainty | Empirically test the model<br><br>Develop scales for the instruments |
| Chu and Wang (2012) | Identify the drivers of relationship quality and its implications for performance in logistics outsourcing | Develop model and empirically tested | RDT supports that higher level of dependence leads to higher relationship quality | Investigate relationship quality from a 3PL perspective<br><br>Investigate other antecedents |

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| Crook and Combs (2007) | Determine if resource qualities give some firms bargaining power. | Develop theoretical propositions | Companies that offer critical resources have greater power than weaker members who lack such resources. | Empirically testing the propositions<br>Explore the link between value creation and bargaining power<br><br>Determine the available gains from SCM and task interdependence |
| Davis-Sramek et *al.* (2010) | Examines the moderating effect of environmental unpredictability on the relationships of two supply chain information technologies (IT) on operational and financial performance | Develop model and empirically tested | Environmental unpredictability as moderator | Gestalts would allow for the simultaneous consideration of many variables |
| Denktas-Sakar and Karatas-Cetin (2012) | Explore the power balances in ports | Theoretical | Inter-organisational relationships between ports and stakeholders are the most relevant strategic resources | Empirical studies<br><br>Single port authority level or multiple ports<br><br>Understanding the interdependencies between port authority and supply chain stakeholders |
| Ellis et *al.* (2010) | Investigate the causal relationships amongst situation, representations of risk, and decision-making within the purchasing domain | Develop model and empirically tested | Two factors are important in determining dependence: (1) the importance of the resource and (2) the concentration of resource control. (technological uncertainty, market thinness, item customization, and item importance ) | Investigate other factors related to supply network complexity, such as geopolitical, natural that may also contribute to supply disruption risk<br><br>Examination of risk mitigation strategies |

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|---|---|---|---|---|
| Handfield (1993) | How and why purchasing is moving towards JIT by facing demand uncertainty | Develop model and empirically tested | RDT used to explain the relationship between Just –In-Time purchasing systems and the transaction uncertainty | Does the industry structure effect on certain purchasing relationships?<br><br>Use of other organisational paradigms for theory-building<br><br>Include the environmental uncertainty |
| He et *al.* (2013) | Examine how power among actors influences knowledge acquisition | Develop framework and hypothesis which empirically tested | The dependence in a firm will decrease, if the other firm has access to alternative sources. | How power influences knowledge acquisition at top management versus plant/operations?<br><br>Which level of knowledge acquisition drive performance improvement ? |
| Handfield et *al.* (2002) | How purchasing managers create relationships with suppliers to achieve a desired outcome? | Develop model and empirically tested | The level of trust between buyers and suppliers can be mitigated by imbalances in market power. | What is the role of contracts in managing buyer–seller relationships?<br><br>Is any difference reaction of buyers and sellers to different supply chain events? |
| Hofer et *al.* (2012) | Explore the performance of suppliers when engaged in supply chain relationships with key retail account (KRA) customers. | Provide hypothesis and empirical study | In this study a collaborative perspective of resource dependency used, where a supplier and its KRAs are partners. | How and why such dependencies influence KRAs?<br><br>Does firms attempts to engage all its partners ? |
| Ireland and Webb (2007) | Develop a framework for managing trust and power in strategic supply chains | Develop a framework and theoretical propositions | Resource dependence theory provides the lenses of power formation and management of inter-organisational relations | Why firms enter into inter-organisational relationships and how initial levels of trust and power are formed?<br><br>The level of power, kinds of power, and inter-organisational circumstances that lead to conflicts and breakdowns in trust in inter-organisational relationships |
| Kibbeling et *al.* (2013) | Identify whether and how firms and suppliers, | Build and test an empirical model | Firms need to satisfy customer demands to survive and depend | Embedding multiple dimensions of innovation |

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|---|---|---|---|---|
| | enable innovativeness in their supply chains | | on other parties such as their suppliers to achieve customer satisfaction | Alternative levels of analysis |
| Lai et *al.* (2013) | Logistics integration and inter-organisational relationships are two effective approaches for 3PL users to cope with their dependence on 3PL providers | Build and test an empirical model | Dependency upon 3PLs may push firms to develop higher levels of integration | Extend to other RDT strategies<br><br>Examine how business environments, such as uncertainty and competition, influence dependence-coping strategies and their effectiveness |
| Paulraj and Chen (2007) | Define how environmental uncertainties (demand, supply and technology) affect strategic supply management. | Hypothesised structural equation model | RDT supports cooperation among partners to produce mutual benefits. | Use of other indicators to tap the construct of demand uncertainty.<br><br>Use more concrete measure<br><br>Is any link between supply uncertainty and strategic supply management (power imbalance)?<br><br>Influence of other dimensions of supply chain uncertainties |
| Pazirandeh and Norman (2014) | Understand the relationship between purchasing strategies practiced by less-powerful buyers and their purchasing power | Build and test an empirical model | RDT suggest four different power/dependency positions: independence, buyer dominance, supplier dominance, and interdependence | Innovative practices, from different contexts, on new strategies to handle the low-power purchasing situation<br><br>Explore the characteristics, problems and practices specific to purchasing practices of humanitarian organizations |
| Petersen et *al.* (2008) | Determine the factors that increase the power over the buyer and what mitigation strategies can be used. | Build and test an empirical model | Buyer dependency (on a supplier) and socialisation play vital role in shaping relational capital. | Replication across other industries<br><br>Use other mediating variables |

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| | | | | Longitudinal data |
| Ponomarov (2012) | Identify the antecedents and consequences of supply chain resilience | Proposing and empirically testing a comprehensive model | RDT supports that in uncertain times stronger relationships allow the firm to access the necessary resources from partners | What are some of the other potential antecedents of supply chain resilience at the firm level of analysis? |
| Shou et *al.* (2013) | Identify what are the key features of power and its impact on operations management | Empirical study | RDT provides insights considering power formation. | How the power affects the profit allocation by supply chain integration?<br><br>How the power affects customer's or supplier's motivation to participate? |
| Touboulic et *al.* (2014) | Investigate sustainable supply chain relationships | Empirical study | RDT helps to explore imbalanced buyer–supplier–supplier relationships in SSCM | Does power imbalance act as a driver or barrier to SSCM?<br><br>How does the power differential influence the management of sustainability practices among the buyer and its suppliers? |

Appendix 2: Case study protocol

| | | |
|---|---|---|
| Purpose of case studies: In chapter 1 the research questions were described and the construct of embeddedness was defined in chapter 2. | Aim | Investigate the potential impact of natural resource scarcity on manufacturing companies |
| | Objectives | 1. To identify the factors that determine the dependence level of companies on specific scarce natural resources, the strategies implemented to minimise or overcome dependence and the implications for organisational performance.<br>2. To develop a conceptual framework for understanding how manufacturing companies can respond to the issue of NRS.<br>3. To validate the proposed framework by applying it to the case study companies and by constructing a survey questionnaire. |
| Research design: in chapter 4 the research design was given. | The unit of analysis | The unit of analysis of the research is identified as the manufacturing companies. |
| | Research questions | RQ1. What are the contingent factors that determine the dependence level of manufacturing firms on specific scarce natural resources?<br>RQ2. What are the supply chain strategies that manufacturing firms can employ to overcome or minimize dependence on scarce natural resources?<br>RQ3. What are the implications of the adopted supply chain strategies on organizational performance? |
| Field procedures: Case studies are selected based on theoretical and practical selection criteria. | Case study sites | Any manufacturing company even in different countries, i.e. USA, UK, Norway and China. Interviews are arranged at either interviewee's work place or telephone interviews due to the distance. |
| | Case selection criteria | 1. company has to be active in the manufacturing industry<br>2. companies have to be from a different context, use different natural resources<br>3. ease of access |
| | Sources of Information | Semi-structured interviews: organisation staff<br>Documents from the manufacturing companies (e.g. publicly available reports)<br>Each interview lasts about one hour. All interviews are audio-taped (except 2) and notes are taken during and after each interview. |
| Guide for case study report: way of analysis is described | Analysis of data | Based on framework approach<br>• Within case study analysis<br>• Cross-case pattern analysis |

| | | |
|---|---|---|
| in chapter 4, chapter 5 and chapter 6 presents the results of this cross-case analysis | Shaping hypotheses | • Iterative tabulation of evidence for each construct<br>• Replication, not sampling, logic across Cases<br>• Search evidence for 'why' behind relationships |
| | Reaching closure | Theoretical saturation |

Appendix 3: The interview guide

**General Respondent Information**

- Please describe what do you do in your job?
- How long have you been working for [your company]?

**Natural Resource Dependence Level**

- What do you see as the main pressures and reasons to manage the issue of natural resource scarcity effectively in your firm that could affect your supply chain and product portfolio?
- When facing a natural resource scarcity issue, how your production and operation will adjust to this change?
- Do you have alternative supply sources (suppliers) for your scarce natural resources? If not what you are doing? What do you feel to hinder your negotiation?

**Supply chain NRS strategies**

- Are those pressures mentioned above being matched with appropriate remedial measures such as product or processes redesign; network structure reconfiguration; recovering that material or/and maintaining safety stock or by collaborating with key suppliers (provide scarce natural resources) or/and by following the strategy of vertical integration or joint venture?
- What is your opinion towards the need to reconfigure the supply network structure (e.g. relocate plants) to locations with sufficient supply of scarce natural resources (for instance, relocate some plants to other regions to have access to water)? Please explain and give examples
- Does your company maintain safety stock in case of supply chain disruptions due to natural resource scarcity? Please explain and give examples
- Don't you collaborate with suppliers that recover natural scarce resources for you?
- What types of supply contract do you generally have with your suppliers that provide you with scarce natural resources?

**Organizational Performance**

- Have your organization's performance been enhanced (e.g. cost minimization) by following natural resource scarcity risks mitigation strategies?
- Do your current strategies enable you to reduce the waste of your scarce natural resource, minimize the consumption of natural resources, and cut of the production cost and purchasing cost of natural resources (i.e. resource efficiency)?

**Outcomes**

- What more can you do to handle the issue of natural resource scarcity? Are you planning to do any of these?

Appendix 4: Survey results

Criticality of the scarce natural resource–Item Purification Results

| Item | Corrected Item Total Correlation | Cronbach's Alpha if Item Deleted | Cronbach's Alpha |
|---|---|---|---|
| | **Stage 1** | | |
| **CR1** | 0.152 | 0.387 | 0.402 |
| **CR2** | 0.263 | 0.310 | |
| ~~**CR3**~~ | ~~0.171~~ | ~~0.398(removed)~~ | |
| **CR4** | 0.228 | 0.329 | |
| **CR5** | 0.239 | 0.322 | |
| | **Stage 2** | | |
| **CR1** | 0.175 | 0.175 | 0.398 |
| **CR2** | 0.349 | 0.349 | |
| ~~**CR4**~~ | ~~0.076~~ | ~~.076~~ | |
| **CR5** | 0.317 | 0.317 | |
| | **Stage 3** | | |
| ~~**CR1**~~ | ~~0.222~~ | ~~0.547(removed)~~ | 0.506 |
| **CR2** | 0.425 | 0.214 | |
| **CR5** | 0.349 | 0.371 | |
| | **Stage 4** | | |
| **CR2** | 0.379 | | 0.547 |
| **CR5** | 0.379 | | |

Purchase of the scarce natural resource–Item Purification Results

| Item | Corrected Item Total Correlation | Cronbach's Alpha if Item Deleted | Cronbach's Alpha |
|---|---|---|---|
| | **Stage 1** | | |
| **PURCH_1** | 0.346 | 0.608 | 0.637 |
| **PURCH_2** | 0.663 | 0.455 | |
| **PURCH_3** | 0.404 | 0.577 | |
| **PURCH_4** | 0.405 | 0.582 | |
| ~~**PURCH_5**~~ | ~~0.214~~ | ~~0.673(removed)~~ | |
| | **Stage 2** | | |
| **PURCH_1** | 0.395 | 0.648 | 0.673 |
| **PURCH_2** | 0.666 | 0.471 | |
| **PURCH_3** | 0.444 | 0.614 | |
| **PURCH_4** | 0.380 | 0.683 | |

Availability –Item Purification Results

| Item | Corrected Item Total Correlation | Cronbach's Alpha if Item Deleted | Cronbach's Alpha |
|---|---|---|---|
| **AVAIL_1** | 0.635 | 0.764 | 0.812 |
| **AVAIL_2** | 0.666 | 0.746 | |
| **AVAIL_3** | 0.744 | 0.707 | |
| **AVAIL_4** | 0.497 | 0.831 | |

Switching costs –Item Purification Results

| Item | Corrected Item Total Correlation | Cronbach's Alpha if Item Deleted | Cronbach's Alpha |
|---|---|---|---|
| **SWITC_1** | 0.493 | 0.886 | 0.870 |
| **SWITC_2** | 0.768 | 0.824 | |
| **SWITC_3** | 0.817 | 0.811 | |
| **SWITC_4** | 0.671 | 0.848 | |
| **SWITC_5** | 0.732 | 0.833 | |

Ownership –Item Purification Results

| Item | Corrected Item Total Correlation | Cronbach's Alpha if Item Deleted | Cronbach's Alpha |
|---|---|---|---|
| **OWN_1** | 0.649 | 0.873 | 0.882 |
| **OWN_2** | 0.759 | 0.848 | |
| **OWN_3** | 0.788 | 0.843 | |
| **OWN_4** | 0.754 | 0.848 | |
| **OWN_5** | 0.657 | 0.873 | |

Accessibility –Item Purification Results

| Item | Corrected Item Total Correlation | Cronbach's Alpha if Item Deleted | Cronbach's Alpha |
|---|---|---|---|
| **ACCESS_1** | 0.643 | 0.772 | 0.816 |
| **ACCESS_2** | 0.594 | 0.785 | |
| **ACCESS_3** | 0.679 | 0.760 | |
| **ACCESS_4** | 0.483 | 0.820 | |
| **ACCESS_5** | 0.662 | 0.764 | |

Usage –Item Purification Results

| Item | Corrected Item Total Correlation | Cronbach's Alpha if Item Deleted | Cronbach's Alpha |
|---|---|---|---|
| | **Stage 1** | | |
| ~~**USAGE_1**~~ | ~~0.176~~ | ~~0.753(removed)~~ | 0.684 |
| **USAGE_2** | 0.606 | 0.515 | |
| **USAGE_3** | 0.490 | 0.604 | |
| **USAGE_4** | 0.616 | 0.515 | |
| | **Stage 2** | | |
| **USAGE_2** | 0.617 | 0.628 | 0.753 |
| **USAGE_3** | 0.531 | 0.727 | |
| **USAGE_4** | 0.603 | 0.650 | |

Product and Process Configuration –Item Purification Results

| Item | Corrected Item Total Correlation | Cronbach's Alpha if Item Deleted | Cronbach's Alpha |
|---|---|---|---|
| **PPCONF_1** | 0.643 | 0.856 | 0.871 |
| **PPCONF_2** | 0.785 | 0.822 | |
| **PPCONF_3** | 0.718 | 0.839 | |
| **PPCONF_4** | 0.732 | 0.835 | |
| **PPCONF_5** | 0.625 | 0.866 | |

Supply Chain Configuration –Item Purification Results

| Item | Corrected Item Total Correlation | Cronbach's Alpha if Item Deleted | Cronbach's Alpha |
|---|---|---|---|
| | **Stage 1** | | |
| **SCCONF_1** | 0.454 | 0.619 | 0.679 |
| **SCCONF_2** | 0.530 | 0.583 | |
| **SCCONF_3** | 0.523 | 0.593 | |
| **SCCONF_4** | 0.441 | 0.626 | |
| ~~**SCCONF_5**~~ | ~~0.253~~ | ~~0.712(removed)~~ | |
| | **Stage 2** | | |
| **SCCONF_1** | 0.459 | 0.674 | 0.712 |
| **SCCONF_2** | 0.491 | 0.656 | |
| **SCCONF_3** | 0.590 | 0.598 | |
| **SCCONF_4** | 0.466 | 0.669 | |

Transactional Mechanisms –Item Purification Results

| Item | Corrected Item Total Correlation | Cronbach's Alpha if Item Deleted | Cronbach's Alpha |
|---|---|---|---|
| **TRAME_1** | 0.609 | 0.826 | 0.845 |
| **TRAME_2** | 0.713 | 0.797 | |
| **TRAME_3** | 0.609 | 0.827 | |
| **TRAME_4** | 0.666 | 0.810 | |
| **TRAME_5** | 0.677 | 0.807 | |

Relational Mechanisms–Item Purification Results

| Item | Corrected Item Total Correlation | Cronbach's Alpha if Item Deleted | Cronbach's Alpha |
|---|---|---|---|
| **RELAT_1** | 0.791 | 0.880 | 0.906 |
| **RELAT_2** | 0.818 | 0.874 | |
| **RELAT_3** | 0.784 | 0.882 | |
| **RELAT_4** | 0.692 | 0.900 | |
| **RELAT_5** | 0.878 | 0.955 | |

Hierarchy Mechanisms–Item Purification Results

| Item | Corrected Item Total Correlation | Cronbach's Alpha if Item Deleted | Cronbach's Alpha |
|---|---|---|---|
| **HIER_1** | 0.908 | 0.950 | 0.962 |
| **HIER_2** | 0.865 | 0.957 | |
| **HIER_3** | 0.899 | 0.951 | |
| **HIER_4** | 0.909 | 0.950 | |

Resource Efficiency–Item Purification Results

| Item | Corrected Item Total Correlation | Cronbach's Alpha if Item Deleted | Cronbach's Alpha |
|---|---|---|---|
| **REF_1** | 0.443 | 0.755 | 0.767 |
| **REF_2** | 0.627 | 0.699 | |
| **REF_3** | 0.519 | 0.731 | |
| **REF_4** | 0.619 | 0.694 | |
| **REF_5** | 0.497 | 0.739 | |

Competitive Advantage–Item Purification Results

| Item | Corrected Item Total Correlation | Cronbach's Alpha if Item Deleted | Cronbach's Alpha |
|---|---|---|---|
| **COMAD_1** | 0.694 | 0.840 | 0.868 |
| **COMAD_2** | 0.698 | 0.839 | |
| **COMAD_3** | 0.733 | 0.830 | |
| **COMAD_4** | 0.775 | 0.821 | |
| **COMAD_5** | 0.573 | 0.871 | |