Impact of bio-based packaging on supply chain complexity

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Purpose

Plastics encompass an essential part of many products that are used in people's daily lives and are a choice material in the packaging industry due to their light weight, cost-effectiveness, functionality, and durability (Reichert et al., 2020). However, plastic packaging poses considerable concerns to the environment regarding rising levels of plastic waste and poor waste management. Therefore, governments are introducing legislation and regulations to control plastic pollution, and companies are moving toward greener packaging to reduce waste and enhance their brand image (Grubor & Milovanov, 2017). Accordingly, bio-based packaging (BBP) has shown substantial growth as the demand for BBP materials is expected to grow tremendously by 2023 (Reichert et al., 2020). A major barrier to adoption of BBP within companies relates to operations and supply chain management (Ritzén & Sandström, 2017). Introducing new materials, processes, and suppliers coincides with the increased complexity in supply chains. Supply chain complexity refers to the level of variety in products, processes, and relationships (detail complexity) considering unpredictability and indistinctness (dynamic complexity) that make up a supply chain (Bozarth et al., 2009; de Leeuw et al., 2013). The multi-dimensional construct of supply chain complexity is summarized into eight drivers: uncertainty, diversity, size, variability, structure, speed, lack of information synchronization, and lack of cooperation (de Leeuw et al., 2013). In this article, we aim to answer the following research questions:

1) *What are the implications of BBP on supply chain complexity?*
2) *How does the adoption of BBP within companies vary based on these implications?*

Design/methodology/approach

In this article, the case study research method is utilized. After problem formulation, we identified two BBP solutions, which are currently implemented by several companies throughout their operations and supply chains. The first is PlantBottle, a fully recyclable plastic bottle made partially from plants, and the second is EcoFishBox, a fully recyclable box made of renewable wood fibers from sustainably managed forests. Following the approach of a comparative case-study design (Yin, 2017), we selected one company from each BBP solution and constructed a focal company's supply chain diagram. To determine supply chain complexity before and after implementing BBP solutions, we compared diagrams regarding the complexity drivers based on literature (Bozarth et al., 2009; de Leeuw et al., 2013). We analyzed complexity originating in manufacturing facilities as well as upstream supply and downstream markets.

In the first case, Coca-Cola's implementation of PlantBottle for their 500 ml classic coke is studied using primary data collected through a semi-structured interview with a communications and sustainability manager, in addition to secondary data derived from publicly available information from Coca-Cola.

In the second case, Kalaneuvos's implementation of 10 kg EcoFishBox for fresh fish is studied using primary data collected through a semi-structured interview with the Chief Operating Officer (COO), in addition to secondary data available in scientific life cycle assessment publications.

Findings

In the first case (Figure 1), the implementation of PlantBottle has increased the level of upstream complexity (both detail and dynamic). Since PlantBottle is made from a combination of fossil- and bio-based plastic, supply, transport, and storage of biomaterials are added to Coca-Cola's current operations. Thus, this solution is not scalable to be utilized for other Coca-Cola products and is even going to be replaced by another carbon-efficient packaging solution: a fully recyclable plastic bottle made of 100% recycled materials.

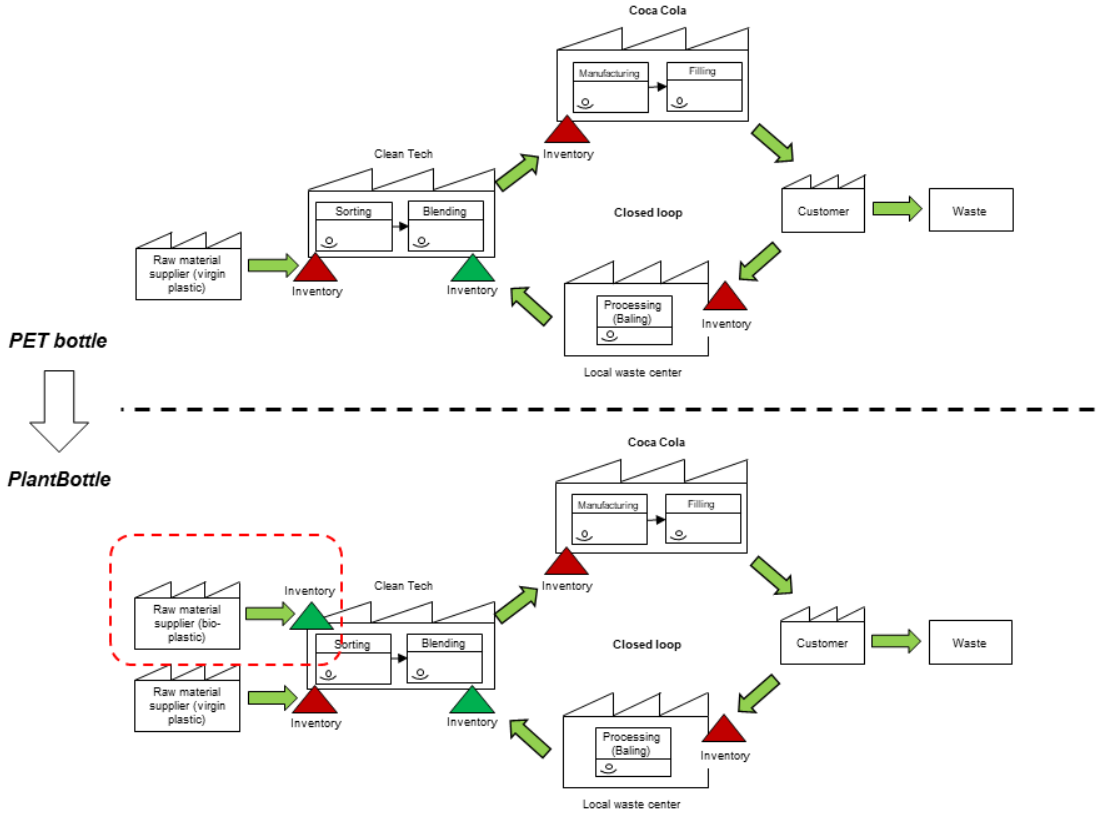

Figure 1. Coca-Cola's 500 ml classic coke supply chain before and after implementing PlantBottle

In the second case (Figure 2), the level of all internal manufacturing, upstream, and downstream complexities are significantly reduced after implementing the BBP solution. The EcoFishBox takes seven times less space in transport and storage than traditional expanded polystyrene (EPS) boxes, as they are transported flat. The EcoFishBox is offered alongside automation for assembly and transport in the Kalaneuvos factory, which leads to greater productivity with less labor. Furthermore, EcoFishBox simplifies waste handling for customers by being easy to flatten and recycle. Due to reduced supply chain complexity and operational

benefits, Kalaneuvos aims to expand the use of EcoFishBox to their other products and eliminate the use of EPS boxes as much as possible.

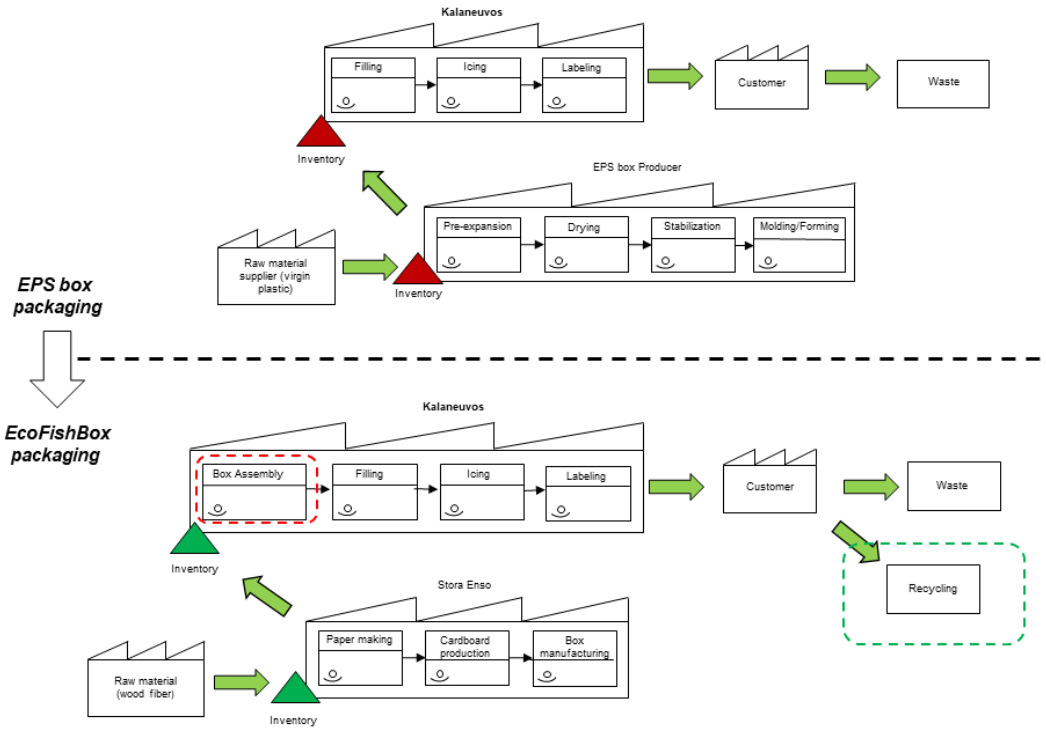

Figure 2. Kalaneuvos's 10kg fresh fish fillets supply chain before and after implementing EcoFishBox

Relevance/contribution

This article extends a detailed understanding of BBP implementation by applying existing theory on supply chain complexity (Bozarth et al., 2009; de Leeuw et al., 2013. Specifically, we illustrate that depending on the type of BBP solution, its implementation can have varied implications on supply chain complexity—either more complexity or less. Moreover, considering the barriers to a sustainable transition (Ritzén & Sandström, 2017) and Roger's adoption theory (Rogers, 2017), a BBP solution that reduces supply chain complexity has a higher adoption rate and more potential for expansion since it overcomes an operational barrier to a sustainable transition.

Regarding managerial contributions, our study has the potential to help company managers opt for an appropriate BBP solution based on its implications on supply chain complexity considering discussed opportunities and obstacles.

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