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Abstract

Purpose – Drawing on the theory of contingency, the aim of this work is to understand how supply chain-related contingencies, arising from climate change, are related to changes in the organisational structure of firms. Further, the authors explore how this relationship influences the perception of sustainability managers on the adoption of low-carbon operations management practices and their related benefits.

Design/methodology/approach – To achieve this goal, this research uses NVivo software to gather evidence from interviews conducted with ten high-level managers in sustainability and related areas from seven leading companies located in Brazil.

Findings – The authors present four primary results: a proposal of an original framework to understand the relationship between contingency theory, changes in organisational structure to embrace low-carbon management, adoption of low-carbon operations practices and benefits from this process; the discovery that an adequate low-carbon management structure is vital to improve the organisations' perceptions of potential benefits from a low-carbon strategy; low-carbon management initiatives tend to emerge from an organisation's existing environmental management systems; and controlling and monitoring climate contingencies at the supply chain level should be permanent and systematic.

Originality/value – Based on the knowledge of the authors, to date, this work is the first piece of research that deals with the complexity of putting together contingency theory, climate-change contingencies at the supply chain level, organisational structure for low-carbon management and low-carbon operations management practices and benefits. This research also highlights evidence from an emerging economy and registers future research propositions.

Keywords Sustainability, Climate change, Low carbon, Emerging economies, Sustainable operations, Low-carbon economy
Sustainable innovation, Sustainable supply chain

Paper type Research paper

1. Introduction

Few studies address the risks of climate change-related contingencies in supply chains in emerging economies and the consequent necessary responses from businesses (Gasbarro and Pinkse, 2016; Winn *et al.*, 2011; Slawinski *et al.*, 2015). This paper aims to understand how companies structure and maintain their low-carbon operations management and how they consider the constraints arising from climate change at the supply chain level. In addition, we also reveal the benefits that organisations could achieve by adopting operational practices of managing carbon emissions.

Climate change is a subject that generates global risks and uncertainties (Kuklicke and Demeritt, 2016; Carrao *et al.*, 2016) due to a series of extreme weather events that have occurred in recent years (Winn *et al.*, 2011; Slawinski *et al.*, 2015); these events have had negative impacts, not only for companies but also for industrial operations (Gasbarro and Pinkse, 2016). Challenging weather events, such as storms, hurricanes and extreme droughts, tend to generate restrictions that can devastate supply chains.

These weather events have a strong influence on supply chain operations because they may directly impact facilities and compromise their access to natural resources and raw materials (Dasaklis and Pappis, 2013; Haverkort and Verhagen, 2008; Busch and Hoffmann, 2007), thus creating

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carbon-related restrictions in supply chains. However, in addition to the occurrence of extreme events, there are other supply chain-related contingencies which may affect organisations because of climate change, such as the emergence of new regulations, technologies and additional costs.

In this work, better organisational performance results from the fit between organisational structure and the external environment in which a company is inserted (Volberda *et al.*, 2012). Organisations should consider climate change and its contingencies to optimise their overall performance. The organisational strategies related to climate change can be a source of competitive advantage and strong performance in the market (Kolk and Pinkse, 2004; Lee, 2012a). Good organisational performance, in the context of climate change, can be obtained through various benefits, as highlighted in the literature (Hoffman, 2005). However, if a company does not consider supply chain constraints resulting from climate change when managing carbon reductions, it may not be prepared to be effective in its actions to reduce emissions nor to achieve benefits from these initiatives.

Carbon management in industrial companies is presented in the literature as being a management process that requires a critical view from top managers. Effective managers must consider the following issues: managing risk (Weinhofer and Busch, 2013), an assessment of capabilities and trade-offs (Pinkse and Kolk, 2010), the establishment of policies and objectives for the reduction of CO_2 (Lee, 2012a), the definition of strategic actions (Pesonen and Horn, 2014), opting for either reduction, compensation or searching for zero emissions (Weinhofer and Hoffmann, 2010), a potential search for external partners to carry out the actions of low-carbon management (Kolk and Pinkse, 2004), a study on the benefits from projects developed by a company (Bocken *et al.*, 2012) and, finally, the weighting of issues of climate change in organisational routines (Boiral, 2006).

Therefore, a question that guides this article is: How do the perceptions of contingencies resulting from climate change at the supply chain level lead to an eventual restructuring of procedures for organisational low-carbon management? Another question that needs to be addressed is: How does the relationship between contingencies and change affect the managers' perception of benefits by adopting practices of low-carbon operations management?

Recent trends justify the relevance of this research. The recent Conference of the Parties of the United Nations (UN) (COP-21) in Paris showed the intention of global leaders in setting targets to reduce CO_2 emissions to combat climate change (UNFCCC, 2015). It has the potential to influence organisational routine and strategy. Another fact is related to the extreme drought that occurred in several countries in Latin America (WWAP, 2016). Among these countries, Brazil witnessed a severe water crisis between 2014 and 2015 (The Guardian, 2015; Reuters, 2016) that affected the local economy, people's wellbeing and supply chain activities due to disruptions in the water supply.

These extreme events are not isolated; in fact, they tend to repeat themselves, so organisations can face many challenges to deal with the contingencies of climate change. In this sense, this work presents an integrated framework to help companies understand low-carbon management in terms of supply chain management contingencies. It also encourages the adoption of low-carbon operations management and helps organisations to better perceive potential benefits. To address these issues, interviews were held with managers of national and multinational companies in Brazil. Brazil was selected for the study due to its economic and geographic relevance and the severe supply chain disruptions it has experienced due to climatic events (drought resulting in water scarcity).

This article is structured as follows: Section 2 presents the concepts of managing carbon from the perspective of the theory of contingency and the potential benefits that businesses can achieve from this. In Section 3, the research method used and the instruments used for data collection and analysis are given. Section 4 presents the results, and Section 5 gathers the discussions and propositions from these results. Finally, in Section 6, the conclusions, contributions and limitations of the study are presented.

2. Theoretical background

Emissions of gases that cause climate change have become more intense since the beginning of the industrial revolution (IPCC, 2014). According to Slawinski *et al.* (2015), emission levels have reached the point where, from now, climate-related physical impacts will be observed on a large scale. Thus, climate has become a source of challenges for organisations (Winn *et al.*, 2011) due to the disruptions it can cause in supply chain operations.

While uncertainties increase, managers will need more information on climate change to restructure their businesses (Gordon and Narayanan, 1984). In this context, the theory of contingency is relevant (Lawrence and Lorsch, 1967) because it deals with organisational management due to external events.

For Drazin and Van de Ven (1985), the proposition that the structure and processes of an organisation should be adapted to its organisational context, either to survive or to be effective, is central to the theory of contingency. However, Sousa and Voss (2008) note that studies in operations management have not fully explored the richness of the influence that contextual issues can have.

The impacts of climate change-related supply chain disruptions are difficult to predict (Winn *et al.*, 2011) and uncertainties from the external environment influence the approach to green practices (Lo and Shiah, 2016). Because of this, the theory of contingency is paramount; managers should consider the constraints arising from climate change to develop strategies capable of conducting low-carbon operations management and, as a consequence, achieving the organisational performance desired.

As there is no unique way to apply the theory of contingency (Horisch, 2013), this work adopts the term strategy for climate change (Lee, 2012a, 2012b), as companies deal with risk-related contingencies from climate change that affects their supply chains. Thus, this research follows the theory of contingency and suggests four main variables of study: contingency factors; internal organisation structure for low-carbon management; adoption of low-carbon operations practices; and effects on performance (Drazin and van de Ven,

1985; Gordon and Narayanan, 1984; Sousa and Voss, 2008; Volberda *et al.*, 2012).

Contingencies are defined as outside events that affect organisations, over which organisations cannot exert direct control (Sousa and Voss, 2008). This article lists four possible contingencies resulting from climate change that can affect the management of supply chains: lack of resources and difficulty of access to raw materials; new advances in technology; regulations; and extra costs. These contingencies are derived from the fact that organisations already face, or will face, supply chain-related disruptions, such as lack of resources and limited availability of raw materials (Smith, 2013; Haverkort and Verhagen, 2008). In addition, companies may be forced to seek new technologies (Busch and Hoffmann, 2007; Plambeck, 2012; Aben *et al.*, 2010). Organisations can also face social and governmental challenges, and new regulations may require taxes, which increase costs, changing the way the companies act globally (Jeswani *et al.*, 2008; Choi *et al.*, 2013; Hitchcock, 2012; Lo, 2010; Burritt *et al.*, 2011).

The second variable, the *internal organisational structure* for low-carbon management, is related to the capabilities that a company has to ensure to promote actions to adapt to emergent contingencies (Gordon and Narayanan, 1984; Volberda *et al.*, 2012). Renukappa *et al.* (2013) state that it is important for a company to manage internal factors, such as:

- the commitment and the establishment of leadership to low-carbon management;
- written policies related to climate change;
- establishment of specific job positions to deal with carbon management;
- systems of rewards for the initiatives of reduction of carbon;
- training programmes for employees; and
- creating a performance reporting procedure for emissions.

In this regard, organisations can define their internal structure through their supply chains by enacting climate change policies (Lee, 2011), aligning objectives and targets to reduce CO_2 emissions (Gopalakrishnan *et al.*, 2012), selecting their suppliers carefully (Dou *et al.*, 2015) and sharing their information about CO_2 emissions with suppliers (Jira and Toffel, 2013).

The third variable is the *adoption of low-carbon operations practices*. Per Sousa and Voss (2008), these practices can be seen as actions that organisations take in response to current or future contingencies. Thus, this work uses low-carbon operational practices called "products", "processes" and "logistics" (Bottcher and Muller, 2015).

Finally, this research aims to understand the relationship between climate-change contingencies and firms' performance. We opted for the benefits outlined by Hoffman (2005), namely:

- improvement in risk management;
- access to new sources of capital;
- anticipation and the influence of climate regulations;
- improvement in human resource management;
- identifying new markets;
- improving the reputation of company; and
- operational improvement.

We believe that companies obtaining these low-carbon management benefits are also improving their overall performance.

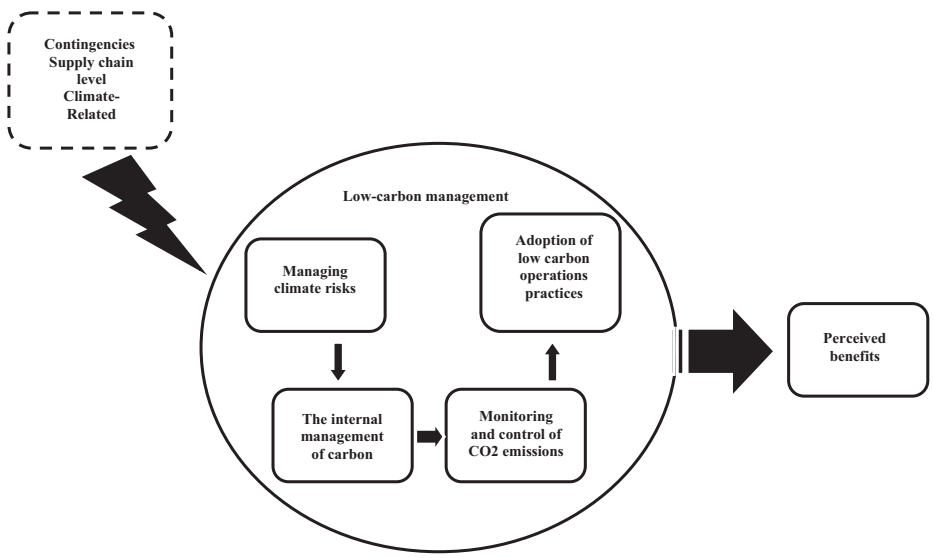
Figure 1 provides a summary of the theoretical background herein explored.

3. Research method

This research adopts a qualitative approach, which has made use of in-depth interviews (Ketokivi and Choi, 2014). Interviews with experts were necessary for this research due to the fact that managers are members of organisations that decide on how to react to environmental contingencies (Horisch, 2013; Russo and Harrison, 2005; Faes and Matthyssens, 2009).

The interviews were conducted with managers of seven companies. The number of companies herein investigated is aligned with the number of companies suggested by other

Figure 1 Low-carbon management in light of supply chain constraints due to climate change, taking into account the theory of contingency



similar studies on the theme of climate change (Okereke and Kung, 2013; Burritt *et al.*, 2011; Aben *et al.*, 2010). Brazil was chosen because more research is needed on climate change in developing countries (Lee, 2012b; Wang *et al.*, 2013).

The choice for large companies is explained by the fact that the larger the size, the greater the exposure to regulations and pressure from stakeholders (Lee, 2012b). In addition, larger companies generally have greater financial resources to invest in low-carbon management (Boiral, 2006; Boiral *et al.*, 2012; Wang *et al.*, 2013). The companies belong to the sectors of energy, retail, manufacturing and agriculture.

The interview script (Appendix) allowed the collection of data during the interviews (Ketokivi and Choi, 2014; Yeung, 1995; Rowley, 2012). In total, ten managers were interviewed, including managers with expertise in sustainability, environment, supply chain, logistics and facilities management.

The interviews were conducted during 2015 and 2016. The total duration of the interviews was around 7 h, with each interview averaging 54.34 min. In this way, the number of interviewees and the duration of interviews is aligned with the literature (Galbreath, 2014; Rowley, 2012).

To start the procedure of data collection, researchers – after determining the companies that would be researched – made contact via phone and email with managers to explain the research objectives and themes (Ketokivi and Choi, 2014; Galbreath, 2014; Rowley, 2012). Once the invitation to participate and the interview schedule was accepted, the interview script was sent to respondents in advance (Yeung, 1995; Galbreath, 2014; Rowley, 2012). The interviewees were able to prepare and organise their thoughts, as well as access secondary data to respond to the issues more clearly.

The script was developed by selecting the contingency factors that impact organisations and how organisations have dealt with them. The internal organisational factors were used to formulate the questions regarding management initiatives. Finally, questions about benefits noted by managers from low-carbon operations were designed.

Secondary data, including information from sustainability reports, internal newspapers and information contained on the websites of the companies investigated, were collected and material from the database of the Carbon Disclosure Project (CDP) as suggested by others (Gasbarro and Pinkse, 2016; Jira and Toffel, 2013; Sullivan, 2009; Burritt *et al.*, 2011; Matisoff, 2013).

All interviews were recorded, so that there would be no loss of data during the conversations. For qualitative data analysis, the interviews were transcribed. We used the NVivo software, recommended by the literature, for qualitative research (Wright, 2009; Galbreath, 2014; Gasbarro and Pinkse, 2016; Solomon *et al.*, 2011). Finally, a tabulation of the data collected was conducted (Ketokivi and Choi, 2014; Voss *et al.*, 2002).

4. Profile of the cases

The first studied company is called *Alpha*, a multinational company in the food manufacturing sector. It has been operating in Brazil for decades. Currently, the company participates in the CDP and GHG Protocol-Brazil programmes, in addition to receiving a low-carbon seal from the Brazilian federal government. We interviewed a manager in continuous improvement who work for the environmental department of the company.

The second company is *Beta*, a Brazilian company in the energy sector with operations in the country for more than 100 years. It has operations in the generation, processing and marketing of electric power, as well as service operations. The company engages in extensive participation in programmes, initiatives and indexes related to sustainability, such as the CDP, GHG Protocol-Brazil, Corporate Sustainability Index (ISE-BOVESPA), Dow Jones Sustainability Emerging Markets (DJSI Emerging Markets), and it actively participates in the conferences of the UN. We interviewed a manager of sustainability at the company headquarters in São Paulo who has worked for six years in the environmental area of the company.

The third company is *Gamma*, a multinational company based in São Paulo engaged in the sector of food and beverages with operations in Brazil. The company participates in the GHG Protocol and in the UN Global Compact. It fabricates such products as desserts and yoghurts. The interviewees were a manager for the supply chain and an environmental manager.

The fourth company is *Delta*, a multinational company in electronics manufacturing with more than 50 years of experience in the market. The company surveyed has no operational unit in Brazil but does have a headquarters and outsourcing production. The company participates in initiatives such as COP and GHG Protocol at the global level, in addition to the Dow Jones Sustainability Emerging Markets (DJSI Emerging Markets) and the UN Global Compact. We interviewed the Brazil-Argentina manager for sustainability.

Sigma, the fifth company, is a Brazilian company in the sector of agriculture in the market for over 20 years. The company has signed a public commitment with Greenpeace to fight deforestation in the Amazon. It also participates in the CDP, GHG Protocol-Brazil, the Forest Footprint Disclosure and Corporate Sustainability Index (ISE-BOVESPA). We interviewed the manager of sustainability.

The sixth company is *Omega*, a multinational company in the retail sector, with operations in Brazil since 1990s. The company participates in the programmes of CDP and GHG Protocol at the global level and the Climate Forum of the Ethos Institute. In addition, the company has a programme for sustainability in Brazil, wherein it works with around 30 suppliers on issues of sustainability. We interviewed three employees here: a coordinator of sustainability for Brazil, a manager of transport and logistics for Brazil and the facilities coordinator.

The seventh company is *Theta*, a multinational company in the sector of agriculture based in Brazil since the 1960s. The company participates in CDP and the GHG Protocol-Brazil, in addition to having signed the New York declaration on Forests and joined the Roundtable on Sustainable Palm Oil (RSPO). We interviewed the manager of sustainability.

Table I summarises the information.

Table I Summary of jobs/hierarchy occupied by respondents

Company	Job position – manager of	Locality
Alpha	Continuous improvement	Manufacturing unit
Beta	Sustainability	Headquarters
Gamma	Supply chain	Headquarters
	Environment	Manufacturing unit
Delta	Sustainability	Headquarters
Sigma	Sustainability	Manufacturing unit
Omega	Sustainability	Headquarters
	Service improvements	Headquarters
	Utilities performance	Headquarters
Theta	Sustainability	Headquarters

5. Results

5.1 Supply chain disruptions caused by natural events and others risks

The first variable herein analysed is the contextual factors or contingencies of climate change at the supply chain level. This work has highlighted four possible contingencies of climate changes that can affect organisations, which are resource scarcity or difficulty of access to raw materials, new regulations, technological advances, and additional operational costs.

When it comes to scarcity of resources and access to raw materials, five companies mentioned a particular episode and some have risk management practices in place for their sources of supply chain level resources. *Alpha* recently went through a shortage of onions, replacing the commodity with onion powder, and *Sigma* stated that there was a large water savings programme when Brazil experienced a long drought between the years of 2014 and 2015. In the case of *Beta*, the interviewee said that the shortage of water for hydroelectric generation of energy meant the use of thermoelectric power instead:

> So, if there is a low level of reservoir, it can be replaced by another source, for example thermoelectric plant, which was what happened last year and this year (interviewee, *Beta*).

With regard to regulations, six companies had some kind of regulations that affected their operations or that they had to meet to not be penalised. *Omega* demanded from its logistics partners the use of better fuel in their trucks to transport their goods (IBAMA, 2009), and *Theta* built a new sugar cane plant in accordance with the law on Brazilian biodiesel (Brazil, Law No. 11.097/2005). A *Gamma* interviewee pointed to the need to meet the legislation for the pollution emitted from trucks (CETESB, 2009).

> Another point that we evaluate are emissions from trucks and the trucks from third parties as well. When trucks enter the factory, staff conducts environmental evaluations (interviewee, *Gamma*).

Necessary technological advances were also considered by studied companies as something that forced the change. Of the seven companies studied, five showed some change in technology that helped reduce CO_2 emissions. *Gamma* reported that the new technologies acquired by the organisation are strongly related with eco-efficiency and meet international standards for emissions because they follow guidelines from Europe. The manager of *Delta* said that the company produces electronic products and keeps in mind the goal of reducing emissions:

> I would say that the staff promotes reduction of emissions to the extent that when we develop new servers and computers that consume less energy we are collaborating to reduce emissions (interviewee, *Delta*).

Finally, regarding the variable additional costs arising from climate change, all seven companies reported to a greater or lesser extent that they had suffered some financial impact due extreme weather events. *Beta* and *Omega* reported that they had indicators of cost per CO_2 emissions produced for their operations. Sigma also highlighted extra cost due to scarcity of water in 2015 when it had an increase by 26 per cent. The manager of *Theta* said that the company monitors water shortage in its operations:

> So, for example, do we monitor the cost of not having water? Yes, we do. We have measures to prevent this from happening and also have measures to mitigate the event from happening. We have had events of this nature that we believe are related to climate change (interviewee, *Theta*).

It can be said that all companies have established a management committee to deal with issues relating to water scarcity as a consequence of the water crisis that occurred in Brazil in the years 2014-2015. It can be summarised that *Beta* and *Theta* engage in a comprehensive management of all of the factors considered (resources, regulations, technology and cost), with constant monitoring and management of risk. *Gamma* reports that there is a team that monitors the development of legislation to facilitate its application when enacted.

Table II summarises climate change contingencies in the seven companies.

5.2 Enabling an organisational structure for carbon management

Inner organisational structure for carbon management is subdivided into factors of structuring of companies that help answer climate change and the factors that relate to monitoring and controlling emissions. Of the seven companies, *Beta*, *Delta*, and *Theta* have policies on climate change. However, climate change is considered as an item included into a broader sustainability policy. *Beta* highlights a policy for climate change, a fact that is also found in the company's annual report:

> The items number eight and nine of our policy are specific to climate change and in parallel, to strengthen them, we have a proper declaration for climate change (interviewee, *Beta*).

In relation to targets and goals, six of the seven companies have that items in their management policy. *Alpha* and *Omega* highlight goals and objectives relating to energy efficiency, whereas the other companies have targets on reducing emissions. The exception is the lack of emissions reduction targets in *Sigma*.

Regarding the hierarchy of job positions relating to climate change, only *Beta* and *Theta* have a committee responsible for the theme but neither of them specifies an exclusive position for activities relating to carbon management.

> [. . .] among other responsibilities, we manage carbon governance, which includes internal planning and institutional relationships (interviewee, *Beta*).

The item "reporting of emissions" was found in all companies. Companies in the CDP disseminate data on CO_2 emissions in

Table II Presence of contingencies change in companies

Bad weather conditions	Alpha	Beta	Gamma	Delta	Sigma	Omega	Theta
Scarcity of resources/Raw materials	✓	✓	✓	–	✓	–	✓
New regulations	–	✓	✓	–	✓	✓	✓
Technological advances	–	✓	✓	✓	–	✓	✓
Extra costs	✓	✓	✓	✓	✓	✓	✓

their annual sustainability reports. However, *Beta* and *Sigma* stand out by participating in the BOVESPA Index (ICO2); in fact, *Beta* even disseminates its results on a prestigious Stock Exchange.

Three companies (*Beta*, *Gamma* and *Theta*) report having some type of training on the reduction of carbon in place. *Theta* reports the existence of workshops and training relating to the change of land use. *Beta* highlights the role of the behaviour of employees towards emission reductions:

> [. . .] employees need to know their role day-to-day, and that the role will contribute to the reduction of emissions (interviewee, *Beta*).

Respondents were asked whether the company's employees received some reward for their results pertaining to emissions reductions achieved. Managers do not gain remuneration for instituting climate change, except the senior managers of *Beta* are rewarded for achieving reduction targets.

Finally, the internal management of information relating to climate change was found in four (*Alpha*, *Beta*, *Gamma* and *Theta*) of the seven companies surveyed. The data shows that the management of information flows throughout data panels, in which systematisation of data is routinely performed.

Table III summarises internal organisational structure of carbon management policies in the seven companies studied.

The monitoring of emissions was highlighted in all annual reports of the companies and also reported by the respondents in all seven companies. Companies seek to monitor their carbon emissions on a daily basis by means of indicators and consolidate them annually. *Omega* reports the calculation made for the monitoring of emissions in its fleet of trucks:

> So how do I calculate the amount of carbon dioxide avoided? We use a measure per litre of fuel (interviewee, *Omega*).

Regarding the possible managerial approaches (reducing, compensating or zero-emission), five of the seven companies seek to reduce their emissions. The manager of the company *Beta* declares the adoption compensation and zero emissions:

> One example is that we've bought credit to compensate for the issue of a plant out here within the group (interviewee, *Beta*).

Finally, the respondents were asked about the extent of managing different types of emissions. The surveyed companies, *Beta*, *Delta* and *Sigma* are working on Types 1, 2 and 3 of emissions, whereas *Alpha*, *Gamma* and *Theta*, only Types 1 and 2. *Omega* only reported emissions for the GHG Protocol in 2008, which included Types 1 and 2, referring to the consumption of electric power and transport. Table IV summarises the organisational structure of the monitoring and control of emissions.

5.3 Low-carbon operations practices

Alpha has actions for adequate land use in place, and it has begun the exchange of fuel for power generation and standardising the size of trucks with logistics partners.

Beta is engaged in three types of operational practices. The company offers products and services with eco-efficiency to public buildings, low-income communities and for businesses with intensive use of electrical energy. In relation to its process, the company uses biomass for production of electrical energy, replacement of mineral oil for vegetable oil in electrical transformers and investing in wind farms and photovoltaic panels for the production of energy. The company has an initiative in low-carbon logistics and uses electric cars in their operations.

Gamma features actions related to low-carbon processes and logistics. Processes that are highlighted include the exchange of diesel oil for steam generation, reduction in the consumption of electric energy when cooling milk and the exchange of gas-based forklifts with electric ones. As for the practices of logistics it declares, the use of trackers to determine the best routes, to facilitate vehicle exchange and to efficiently maintain its fleet for fuel consumption.

Delta declares the adoption of low-carbon products and logistics. The interviewee said that products consume less energy during their use. It seeks to reduce the number of trips using transport logistics with suppliers of raw material through a better scheduling plan.

Sigma is engaged in the control of deforestation when managing cattle in the Amazon, and uses renewable fuels for energy production.

Omega reports improvements in its thermodynamic refrigeration units and the switch of fluorescent lights for

Table III Internal structure of management of carbon

Internal management of carbon	Alpha	Beta	Gamma	Delta	Sigma	Omega	Theta
Climate policy	–	✓	–	✓	–	–	✓
Goals and objectives	✓	✓	✓	✓	–	✓	✓
Structure of positions	–	✓	–	–	–	–	✓
Reporting of emissions	✓	✓	✓	✓	✓	✓	✓
Specific training on carbon footprint	–	✓	✓	–	–	–	✓
Rewards for employee initiatives	–	✓	–	–	–	–	–
Managing internal information	✓	✓	✓	–	–	–	✓

Table IV Monitoring and controlling emissions

The monitoring and control of emissions	Alpha	Beta	Gamma	Delta	Sigma	Omega	Theta
Emissions monitoring	✓	✓	✓	✓	✓	✓	✓
Type of emissions management	Reduce	Reduce, Offset and Zero	Reduce	Reduce	–	Offset	Reduce
Extension of the management of emissions (scope)	1 and 2	1, 2 and 3	1 and 2	1, 2 and 3	1, 2 and 3	1 and 2	1 and 2

LEDs. Logistics has improved considerably because it has used software to optimise routes.

Finally, *Theta* engages in three types of low-carbon operations management operational practices. "Product" is related to the production and certification of biodiesel on a commercial scale. "Process" is the use of biomass for energy production and proper use of soil, avoiding deforestation in different regions of the country, including the Amazon region. The practices of "logistics" are exchanges of transport modals and intensified exchange of road with rail.

Table V summarises the operational practices adopted by the seven companies surveyed.

5.4 Benefits from adopting low-carbon operations practices

The first type of benefit was access to new sources of capital. Companies may receive investments and financial contributions when they act proactively in the context of climate change. Only companies *Beta* and *Theta* get this benefit. *Theta* exemplifies the government's incentive to produce biodiesel, whereas *Beta* ensures that disclosures of rates of emission/sustainability on the stock market attract the attention of investors for the company:

> For people looking to buy shares or for a bank that will finance us, they will look at carbon management aspects (interviewee, *Beta*).

Thereafter, an improvement in the company's reputation is beneficial because it lowers criticism from stakeholders and improves the company's standing in the marketplace. Four companies perceive this benefit: *Beta*, *Theta*, *Delta* and *Sigma*. *Beta* associates the benefit with new sources of capital. *Theta* reports that customers of large multinationals sought to understand how it engages in soil management. *Delta* and *Sigma* say their attitude directly influences the consumer's behaviour:

> [. . .] our consumers have access to a tool that we offer. It is called Carbon Footprint Calculator and every customer can calculate emissions based on energy consumption [. . .] (interviewee, *Delta*).

The third benefit, identification of new markets, concerns the provision of new technologies or services related to climate change. In this case, *Beta* reports that it identified the opportunity to acquire a company to generate energy from renewable non-polluting forms: wind and solar power. *Theta* reports that it realised this benefit after the promulgation of the law on biodiesel; in fact, the company built a new plant for the production of fuel:

> [. . .] we built a plant for the production of biodiesel here in Brazil. This is a regulation that has had an impact that I consider positive and inclusive and that generates other related impacts that are, in my view, quite useful (interviewee, *Theta*).

The fourth benefit refers to the improvement of human resource management. It is considered as a way to improve morale within the company, reducing costs of hiring and training new employees and increasing productivity in the workplace through actions to combat climate change. Of particular note is *Gamma*, in which the interviewed recounts the feeling of employees:

> [. . .] they feel motivated, yes. They think "I have identified something related to environment" (interviewee, *Gamma*).

The fifth type of benefit is anticipation and influence on the climate. This consideration addresses the possible benefits of new regulations in the market of carbon credits and the creation of new taxes; it also considers the possible influence that the industry can exert so regulations may be softened. *Beta* reports that it needs to draw up an inventory of emissions and send it to the governmental authority, and this will help the government to create taxation or penalties in the future. Finally, *Theta* recounts its participation in the regulation of deforestation:

> For example, the forest code, we participated in the processes [. . .] we were able to anticipate, to help, and even to promote this new legislation that we believe is very important and relevant (interviewee, *Theta*).

> An inventory of emissions is a way in which the Government verifies companies in a specific sector which are carbon intensive and creates a tax or penalty (interviewee, *Beta*).

The sixth type of benefit is improvement in risk management. This deals with the expected loss and extra costs caused by physical damage to structures and facilities and government regulations in certain economic sectors. *Gamma* reports that it is able to anticipate any kind of regulation because there is a team dedicated to managing risk-related issues within the company. *Theta* reports they constantly manage their energy usage and resources, and those actions make it more resilient to possible interruption of operations. *Beta* reports that its risk management provides distribution of power without interruptions by electrical discharges.

> This operating model makes us a little more resilient, let's say that those impacts are very relevant and that they occur with some frequency: energy shortage, and the shortage of water, in particular (interviewee, *Theta*).

> [. . .] today has a lot of incidence of lightning, bigger than before; and this year will hit a record electrical discharge in São Paulo State and also experience concentrated rain with much wind that also ends up affecting the distribution of power. So we also have to conduct some risk analysis [. . .] (interviewee, *Beta*).

The final benefit is operational improvement. This benefit relates to improvement in efficiency, reduction of waste in the production process and optimisation of fleets used in transport, among others. Five of companies realise this benefit: *Alpha*, *Beta*, *Gamma*, *Omega* and *Theta*. In general, they recognise that there are operational improvements as a result of dealing with the issue of climate change.

Table VI summarises the perception of respondents regarding the benefits of adopting low-carbon operations practices.

Table V Examples of low carbon operations practices adopted by the studied companies

Operational practices of low carbon management	Alpha	Beta	Gamma	Delta	Sigma	Omega	Theta
Products/services	–	Provision of services for energy efficiency	Reduction of weight of packaging	Provision of new products with better carbon-efficiency	–	–	Production of biodiesel
Processes	Change in land use	Use of biomass for energy generation	Replacement of fuel to generate its energy	–	Control of deforestation in the Amazon Biome	Improvements in the structures of chillers	Generation of its own energy
	Exchange of fuel to generate its own energy	Investment in solar and wind energy	Cold manufacturing–milk				
		Replacement of oil in electrical transformers	Replacement of gas-powered lift trucks per outlet		Generation of its own energy	Exchange of fluorescent lights by LED	Change in land use
Logistics	Standardization of trucks	Use of electric cars in operation	Replacement of vehicles (trucks for vans) Maintenance of vehicles Trackers and software for definition of routes	Reduction in the number of trips to transport raw materials	–	Software for optimizing routes Trade in vehicles (trucks for road-train) Exchange of modes of transport (road by rail)	Replacement of modes of transport (road by rail)

Table VI Benefits to adopting low carbon operational practices

Benefits	Alpha	Beta	Gamma	Delta	Sigma	Omega	Theta
Sources of capital	–	✓	–	–	–	–	✓
Organisation's reputation	–	✓	–	✓	✓	–	✓
Identifying new markets	–	✓	–	–	–	–	✓
Human resource management	–	–	✓	–	–	–	–
Anticipation of regulations	–	✓	–	–	–	–	✓
Improving risk management	–	✓	✓	–	–	–	✓
Operational improvement	✓	✓	✓	–	–	✓	✓

6. Discussion

Using the theoretical perspective of contingency, this work has sought to identify first if the studied companies have already witnessed some contingencies relating to climate change that have created difficulties at the supply chain level and then to determine how they manage these contingencies in their operations.

Each organisation was questioned about the existence of possible risk management. *Beta* and *Theta* stand out by having risk management in place for contingencies (Weinhofer and Busch, 2013; Pinkse and Kolk, 2010). The other organisations present a less comprehensive risk management. In this way, it appears that companies react to the context of climate change when they witness risks to their operations.

With regard to the regulations related to climate change, the studied companies also witnessed such contingencies. Some reported the need to issue a report at the end of each year for regulatory agencies of the government, and others reported the need to monitor the emissions level of trucks and the addition of chemical additives as per the law for the reduction of emissions of CO_2 or equivalent.

Finally, all companies have reported, in some way, that climate change affected their business in financial terms. The 2015 CDP questionnaires confirm that extreme weather events affected their facilities, supply of raw materials and the sale and distribution of their products. Hence, each company reported climate-change related disruptions at the supply chain level.

Therefore, companies do face contingencies arising from climate change, and they try to monitor them as much as possible. However, some of the companies have a more structured and better way of managing risk (*Beta* and *Theta*).

In general, the companies studied have been monitoring at least one contingency (scarce resources, new regulations, technological advances or extra costs). As a way to synthesise the results, it seems that there is a relationship between contingencies arising from climate change and corporate attention paid to risk management. Thus, it is possible to put forward the following proposition for future studies:

P1 Organisations that face risks from climate change trigger a more structured approach to management of climate risks.

According to the theory of contingency, when faced with external contingencies, organisations change internally in terms of organisational structure (Sousa and Voss, 2008; Schneider *et al.*, 2014; Horisch, 2013; Gordon and Narayann, 1984). Overall, the studied companies do not have a managerial structure with all the characteristics suggested by the literature (Lee, 2012a). The climate policies found in three of the seven companies show that the issue of climate change tends to be part of the environmental policy previously established.

In relation to targets and objectives, most of the companies seek to establish goals for the reduction of impacts and better efficiency. To this fact, it is observed that all employees have a certain way of managing their responsibilities towards achieving these goals and objectives. On the other hand, except in the cases of *Beta* and *Theta*, businesses do not have high hierarchical job positions to perform activities closely linked to climate change.

In general, *Beta*, *Gamma* and *Theta* train their employees by embedding the climate change in their training sessions on environmental issues. However, the companies do not establish training unique to the topic in their daily routines of training.

Rewards for achieving such goals and objectives still remain an exception. Only *Beta* reports that its managers receive some kind of reward for achieving the reduction targets proposed by the organisation.

The reporting of emissions occurs in all the companies interviewed. They are looking for ways to share their efforts to combat carbon emissions and participate in the CDP. This objective is accompanied, in many cases, by managing emissions information that passes through all the hierarchical levels of the company.

In this way, neither complete adherence was found in the managerial structure for low-carbon management when compared with what is proposed in the literature in terms of defining policies, roles, goals and objectives and training (Lee, 2012a; Renukappa *et al.*, 2013) nor there was a systematisation of data for communication and definition of proper climate change strategies and action plans (Pesonen and Horn, 2014). The only companies that are approaching this kind of structure are *Beta* and *Theta*, in which there is a definition of climatic aspects in the environmental policy of the companies, existence of goals and objectives, communication of results and indicators, systematisation of information management by a committee that is responsible

for carbon emissions, as well as training and rewards for managers.

Hence, one can check for an integration of factors related to climate change and environmental management in organisations, because there is no exclusive and totally different approach for low-carbon management currently in existence (Renukappa *et al.*, 2013; Lee, 2012a; Pesonen and Horn, 2014). Thus:

P2 Organisations integrate low-carbon management initiatives into the previously existing environmental management structure.

Some companies that have little internal structure to deal with climate change seek a way to compensate for that lack by adopting control and monitoring of emissions (*Alpha*, *Delta* and *Sigma*). It seems that these cases focused on monitoring and controlling emissions as a way of compensating for the lack of managerial structure. However, to adopt practices of low-carbon operations (products, processes and logistics), organisations should seek to align the managerial levels, strengthen the need for managerial support for monitoring practices of low-carbon and then ensure the most appropriate response to the contingencies faced are enacted (Correia *et al.*, 2013; Schneider *et al.*, 2014; Horisch, 2013).

It was noted that the adoption of practices of low-carbon operations management of three companies (*Alpha*, *Delta* and *Sigma*) do not present a wide and innovative variety of activities related to reducing CO_2 emissions. These practices of low-carbon operations management run by these companies are similar to the practices studied in the literature (Okereke and Küng, 2013; Sharma and Henriques, 2005; Pourbafrani *et al.*, 2014; Daneshi *et al.*, 2014; Islam and Olsen, 2014) and seems to confirm a statement made by Renukappa *et al.* (2013) that the practices related to logistics prevail initially in organisations.

In relation to the monitoring and control of emissions, three companies (*Alpha*, *Delta*, and *Sigma*) have an appropriate management in place. All three have an inventory of emissions and two of them (*Alpha* and *Delta*) state that their actions are designed to reduce CO_2 emissions.

The benefits perceived by the respondents from all three companies (*Alpha*, *Delta* and *Sigma*) are also reduced. The interviewee from *Alpha* says it realises the operational improvements, whereas the interviewees from *Delta* and *Sigma* declare the importance of these practices are to improve the reputation of the company.

P3a There is emphasis on managerial monitoring and control of emissions, with little explanation on the adoption of low-carbon practices and the perception of their benefits. The adoption of low-carbon practices and the perception of benefits tend to be related more to the organisation structure in charge of climate change issues.

Thus far, the discussion has analysed the results aligned with the theory of contingency. In other words, if there is no internal suitable organisational structure, there will be few practices and few perceived benefits. However, this article also found two other cases, *Gamma* and *Omega*, in which the companies diversify their practices of low-carbon management, adopting a wide range of practices in terms of products, processes and logistics.

According to the theory of contingency, if a company diversifies its operations, it does not guarantee greater effectiveness in its performance (Sousa and Voss, 2008; Drazin and van de Ven, 1985; Volberda *et al.*, 2012; Horisch, 2013). *Beta, Theta* and *Gamma,* showed greater contingency management of climate risks, but only *Beta* and *Theta* may be considered internally well-structured according to the literature (Renukappa *et al.*, 2013; Lee, 2012a; Pesonen and Horn, 2014).

In terms of benefits, both *Beta* and *Theta* illustrate almost all the types of benefits listed by Hoffman (2005). *Gamma* was more restricted and declared the improvement of human resource management, anticipation of regulations and operational improvement. *Omega* mentions only operational improvement.

Thus, by drawing on the concepts of contingency management, companies may diversify their actions to reduce CO_2 emissions but do not guarantee the effectiveness of these practices (Sousa and Voss, 2008; Drazin and van de Ven, 1985; Volberda *et al.*, 2012; Horisch, 2013). Therefore, it is the structure for managing low-carbon that matters and leads the company to realise more benefits. Consequently:

P3b According to the perspective of the theory of contingency, even if an organisation diversifies its practices towards low-carbon operations management, these practices themselves do not guarantee benefits. What matters is the organisational structure which supports carbon management.

Alpha, *Gamma*, *Sigma*, *Omega* and *Theta* state that they have made changes in their logistical activities to reduce their emissions. These companies utilize software and dedicated teams for the monitoring of logistics with objective of optimising routes and exchanging vehicles to reduce fuel consumption and emissions. The focus on low-carbon logistics, therefore, is aligned to the literature (Handler *et al.*, 2014; Islam and Olsen, 2014; Norlund and Gribkovskaia, 2013).

If we examine the companies *Beta, Theta, Gamma* and *Omega* together, the practices of low-carbon operations are more prominent than low-carbon logistics. Thus, this finding suggests alignment with an affirmation by Böttcher and Müller (2015) which states that companies give more importance to the practices of processes than to the logistics. However, both *Beta* and *Theta* have diversified their actions by adopting three possible practices.

Therefore, taking into account the cases studied and the use of the theory of contingency, the better the structure for low-carbon management, the greater the variety of low-carbon operations management practices adopted. Thus:

P3c From the perspective of the theory of contingency, the better the organisational structure for managing climate change, the greater the adoption of the three types of practices of low-carbon operations management.

7. Conclusion

This article has explored how organisations deal with the contingencies arising from climate change at the supply chain level. We adopted the perspective of the theory of contingency to discuss how companies understand climate change-related issues, how climate change is translated into creating a structure for managing issues of low-carbon within the companies and how the companies adopt low-carbon operations management and realize its related benefits. The theoretical background was analysed considering the Brazilian context. Through interviews with managers of seven large companies from different sectors in Brazil, a country that has recently witnessed climatic adversity (drought), it was possible to obtain the following major evidence:

- A suitable structure for managing carbon emissions (definition of management of climate risks, policies and targets to reduce CO_2 emissions, training the staff and communication of results) is essential to improve the perception of the benefits derived from the adoption of low-carbon operations management practices (products, processes and logistics).
- Initiatives for controlling and monitoring of carbon emissions seem to be insufficient to allow managers to recognise the benefits of embracing climate change strategies.
- Controlling and monitoring of climate contingencies should be something permanent and systematic (risk management) to enable a suitable organisational structure for managing carbon emissions and, consequently, for improving the perception of benefits.
- Low-carbon management initiatives are started from environmental management systems that already exist. Therefore, organisations interested in starting a strategy for managing emissions may have already commenced working on environmental systems and practices to start embracing low-carbon management practices.
- The findings of this research can potentially contribute to teaching case studies for discussing the implications of climate change in business strategy and the impacts of contingency theory for planning inner organisational structure in response to climate change risks.

Future research could explore the research propositions highlighted in Section 6 and pursue further discussions to promote additional evidence on the complex issues of climate change contingencies, supply chain, low-carbon operations management and the benefits of low-carbon management in emerging economies.

Finally, it should be emphasised that the exploratory nature of the study has its limitations. Therefore, it is suggested that the propositions made are still subject to confirmation and any tentative generalisations can be seen as fragile.

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Appendix. Script of interviews

- How are scarcity of natural resources, raw materials and restricted access to resources managed by the company? How are these threats identified, assessed and avoided? Provide examples.
- Has the company ever faced any new government law that modified its actions in the market as well as the demand for its products? How did the company manage this problem? How does the company analyse its capabilities to act in the context of climate change? Provide examples.
- How does the company adopt/follow trends regarding new low-carbon technologies? How often does the company purchase or update its technologies? Cite examples.

- How does the company monitor its operations costs to adapt to climate change issues? What are the types of costs? Cite examples.
- Has the company adopted a climate change policy? When was this policy adopted? Does the climate change policy have support from all managers in the company?
- Are there positions in the company for dealing with climate change issues? Does the company have a specific leader to manage climate change issues? Is there any kind of annual report through which the company reports its performance to stakeholders? Cite examples.
- Does the company have a specific training for employees regarding low-carbon operations? What are rewards the company provides to employees when they take part in actions in this context? How does the company monitor and manage the information about greenhouse gas emissions? Cite examples.
- Does the company have indicators to update its low-carbon operations? Does the company look to compensate, reduce or achieve carbon independence? Does the company focus on its internal processes or consider the supply chain?
- Has the company adopted practices of low-carbon products? What are the initiatives? What are the benefits managers noted in adopting practices of low-carbon production? Explain further.
- Has the company adopted low-carbon processes? What are the initiatives? Examples? What are the benefits the manager noted in adopting low-carbon processes? Explain further.
- Has the company adopted practices of low-carbon logistics? What are the initiatives? Examples? What are the benefits the manager noted in adopting practices of low-carbon logistics? Explain further.

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