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Sustainability and innovation in the Brazilian supply chain of green plastic

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ABSTRACT

Climate change has intensified the demand for better social and environmental conservation efforts, motivating organisations to become more engaged in the development of sustainable technologies. This study analyses the innovation process in the production of green plastic, a process which replaces a non-renewable resource (naphtha) for a renewable one (ethanol from sugarcane), through the lens of sustainable supply-chain management (SSCM). An in-depth case study was conducted with a Brazilian petrochemical company, including interviews with agents of the supply chain. The results show that collaborations between the focal organisation and other agents of the supply chain are important for product development. The focal organisation has created many industry-wide initiatives, such as certification programmes and seal of quality/approval, to support the production of green plastic and reduce the social and environmental impact along the supply chain.

1. Introduction

Throughout history, the use of natural resources has been central to economic development, generating such benefits as a wider variety of products available for consumption. However, while industrialisation has resulted in progress and modernity, bringing advantages to organisations and social well-being, it has also caused significant social and environmental problems.

The consequences of these production and consumption patterns have led society, particularly private, public and non-profit organisations, to take more intensive action towards sustainability. These consequences have underlaid discussions on sustainable development (SD) from the 1970s, especially those focusing on global warming, greenhouse effects and ocean acidification. These environmental issues, which have been primarily attributed to fossil-fuel burning, has sparked interest in renewable energy sources (Abbasi and Abbasi, 2012; Hall et al., 2014).

Corporations are assuming an increasingly significant role in the quest for sustainability, seeking to minimise the social and environmental impacts caused by production. Innovation is now understood as a way to contribute to SD (Boons et al., 2013; Carvalho and Barbieri, 2012; Jansen, 2003; Matos and Silvestre, 2013; Seyfang and Smith, 2007; Silvestre, 2015a, b; Smith, 2010; Vollenbroek, 2002).

Sustainability-oriented innovation may include renewable resources, reverse logistics, eco-efficiency, green supply chain and the involvement of the entire supply chain. It can also be considered an environmentally friendly business strategy (Hansen et al., 2009; Katsikeas et al., 2016). The use of renewable energy sources provides an alternative to fossil fuels, thereby improving the environment. For example, the petrochemical industry substitutes the

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use of green plastic, which is the topic of the present research.

Green plastic (green polyethylene [PE]) differs from traditional plastic in terms of sustainability, as green PE helps reduce greenhouse gas (GHG) emissions along the production chain. The cultivation of sugarcane, which sources green PE production, also aids in the capture and sequestration of carbon, which contribute to climate change mitigation. Green PE is the first certified plastic made from a renewable source worldwide, making the petrochemical industry a pioneer in this field.

Another concept emerging from green production is sustainable supply-chain management (SSCM). In general, SSCM involves characteristics of business sustainability (i.e. economy, environment, society, stakeholders, volunteers, resilience and long-term goals) and supply-chain management (SCM) (i.e. flow, coordination, stakeholders, relationships, value, efficiency and performance) (Ahi and Searcy, 2013; Diabat et al., 2014). The discussions on innovation, SD and SSCM provide a backdrop for modifications made in the petrochemical production chain over recent years, including the use of raw materials (as renewable energy) for green plastic production. These modifications are especially observed in Brazil, an emerging economy, which has positioned itself as a global leader in sustainable energy and agriculture through technological innovation (Hall et al., 2011).

In consideration of the arguments presented, the present study analyses the innovation process in the production of green plastic, a process which replaces a non-renewable resource (naphtha) for a renewable one (ethanol from sugarcane), through the lens of SSCM. Many previous studies (e.g. Ahi and Searcy, 2013; Carter and Rogers, 2008; Diabat et al., 2014; Dubey et al., 2017; Gosling et al., 2017; Reefke and Sundaram, 2017; Seurer and Muller, 2008; Svensson, 2007) have developed frameworks for the study of SSCM, but each provides only a brief description of the enterprise-led initiatives. The present study applies the concept of SSCM within a specific context: green plastic production by an important organisation in the Brazilian petrochemical industry. In addition, this study aims to demonstrate the importance of engaging supply-chain agents in the sustainable development of the product.

This article is organised into five sections, beginning with the introduction. In the second section, we present the methodology. The third section outlines the theoretical background. In section four, we analyse the results obtained from the data collection. Finally, section five concludes our research and provides recommendations for future studies.

2. Materials and methods

The present study is classified as exploratory and descriptive, focusing on a qualitative approach and using data collected through field research. A case study of a Brazilian petrochemical company that develops green plastic was conducted. To preserve anonymity, the company's name and precise location has been withheld.

There are five main stages in the production chain of green plastic. The first stage consists of sugarcane cultivation. The sugarcane produced is sold to power plants that supply ethanol, which is the second stage. The petrochemical company (the focal organisation) is involved in the third stage of the supply chain. The fourth stage includes manufacturing by third-generation organisations within the plastic industry, which transforms green PE into various products. The fifth stage, which is not analysed in this research, is consumption, which involves wholesalers, retailers and/or the final consumers, depending on the sales strategy of each manufacturing industry.

To better understand the organisational dynamics of the first and second stages, we analysed the Code of Conduct for Ethanol Suppliers of FOs (information gathered from a report by the FO) and other documents and bibliographies related to this issue. Regarding the third and fourth stages of the supply chain, we performed interviews with key informants, which provided information on business strategy necessary to this research. Based on the theoretical background, two scripts were designed for the semi-structured interviews: one for the focal organisation (third stage) and another for the manufacturers (fourth stage). These interviews were conducted in-person and online, depending on the interviewees' availability (Table 1). The average duration of each interview was 65 min.

We conducted interviews with seven agents involved in the supply chain of green plastic. This sample size was determined by the concept of saturation, which refers to when the collection of new data does not add more information related to the issue under investigation (Mason, 2010). The sample size, although low, allowed for a satisfactory overview of the relationships between the agents of the supply chain. The interview transcripts totalled 34 pages. After transcribing the interviews, we organised the material in preparation for the content analysis, which followed three phases: analysis and material exploration, treatment of results and interpretation (Bardin, 2016).

2.1. Green plastic

The present research explores the production of plastic resins as part of the petrochemical industry, focusing on green plastic. Green plastic is also known as green polyethylene (PE), green polymer, biopolyethylene, biopolymer, polymer resin or green resin.

The chemical industry is one of the leading industries worldwide, and the petrochemical sector is one of its most significant components. The global industry of plastic resins is formed by multinational, vertically integrated chemical organisations. The FO under analysis integrates the first (basic petrochemicals) and the second (thermoplastic resins) generations of the production process for traditional and renewable plastics. The FO has a thermoplastic resin and basic chemical production capacity of 16 million tonnes per year (information gathered from a report by the FO).

Global demand for renewable products has initiated the development of innovative products within the chemical industry. Bioplastics, also known as bio-based polymers or biodegradable polymers, are currently available on the market (European Bioplastics, 2016). In Brazil, bioplastic production using sugarcane is possible due to the nation's climatic advantages and the extent of land available for this crop. In response to the debates on global warming and GHG emissions, renewable resources serving as raw material for manufacturing plastics have emerged as an alternative to fossil fuels and assist with carbon-dioxide capture. The FO creates and enhances biodegradable polymers from renewable resources, the most notable of which is green plastic made from sugarcane-derived ethanol. In this case, sustainability is mainly achieved through a renewable resource, which promotes a low-carbon economy.

From sugarcane cultivation to the production of green polyethylene, each kilo of green polyethylene produced captures about 3.09 kilos of CO_2 (the life cycle assessment of green polyethylene cited by the FO), which is a calculation that considers the CO_2 gains and losses in all stages of the production process. The importance of green plastic is demonstrated in a comparison to previous data on naphtha, a traditional polyethylene.

CO_2 is captured from the atmosphere during sugarcane cultivation and remains fixed during the entire life cycle of green plastic products. To ensure that the green plastic produced is renewable, the world leader in analysing carbon isotopes conducts dating tests of the products across all lots at the FO (information gathered from a report by the FO).