

Postponement Strategies for Global Downstream Supply Chains: A Conceptual Framework

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Abstract

Postponement is a well-known organizational concept and usually relates to the deferment in time of manufacturing and/or logistics operations. In the current global competitive landscape, situations where postponement can be applied are rapidly increasing. Faced with the wide range of customs duties and free trade agreements currently in place, companies need to (re)design their postponement strategies to customize their products appropriately, and to the proper degree, in each market. As the actual location where operations take place has a major impact on a company's overall performance, the spatial perspective must also be taken into account when designing global postponement strategies, alongside the conventional temporal perspective.

Heretofore, the academic literature does not offer any comprehensive framework on a global scale either for handling what is known as the postponement boundary problem, or for conceptualizing the related postponement strategies. Building on previous research, the aim of the present study is to investigate the postponement concept in a global environment with a downstream focus. The intended purpose is twofold: first, to review and expand previous studies on the subject and, second, to provide some guidelines for conceptualizing global postponement strategies.

A structured literature review was first conducted, followed by the development of a framework that combines both the temporal and the spatial dimensions. Finally, the framework was applied to a group of 28 business cases taken from the literature, to act as a bridge between academic theories and practitioners' current business operations.

Keywords: postponement, global supply chain, international distribution, downstream network design, conceptual framework.

Introduction

First proposed in the mid-20th century (Alderson, 1957) as the “simple but powerful idea that timing matters in marketing and distribution” (Zinn, 2019; p. 66), postponement is currently a well-known organizational concept that can be applied to different parts of the supply chain. It describes the strategy whereby any movement or final configuration of goods is delayed for as long as possible (Bucklin, 1965; García-Dastugue and Lambert, 2007), if not explicitly until receiving the customers’ orders (Zinn and Bowersox, 1988; van Hoek, 2001).

Several different postponement strategies have been proposed within the context of supply chain management and logistics (Zinn and Bowersox, 1988; Yang et al., 2004b; Boone et al., 2007), all of which involve a combination of three basic elements: form, time, and place postponement (Bowersox and Closs, 1996; Pagh and Cooper, 1998). According to the part of the supply chain considered, a further distinction between upstream and downstream postponement emerges (Ernst and Kamrad, 2000; Waller et al., 2000). From a strictly downstream perspective (i.e., from factories to customers), postponement refers to light manufacturing operations (such as assembly, packaging, or labeling) where no product re-design or change to the work sequence comes into play (Zinn and Bowersox, 1988). It affects the representation of either the customer order decoupling point (CODP; van Hoek, 2001) or the differentiation point (DP; García-Dastugue and Lambert, 2007). Several frameworks have been proposed as blueprints for studying postponement strategies. Concerning downstream postponement, it would appear that the most popular framework was the one suggested by Pagh and Cooper (1998). They associated form postponement with manufacturing, and time and place postponement with logistics, linking them to customers’ orders and thus referring to a temporal perspective (as per Zinn and Bowersox, 1988).

A global approach toward postponement is not new to the research agenda (Cooper, 1993; van Hoek, 1996; van Hoek, 2001). Nevertheless, global supply chains have evolved over time, being affected by factors such as government regulations, subsidies provided by governments, customs tariffs, international trade and transport considerations, differences in workers’ knowledge and expertise,

and differences in international production costs (MacCarthy and Atthirawong, 2003; Häntsch and Huchzermeier, 2016). Therefore, in the current competitive landscape, new opportunities for implementing postponement strategies are on the rise (Lee, 2010; Olhager et al., 2015). Faced with the many customs duties and free trade agreements currently in place, companies need to (re)design their postponement strategies if they intend to achieve the right level of product customization in each market region (Choi et al., 2012). According to Lee (2010), the key question is “what should be the portion of the product to be built at the factory, and what should be the portion to be built at the (multiple and distributed) distribution centers that are in the market regions. [...] Defining what is to be assembled in the factory and what is to be assembled in distribution is termed the postponement boundary problem” (p. 178 and 182).

The importance of introducing a spatial perspective alongside the temporal one has been already acknowledged in literature (van Hoek, 1996), but the existing contributions mainly deal with specific cases/strategies of global postponement (Choi et al., 2012; Guericke et al., 2012), and no general framework is available for conceptualizing postponement on a global scale from a downstream perspective.

The present study aims to build on previous research, specifically the work undertaken by Pagh and Cooper (1998) and Lee (2010), and develop an original framework that conceptualizes postponement in a global environment while also addressing the postponement boundary problem. Following Waller et al. (2000), this study intends to pave the way for future research on the topic and provide the basis for further studies on different strategies in relation to cost effectiveness and fields of application.

The research was conducted in two main phases. The first phase involved a structured literature review (SLR) on global postponement with a specific focus on downstream supply chain processes. In the second phase, a conceptual framework was developed. As a result, 12 different postponement strategies were identified. To validate the framework’s effectiveness in classifying these strategies, as well as to highlight their application, 28 business cases taken from the literature were positioned

within the conceptual framework's effectiveness in classifying these strategies and to demonstrate their application, 28 business cases from the literature were positioned within the conceptual framework. The framework was then expanded to focus on one postponement strategy at a time, thereby showing how the spatial and temporal perspectives can be combined when defining postponement strategies within global downstream supply chains.

The remainder of the paper is organized as follows. The next section contains the literature review, followed by a section on the research questions (RQs) and methodology. The development of the framework is subsequently described and applied to the 28 business cases taken from the literature. The contribution of this study in the literature and its main elements of novelty are presented in the discussion section. Finally, conclusions are drawn, together with considerations about possible directions for future research.

Literature Review

Postponement has a long history in terms of its practical applications as a strategy, as well as being a concept studied within the academic literature (Pagh and Cooper, 1998; Zinn, 2019). It was first proposed as a method for improving efficiency in marketing systems. The aim was to reduce costs related to uncertainty and the physical movement of goods, by delaying changes to either the product's form or the inventory's location to the latest possible moment (Alderson, 1957; Bucklin, 1965).

Building upon this concept, several studies tackled the problem by analyzing three basic elements: time postponement, form postponement, and place postponement (Zinn and Bowersox, 1988; Bowersox and Closs, 1996; van Hoek, 1997). Furthermore, Zinn and Bowersox (1988) introduced the concept of delaying the final form/configuration of a product or its delivery until receiving the customers' orders, rather than generically delaying to the latest possible point in time. Although most of the extant contributions looked at postponement from the perspective of internal supply chains (van Hoek, 2001; Yang et al., 2004b), some scholars applied postponement as part of an external

supply chain approach (Yang and Burns, 2003; García-Dastugue and Lambert, 2007). Table 1 summarizes the relevant literature on time, form, and place postponement, highlighting that multiple – and sometimes contradictory – definitions have been introduced over time. For a comprehensive overview, refer to Zinn (2019) or to other literature reviews available in the field (van Hoek, 2001; Yang et al., 2004a; Boone et al., 2007).

- Take in Table 1 -

CODP versus DP

The postponement process may start at the manufacturing, assembly, packaging, or labeling operations (Zinn and Bowersox, 1988; Kouvelis et al., 2004; Pashaei and Olhager, 2017).

Since postponement helps businesses to cope with uncertainties (Yang et al., 2004a), it is closely linked to two concepts that are also used in mass customization: the CODP and DP (Ernst and Kamrad, 2000; Hsuan Mikkola and Skjøtt-Larsen, 2004). CODP is the point in the flow of materials or the stage in the manufacturing value chain (Brun and Zorzini, 2009) where a product is linked to a specific customer order (Wong et al., 2009). Internal supply chains usually involve a single CODP, whereas multiple CODPs may be needed in external supply chains (García-Dastugue and Lambert, 2007). The further upstream the CODP is placed, the higher is the level of form postponement (van Hoek, 1997).

The DP is defined as the point or stage in the production process where semi-finished goods (i.e., work-in-process) that are yet to be diversified are customized through specialized processes and/or components to create a series of different end products (Lee and Tang, 1997; García-Dastugue and Lambert, 2007). There may be more than one DP within a single production process, and each depends upon the product's specific features and the relative market segments and sales regions (Yang and Burns, 2003). The purpose of form postponement is to move the DP as far downstream as possible, by redesigning the process and/or by standardizing and/or modularizing the components.

The terms CODP and DP have sometimes been treated as synonyms (Mason-Jones and Towill, 1999), although they are two distinct concepts (García-Dastugue and Lambert, 2007; Zinn, 2019). From a downstream perspective, positioning the CODP based on customer orders or forecast demand appears to reflect the various measures employed in push and pull strategies. Starting from the assumption that postponement is a strategy at the boundaries of push and pull, postponement constitutes the decision taken by a company to delay the manufacturing of a specific product until the customers' orders are received, or until demand is certain or can be pinpointed more accurately (Simchi-Levi et al., 2003). This clear link to the temporal dimension (“*when*”) is not necessarily the case when applying the DP (García-Dastugue and Lambert, 2007).

Manufacturing and Logistics Postponement

Several frameworks have been proposed (Cooper, 1993; Pagh and Cooper, 1998; Yang et al., 2004a) to study postponement strategies through a combination of the three basic elements of form, time, and place postponement. Concentrating on a downstream perspective, Pagh and Cooper (1998) developed a two-axis framework whereby form postponement is associated with manufacturing, and time and place postponement with logistics. Manufacturing postponement refers to “*what*” final manufacturing operations are to be performed to customize the product after the customers' orders are received. This also means that the same components and/or modules can be used for a variety of end products (Lee and Billington, 1994; Hsuan Mikkola and Skjøtt-Larsen, 2004). CODPs and/or DPs can be used to determine the point at which products are transformed to acquire their unique identities (Yang and Yang, 2010).

Logistics postponement, on the contrary, refers to the place where the inventory is held, and consists of deferring in time any change to the inventory location occurring downstream in the supply chain (for instance, stock centralization in a single warehouse). As a stand-alone concept, logistics postponement refers to delaying the distribution of finished products (Weskamp et al., 2019). When combining logistics postponement with manufacturing postponement, inventories can refer to either

finished or semi-finished products or both, depending on the manufacturing postponement strategy adopted (van Hoek, 1996; Pagh and Cooper, 1998). In this broader perspective, logistics postponement can refer to shipping finished or semi-finished goods from central factories to the downstream nodes of the distribution network (Weskamp et al., 2019). Consequently, when referring to manufacturing operations, logistics postponement can enable one or more final manufacturing operations (light manufacturing, final assembly, packaging, and labeling) to be performed downstream in the supply chain (Pagh and Cooper, 1998). The inclusion of postponement aspects in distribution network design is usually referred to as “customizing in the channel” (Schwartz and Voß, 2007; MacCarthy and Jayarathne, 2010; Chaudhry and Hodge, 2012). It aims to reduce demand uncertainty and/or offer customers a higher level of customization, in line with the waiting time accepted by these customers and the economies of scale for each activity (Waller et al., 2000; Aviv and Federgruen, 2001; Wong et al., 2011). Pagh and Cooper (1998) paved the way for most of the subsequent work in this area (van Hoek, 2001; Yang and Burns, 2003; Cholette, 2009; Olhager, 2010).

Factors Relevant to Postponement in Global Downstream Supply Chains

The application of postponement in global supply chains has attracted increasing interest since the late-20th century (van Hoek, 2001; Boone et al., 2007; Zinn, 2019). Two literature streams can be identified among the papers covering postponement strategies on a global scale. The first stream comprises studies investigating the enablers, drivers, and benefits of postponement strategies in global downstream supply chains, without taking into account the logistics aspects related to cross-border shipments and the associated costs and risks (van Hoek, 1996; Twede et al., 2000). The potential benefits of applying postponement within a global supply chain lie in the potential reduction in stock-holding and transport costs (Cooper, 1993; Lee et al., 1993), as well as the improvement of the supply chain’s environmental footprint (Varsei et al., 2017; Harris et al., 2018). At the same time, companies applying this strategy can continue to achieve economies of scale in the upstream stages

(Yang and Burns, 2003; Abukhader and Jonson, 2007). Further, they can improve the supply chain's flexibility (Fan et al., 2017) without affecting, other than improving, customer service levels in terms of product range (van Hoek, 1996; van Hoek, 2001) and lead time/responsiveness to local market requirements (Yang and Burns, 2003).

In the second literature stream, studies claim that additional factors should be considered in addition to inventory centralization. These include the following: (1) customs duties and tariffs (Goetschalckx et al., 2002; Mariel and Minner, 2015), especially when comparing the different duty rates charged for components and finished products (Lee et al., 1994; Choi et al., 2012); (2) trade barriers and cross-border trade processes (Lee, 2010); (3) transfer prices and corporate tax rates (Vidal and Goetschalckx, 2001; Fernandes et al., 2015); (4) government regulations and local content requirements, or LCRs (Lee, 2010); (5) different transport modes (Zeng and Rossetti, 2003; Fan et al., 2017); and, (6) the fluctuating costs of production factors (Ferdows, 1997) and of raw materials and components across different countries (Lee and Billington, 1994).

Table 2 provides a summary of the main factors to be considered when designing a global postponement strategy, which have emerged from the analysis of the literature.

- *Take in Table 2-*

Postponement Strategies for Global Downstream Supply Chains

A company operating in a variety of international markets can customize and localize products closer to its market, according to customer demand and local market circumstances (Cooper, 1993; Chiou et al., 2002). In domestic supply chains, the primary objective of postponement is to reduce the costs of uncertainty by tackling lead time considerations, as well as inventory reduction options (Pagh and Cooper, 1998). In global supply chains, however, as discussed in the previous section of this review, the allocation of light production operations to the downstream nodes of the network is also driven

by other factors. Consequently, the geographical reconfigurations involved in implementing postponement strategies within global supply chains deserve further investigation (van Hoek, 2001). While upstream activities are centralized in one or a few facilities (factories), the final manufacturing operations may take place in facilities closer to the end customers, thereby involving an international transport stage (Lee, 2010). In this way, one or more operations can be postponed by up to several weeks without modifying the product or the process, because of the long ocean freight transit times (van Hoek, 1996; Guericke et al., 2012). In addition, the search for profit optimization could lead to a global supply chain structure where some operations are performed within the global distribution network even when they are not based on customers' orders (Lee, 2010). Therefore, when designing global postponement strategies, it is necessary to consider a spatial perspective ("*where*") in addition to the purely temporal perspective ("*when*"), and the various downstream manufacturing operations must be considered independently from each other (van Hoek, 1996; van Hoek, 2001).

Although some authors have examined the area of distribution network design when studying the various aspects of a postponement strategy (Schwartz and Voß, 2007), the notion of broadening the viewpoint to a global perspective is still under-examined in the academic literature. An issue that emerged was how to select the operations to be performed within the international distribution network rather than in the centralized factories and this was defined as the postponement boundary problem (Lee, 2010). The problem was originally formulated for assembly operations and was subsequently extended to the entire manufacturing and distribution process (Choi et al., 2012), highlighting how it can lead to significant cost savings in a global supply chain (Guericke et al., 2012).

RQs and Methodology

In the light of the geographical challenge for postponement raised by van Hoek (2001), the present study builds on previous research – in particular, on Pagh and Cooper (1998) and Lee (2010) – to develop an original framework for studying postponement in a global environment. The study tackles

the perspective of internal supply chains, in line with Zinn and Bowersox (1988) and Pagh and Cooper (1998). The need to identify and analyze research that summarizes current practices has led to the development of a blueprint that is both theoretical and descriptive, set out according to the definitions provided by Croom et al. (2000).

The intended aim is twofold: first, to consolidate and categorize the previous contributions and further expand this research topic and, second, to provide some guidelines for conceptualizing global postponement strategies. The present conceptual framework focuses on downstream supply chain processes, meaning that operations such as product design, sourcing of raw materials, and production of components are out of the scope of this study.

To address this specified aim, the following RQs have been identified:

- RQ1: What dimensions come into consideration when studying global postponement strategies with a downstream focus?
- RQ2: What are the resulting global postponement strategies?

The research to address these RQs was conducted in two main phases. In the first phase, an SLR was conducted to understand the features related to postponement and the associated strategies, with a specific focus on global downstream supply chains. The literature review provided the means to identify the relevant patterns, themes, and issues while also helping to identify the conceptual content of the field and contributing to developing the theory (Seuring and Muller, 2008). The review protocol, shown in Figure 1, is based on the SLR guidelines (Durach et al., 2017) that have also been applied in recent publications (Kembro et al., 2018).

- Take in Figure 1 -

A first preliminary review was conducted to identify the gap in research within the field and define the scope of the SLR and the appropriate terminology (Kembro et al., 2018). Following this initial review, the criteria to be used to identify the relevant literature were then established. Given the

specific scope, the focus was on literature dealing with global downstream supply chains and/or the possibility that manufacturing operations were taking place within distribution networks. As such, studies focusing only on upstream postponement strategies or modularization were excluded. The contribution by Zinn and Bowersox (1988) emerged as the seminal publication, and hence it was decided to examine postponement literature published between 1988 and January 2019. The material investigated included international peer-reviewed scientific journal papers, conference proceedings, and work papers and books, all published in English and falling within the subject areas of engineering, operations research management, business management and accounting, management, and decision sciences. To minimize the risk of excluding relevant literature, the most commonly used digital and complementary databases – Scopus, Web of Science, and Business Source Complete (via EBSCOhost) – were utilized. The identified keywords (postponement, global, downstream, supply chain, strategy, distribution, and logistics) were applied in combination with Boolean operators (OR and AND). The duplicates were removed based on a search by title. Two of the authors carefully read the complete text of each remaining publication, and backward and forward cross-referencing were then applied. The entire procedure led to 61 articles/publications being identified; they were subsequently taken into account for the SLR. The selected publications mainly focused on classification models for postponement strategies, conceptual and quantitative research on the postponement boundary problem, and the implementation of postponement strategies in global supply chains.

Starting with the results obtained in the first phase, the second phase consisted of developing a conceptual framework for global postponement strategies, with a specific focus on downstream supply chain processes. The result was a two-step framework based on the dimensions of “*what*”, “*where*”, and “*when*”, as determined in the literature review. The first step was based on the “*what*” and “*where*”, while the second step brought also the “*when*” into the picture. The framework was then used to classify 28 business cases taken from the literature, to validate the framework’s robustness and to highlight its practical relevance, in line with van Hoek (2001).

Framework Development and Application

To address RQ1 (“What dimensions come into consideration when studying global postponement strategies with a downstream focus?”), the conceptual framework presented in Figure 2 was constructed.

- Take in Figure 2 -

The framework refers to a global downstream supply chain where multiple operations are to be performed and the factory and customers are located in different geographical regions. Geographical regions are assumed to be different if the downstream supply chain process entails going through customs (Lee, 2010), meaning that each free-trade zone can be viewed as a distinct region (Krugman, 1991).

The “*where*” and “*what*” discussed in the literature section are represented by two axes, with the horizontal axis referring to the region/s where the operations take place (“*where*”) and the vertical axis referring to the type of downstream supply chain operations (such as manufacturing and/or distribution) that potentially take place in each region (“*what*”).

As regards the “*where*”, three options were identified:

- **Home region:** the place where the main production facility is located. This facility manufactures the components that are later assembled into finished products. Each final manufacturing process can be performed either in this facility or downstream in the supply chain. Depending on the service level constraints, the customized finished products can also be held in this region, ready to be shipped downstream once the customers’ orders have been received, in line with Cooper (1993).
- **Third-country region:** a geographical region outside the location of the factory and the customers’ sites. As reported by Henkow and Norrman (2011), some companies design distribution networks based on fiscal optimization. This may lead to the introduction of cross-

border activities (related, for example, to manufacturing, transport, and/or distribution). For instance, a company may open a warehouse in a third-country region to serve one or more destination regions. In some cases, it can be beneficial to distribute finished products from a facility of this kind. As an example, when service level requirements are such that it makes no sense to hold inventories in the company's home region, the risk-pooling effect (Zinn and Grosse, 1990) can still be exploited by centralizing stock intended for several end markets within the third country. Additionally, one or more final manufacturing tasks can be completed in this region. A possible economic reason for this choice may be linked to production factor costs that are lower compared to those in the company's home region or destination region (Lee, 2010), or to fiscal issues (Henkow and Norrman, 2011). Companies may also use this strategy when the duties charged for importing goods to the destination region are lower if the product's origin is in the third country rather than in the company's home region (Goetschalckx et al., 2002). In practice, the advantage of lower duties can be exploited only when the manufacturing operations conducted in the third country result in a "substantial transformation" of a product.

- **Destination region:** the end market region, where products are delivered to customers. One or more warehouses can be located in this area so that stock is held nearer to the market, as per van Hoek (2001). The manufacturing process may be completed at these regional warehouses, after transporting the semi-finished products internationally from other countries/regions.

Looking at the vertical axis (the "*what*"), the operations identified consist of (1) the assembly of components into finished products, (2) packaging, (3) labeling, and (4) the distribution of the finished products. The vertical axis refers to all the operations that can be carried out in the downstream supply chain. These tasks can be postponed from either a temporal or a spatial perspective, and it has been assumed that they can take place either in the factory or in other nodes in the global distribution network (Guericke et al., 2012). As mentioned, the concept of postponement boundary problem was

originally devised for assembly operations (Lee, 2010), but was further extended to the other operations executed downstream in the supply chain, as per Zinn and Bowersox (1988) and Guericke et al. (2012).

A two-step classification framework was derived from the framework presented in Figure 2. In the first step, the conceptual framework was adopted to compare and classify different postponement strategies for global supply chains. Here, the “*what*” was expected to be the first operation to be postponed (as per Figure 3; see the “Classification framework for postponement strategies in global downstream supply chains – Step 1” section below). Figure 3 displays the possible global postponement strategies for downstream supply chains. The first operation to be delayed from a geographic viewpoint corresponds to the point at which global postponement is introduced and this, in turn, identifies the corresponding global postponement strategy.

Having established the activity position on the vertical axis (the first task to be postponed), the assumption was that all previous operations are carried out in the home region. This process led to 12 different postponement strategies being identified, thus addressing RQ2 (“What are the resulting global postponement strategies?”) based on the first activity to be postponed in combination with its associated region.

In the second step, the conceptual framework was elaborated further to address one postponement strategy at a time. In this case, the vertical axis corresponded to all the manufacturing operations to be executed in the downstream supply chain, and the horizontal axis (“*where*”) showed where each activity took place. Moreover, since this representation simultaneously shows all the operations to be performed, a third dimension (“*when*”) was introduced to indicate at which point each of these tasks would be performed (that is, according to either forecast demand or customer orders).

The sections below provide a detailed explanation of the proposed framework for the two applications.

Classification Framework for Postponement Strategies in Global Supply Chains – Step 1

The first step in this classification framework is presented in Figure 3. The spatial and temporal distribution of each manufacturing/distribution operation along the network are not addressed, because the main aim here is to classify all the postponement strategies that can be employed, together with identifying other solutions to the postponement boundary problem defined by Lee (2010), by adopting a spatial perspective alone.

- Take in Figure 3 -

The position of a given activity on the horizontal axis (“*where*”) helped to divide the postponement strategies into the following categories:

- **“Pure” postponement strategies:** The term “pure” refers to strategies that include a traditional perspective on postponement, in line with Yang and Burns (2003), with manufacturing occurring in the home region. Other activities are still carried out in the production region but, in this case, no geographic postponement comes into play since the operations take place within the same region and so only temporal postponement can occur. Therefore, in the case of “pure” strategies, the decision to postpone operations is usually driven by the customers’ orders, in line with Pagh and Cooper (1998) and Yang and Burns (2003).
- **“Third-country” postponement strategies:** The first task to be postponed (such as packaging, in the case of “third-country packaging postponement”) is completed in the third-country region after the finished or semi-finished goods shipped from the home region are received. One or more operations take place here and the goods are then forwarded to the destination regions.
- **“Global” postponement strategies:** One or more manufacturing and/or distribution operations are carried out in the destination regions, after the semi-finished goods (in global

“assembly”, “packaging”, or “labeling” postponement) or finished products (in “global logistics postponement”) have been transported internationally.

The position of a given operation/activity on the vertical axis (“*what*”) was intersected with the location on the horizontal axis (“*where*”), defining where the first task to be geographically postponed is undertaken and thereby identifying 12 different postponement strategies for global supply chains.

The strategies that involve cross-country flows within the same home and destination region were considered out of scope as, in those cases, the selection of the configuration could be driven by offshoring issues (such as lower production costs) rather than postponement strategies.

Finally, to validate the framework’s effectiveness in classifying postponement strategies, 28 business cases from the literature were positioned within the framework and then classified. These 28 business cases are shown in Figure 3 and described in the Appendix.

The suitability and robustness of this framework were demonstrated when it was applied to the various cases, as all of them were fully described and (re)classified. The specific business cases and their respective postponement strategies set within the framework are reported in Table 3.

- *Take in Table 3* -

Examining the classification framework in Figure 3, 10 of the 12 strategies in the framework are shown to be associated with a corresponding business case taken from the extant literature. Additionally, both of the missing strategies relate to “third-country” postponement. Although this latter subject is gaining interest among academics (e.g., Henkow and Norrman, 2011), the topic is still under-represented and would merit further consideration.

Classification Framework for Postponement Strategies in Global Supply Chains – Step 2

In the second step, the classification framework shown in Figure 3 was elaborated further to focus on one postponement strategy at a time. Starting from a given postponement strategy, the main aim here was to display the spatial distribution (“*where*”) of each manufacturing and distribution operation along the network. For this purpose, the vertical axis (“*what*”) assumed a different meaning in Step 2 compared to that in Step 1, since it referred to all manufacturing operations to be executed in the downstream supply chain, rather than only to the first task to be geographically postponed.

Moreover, the temporal dimension (“*when*”) was explicitly introduced here by separating the operations undertaken before receiving the customers’ orders (forecast-driven activities) from those performed afterward (order-driven activities). To be more precise, given that the CODP separates the operations that are carried out according to demand forecasts from those carried out after the customers’ orders are received (van Hoek, 1997; Wong et al., 2009), there is a clear distinction between the activities positioned before or after the CODP (denoted by a white or black circle in Figure 4, respectively). Thus, in the second step of the classification framework, each global postponement strategy (as per Figure 3) can be mapped in terms of activities to be performed, related regions, and how the operations are positioned with respect to the CODP. Once the postponement strategy has been defined (according to its “*where*”), the same strategy can relate to different positions for the CODP. The spatial and temporal dimensions are not necessarily correlated with each other. For instance, as shown in Figures 4 and 5, packaging can take place in the destination region based on orders (Figure 4) or on forecasts (Figure 5), highlighting two different facets of the same strategy.

- *Take in Figure 4 –*

- *Take in Figure 5 -*

As an example, Figures 4 and 5 show two applications of the second step in the classification framework. They describe the global packaging postponement strategy, where components are assembled in the home region (based on forecasts) whereas the packaging, labeling, and distribution of the finished product are carried out in the destination region. In Figure 4, the operations executed in the destination region are based on customer orders; therefore, the CODP is placed immediately before the packaging stage. A real-case application of this strategy is how Polaroid introduced “packaging postponement” for its i-Zone instant pocket cameras, as per Twede et al. (2000). In Figure 5, packaging and labeling still take place in the destination region but they depend on forecasts, while the finished products are distributed once the orders arrive. In the second real-case application, BT Health Care (van Hoek et al., 1998) assembles the parts at a US-based plant and then ships them to a facility in Europe, where the assembled goods are packaged and labeled according to the company’s forecasts, and are distributed only after the company receives the customers’ orders.

Discussion

The proposed framework was developed to build a bridge between the existing contributions on postponement and the associated global challenges. In domestic supply chains, postponement refers to determining when specific manufacturing and/or logistics operations are to be executed (Zinn and Bowersox, 1988; Pagh and Cooper, 1998). In global supply chains, the place of manufacturing and the place and form in which stock is held (finished or semi-finished products) also have a major impact on the company’s overall performance (Cooper, 1993; van Hoek, 1996). Determining which operations to perform within the global distribution network (“*what*”) refers to the postponement boundary problem (Lee, 2010).

If this 2-axis framework is compared with the one proposed by Pagh and Cooper (1998), this framework has expanded the vertical axis to include all the operations (related to both manufacturing and logistics) whereas, in Pagh and Cooper’s (1998) configuration, this axis only held the manufacturing operations. Thus, the horizontal axis becomes available and can be used to introduce

a new dimension, namely, where the operations are to be performed. In this manner, the present framework explicitly includes a spatial perspective (“*where*”). Building on van Hoek (1996), who generically referred to geographically deferring downstream operations, the present framework has introduced the concept of geographical regions. This made it possible to highlight where the operations are performed and to include the impact of the different duty rates charged for components and finished products, which can become extremely relevant (Choi et al., 2012; Guericke et al., 2012). Thus, the proposed framework presents an answer to Lee’s (2010) postponement boundary problem, which involves bridging the gap between the “*what*” and the “*where*” perspectives.

Second, the present framework was further elaborated to identify the operations undertaken before or after companies receive the customers’ orders. Consequently, global postponement strategies have been explicitly linked to the traditional perspective on postponement (e.g., Yang and Burns, 2003) through the temporal dimension (“*when*”). In particular, when referring to the distribution of finished products, the “*when*” represents the choice between logistics speculation and logistics postponement (Pagh and Cooper, 1998), in the sense that decisions concerning the distribution of the end products are made based on the forecast demand or after the customers’ orders are received (van Hoek, 2001). The same applies when transposing the final manufacturing tasks (assembly, packaging, and labeling). The proposed framework, therefore, also describes the choice that companies have to make between postponement and speculation for each operation (Pagh and Cooper, 1998), which involves bridging the gap between the “*what*” and the “*when*.”

By introducing this view, the concepts of CODP and DP were clearly distinguished from one another. This means that bridging the gap between the “*what*” and the “*where*” helps to highlight where the DP is positioned within global supply chains whereas bridging the gap between the “*when*” and the “*what*” helps to identify the position of the CODP. Despite this, there is still a close relationship between CODP and DP. When the distribution points are located in regions other than the home region, moving downstream operations to these other regions means that the DP can be deferred closer to the final customers. The position of the DP determines the total lead time of sending products

to the market (Zinn, 2019). The more customized a product is, the longer the lead time is (Yang and Burns, 2003). Nevertheless, due to long international transport lead times, geographically postponing some operations may allow the CODP to be changed as well. With distribution points being closer to the market, it could be feasible for companies to delay operations until receiving the customers' orders, while at the same time respecting delivery lead time requirements.

Furthermore, the proposed framework allows both the temporal and spatial perspectives to be taken into account. On the one hand, when implementing a "pure" postponement strategy, spatial postponement cannot occur, and temporal postponement alone can help to define the strategy. On the other hand, when "third-country" or "global" postponement strategies are applied, spatial postponement and temporal postponement may be applied simultaneously.

The challenge of developing a global perspective of postponement is still ongoing, and an aspect needing particular attention is how to identify the key enablers and inhibitors of postponement in different countries and regions (Boone et al., 2007; Zinn, 2019). On the one hand, manufacturing products at a central factory increases the economies of scale, and production and quality control are easier to execute (Yang and Burns, 2003). On the other hand, increasing protectionism and the resulting tariffs can motivate companies' decision of undertaking some operations downstream in distribution facilities (either in a third country or in the final destination market). Indeed, different legislations and requirements may have significant tax implications that require careful management considerations when making decisions about the postponement boundary problem. Depending on the relative legal/fiscal system currently in place, the same operation may or may not be allowed in different countries. For instance, postponing packaging operations to third countries can be feasible in some cases whereas other tax systems might require labeling to be carried out in advance, before products enter the country. In addition, trade agreements may result in lower customs duties or special treatment for some products and trading partners, if specific requirements are met.

Conclusions and Future Research

Postponement is an important topic in the production and inventory management literature, as well as in the logistics and supply chain literature. Studying postponement strategies in a global context means expanding the “traditional” temporal perspective on postponement (“*when*”), as production operations may be allocated to downstream network nodes (van Hoek, 1996), thereby introducing a spatial perspective (“*where*”). The SLR, however, revealed the lack of research on what is known as the postponement boundary problem and on the conceptualization of postponement strategies in a global context (Lee, 2010; Choi et al., 2012, Guericke et al., 2012).

Building on the studies by Pagh and Cooper (1998) and Lee (2010), the present study fills this gap by developing an original conceptual framework for studying postponement in global downstream supply chains. Two axes are identified, to address the “*where*” (on the horizontal axis, which refers to the region/s where the operations take place) and the “*what*” (on the vertical axis, which refers to the types of downstream supply chain operations that can take place in each region), as discussed in the literature section.

A two-step classification framework was derived from the conceptual framework. In the first step, this framework was adapted to compare and classify different postponement strategies to use in global supply chains. Here, the “*what*” was the first activity to be postponed. This led to 12 different postponement strategies being identified, based on the combination of the first activity to be postponed with the region in which it takes place. Subsequently, 28 business cases found in the literature were classified based on the proposed framework to validate its effectiveness in classifying global postponement strategies. In the second step, the conceptual framework was further expanded to focus on one postponement strategy at a time. By introducing this extension, it was possible to clearly distinguish between the concepts of CODP and DP. This resulted in bridging the gap between both the “*what*” and “*where*” perspectives – helping to highlight the position of the DP within the global supply chain – and the “*when*” and “*what*” perspectives, thereby helping to identify the position of the CODP.

The study offers a contribution in terms of both academic and practical implications. From an academic perspective, the literature analysis provided a basis for identifying several significant factors that affect global postponement strategies, paving the way for a more holistic investigation of additional and potentially important factors. At the same time, the proposed framework built on the existing literature on postponement, providing a new perspective from which to address global postponement with a downstream focus. Specifically, it formalized the fact that global postponement does not refer exclusively to when operations are to be performed, but also to where. The classification framework described previous cases found in the literature and helped to determine the strategies that need to be further examined.

From a practical viewpoint, the proposed framework has highlighted and classified the strategies that companies can adopt to exploit the opportunities linked to managing the postponement boundary problem. Managers can use this framework as a basis for analyzing their supply chains and for deciding where and when to perform each operation. They can evaluate the suitability of the various postponement strategies, as well as investigate future developments, by observing how the range of factors proposed in Table 2 can influence or even improve their decision-making ability.

Nevertheless, some limitations do exist, and avenues for future research can be recommended. First, the scope and focus of the framework are limited to downstream supply chain operations. In this regard, further developments could take the form of introducing a comprehensive framework that includes all the supply chain phases, from the sourcing of raw materials to the distribution of products to the end customer, as well as investigating implications specifically related to some industries and/or countries. Second, the framework adopts a qualitative approach, without including a quantitative evaluation of the identified postponement strategies. Therefore, this study offers opportunities for the development of further quantitative analyses, for example, building ad hoc models to compare different postponement strategies, whose suitability may also depend on their application context. Third, the framework refers to internal supply chains. This may result in a sub-optimization from an external supply chain perspective, and further research could explore its

implications by examining the entire supply chain. Finally, future research could look toward gaining a deeper understanding of the drivers that lead to the implementation of the examined postponement strategies. Case study research is highly recommended, as it can provide profound insights into complex, multifaceted phenomena, especially when the boundaries between a phenomenon and its context are not clear (Fawcett et al., 2014). New research could address the impact of the temporal dimension – understanding when to ship goods or when to undertake the various activities in the case of cross-country flows, a standpoint that also involves the postponement boundary problem. Finally, further studies could target the applicability and implications of postponement in practices related to the emergence and rapid growth of global e-commerce and omnichannel supply chains. In addition, with the advanced analytics currently available, companies are increasingly able to make highly informed decisions about placing inventories closer to customers, in anticipation of demand, and processes such as additive manufacturing enable customers to carry out the final customization themselves. Factors such as these are creating further topics to research in the global postponement field.

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Postponement decisions	Main focus		Main references
Time postponement	Delaying forward shipment of goods	Until customers' order	Zinn and Bowersox (1988); Bowersox and Closs (1996); van Hoek (1997); Pagh and Cooper (1998); van Hoek (1998a); van Hoek (1998b); van Hoek (2001); Boone et al. (2007); Brun and Zorzini (2009); Guericke et al. (2012)
		As late as possible	Alderson (1957); Bucklin (1965); Boone et al. (2007); Garcia-Dastugue and Lambert (2007); Choi et al. (2012)
	Delaying manufacturing/differentiating tasks		Lee and Billington (1994); van Hoek (2001); Su et al. (2005); Boone et al. (2007); Garcia-Dastugue and Lambert (2007); Wong et al. (2009); Choi et al. (2012)
Form postponement	Upstream		Cooper (1993); Lee and Billington (1994); van Hoek (1996); Lee and Tang (1997); van Hoek et al. (1998); Ernst and Kamrad (2000); van Hoek (2001); Yang et al. (2004a,b); Hsuan Mikkola and Skjøtt-Larsen (2004); Su et al. (2005); Boone et al. (2007); Brun and Zorzini (2009); Yang and Yang (2010); Choi et al. (2012)
	Downstream		Alderson (1957); Bucklin (1965); Zinn and Bowersox (1988); Zinn and Grosse (1990); Cooper (1993); Lee et al. (1993); Lee and Billington (1994); van Hoek (1996); Lee and Tang (1997); van Hoek (1997); Pagh and Cooper (1998); van Hoek et al. (1998); van Hoek (1998b); Ernst and Kamrad (2000); van Hoek (2001); Yang and Burns (2003); Yang et al. (2004a,b); Su et al. (2005); Boone et al. (2007); Garcia-Dastugue and Lambert (2007); Brun and Zorzini (2009); Wong et al. (2009); Lee (2010); Yang and Yang (2010); Olhager (2010); Kisperska-Moron and Świerczek (2011); Choi et al. (2012); Guericke et al. (2012); van Kampen and van Donk (2014); Ngniatedema et al. (2015a,b); Ferreira et al. (2015); Ferreira and Alcântara (2015)
Place postponement	Delaying forward shipment of goods, with a specific focus on keeping goods at central locations, until customers' order		Bowersox and Closs (1996); van Hoek (1997); van Hoek (1998a); van Hoek (1998b); van Hoek (2001); Yang and Burns (2003); Wong et al. (2009); Choi et al. (2012)

Table 1 – Time, form and place postponement: summary of main contributions

Factors to be considered in global supply chains		Main references
International transport	Transport modes costs and performance	MacCarthy and Atthirawong (2003); Choi et al. (2012); Fan et al. (2017)
	Benefits of components bulk-shipping	van Hoek (1996); Yang et al. (2004a); Cholette (2009); Choi et al. (2012)
Longer lead times	International transport	Lee and Billington (1994); Cholette (2009); Guericke et al. (2012)
	Customs operations	Choi et al. (2012)
Inventory reduction options		Lee and Billington (1994); van Hoek (1996); Yang and Burns (2003)
Various requirements of different geographical markets	Brand, product formulation, peripherals	Cooper (1993); van Hoek (1996)
	Taste, language environment	Lee et al. (1993); van Hoek (1996)
	Contents or pack forms	Abukhader and Jonson (2007)
	Technological specifications and culture	Yang et al. (2004a and 2004b)
Differences in production factors costs across countries		van Hoek (1996); MacCarthy and Atthirawong (2003); Lee (2010)
Differences in materials and parts costs across countries		Lee and Billington (1994); van Hoek (1996); Zeng and Rossetti (2003)
Differences in knowledge level of workers		MacCarthy and Atthirawong (2003)
Trade agreements and regulations	Duties on import	Lee and Billington (1994); Goetschalckx et al. (2002); Yang et al. (2004a); Lee (2010); Choi et al. (2012)
	Duty drawbacks	Mariel and Minner (2015); Häntsch and Huchzermeier (2016)
Government laws, regulations and local content requirements		Lee et al. (1993); Lee and Billington (1994); MacCarthy and Atthirawong (2003); Lee (2010)
Differential tax rates and transfer pricing schemes		Vidal and Goetschalckx (2001); Lee (2010); Fernandes et al. (2015)
Exchange rate fluctuations		Manuj and Mentzer (2008); Lee (2010)
Environmental concerns		Varsei et al. (2017); Harris et al. (2018)

Table 2 – Summary of the factors relevant to postponement in global downstream supply chains

ID	Case	Reference (year)	“What”	“Where”	Postponement Strategy	CODP Positioning
A	HP Deskjet printers	Lee et al. (1993)	Assembly	Destination region	Global Assembly	Assembly
B	Caterpillar lift-trucks	Cooper (1993)	Assembly	Destination region	Global Assembly	Assembly
C	PC Manufacturer	Van Hoek (1996)	Assembly	Destination region	Global Assembly	Assembly
D	Dell	van Hoek (1998b)	Assembly	Home region	Pure Assembly	Assembly
E	BT Health care company	van Hoek et al. (1998)	Packaging	Destination region	Global Packaging	F.P. Distribution
F	Polaroid i-Zone	Twede et al. (2000)	Packaging	Destination region	Global Packaging	Packaging
G	Wine company	van Hoek (2001)	Packaging	Home region	Pure Packaging	Packaging
H	MCC	van Hoek (2001)	Assembly	Home region	Pure Assembly	Assembly
I	Compal Computers	Chiou et al. (2002)	Labeling	Destination region	Global Labeling	Labeling
J	D-Link	Chiou et al. (2002)	Packaging	Destination region	Global Packaging	Packaging
K1	Bang and Olufsen (MTS)	Appelqvist and Gubi (2005)	F.P. Distribution	Home region	Pure Logistics	F.P. Distribution
K2	Bang and Olufsen (ATO)	Appelqvist and Gubi (2005)	Assembly	Home region	Pure Assembly	Assembly
L1	Renault Logan (CBU)	Lee and Silverman (2008)	F.P. Distribution	Destination region	Global Logistics	Not specified
L2	Renault Logan (CKD 1)	Lee and Silverman (2008)	Assembly	Destination region	Global Assembly	Not specified
L3	Renault Logan (CKD 2)	Lee and Silverman (2008)	Assembly	Third-country region	Third-country Assembly	Not specified
M	Illva Saronno	Brun and Zorzini (2009)	Packaging	Home region	Pure Packaging	Packaging
N	Spanish appliances producer	Saiz and Uribe txebarria (2012)	Assembly	Third-country region	Third-country Assembly	F.P. Distribution
P	Dairy food company	van Kampen and van Donk (2014)	Assembly	Home region	Pure Assembly	Assembly
Q	DIY company	Fernandes et al. (2015)	F.P. Distribution	Third-country region	Third-country Logistics	F.P. Distribution
R1	Orange juice – time postponement	Ferreira and Alcântara (2015)	F.P. Distribution	Destination region	Global Logistics	F.P. Distribution
R2	Orange juice – form postponement	Ferreira and Alcântara (2015)	Assembly	Destination region	Global Assembly	Assembly/F.P. Distribution
R3	Orange juice – base process	Ferreira and Alcântara (2015)	Packaging	Destination region	Global Packaging	Packaging/F.P. Distribution
S	R&D	Luo et al. (2017)	F.P. Distribution	Destination region	Global Logistics	F.P. Distribution
T1	WineCo – base case	Varsei et al. (2017)	Packaging	Home region	Pure Packaging	Not specified
T2	WineCo – alternative case	Varsei et al. (2017)	Packaging	Destination region	Global Packaging	Not specified

U1	UK wine import – base case	Harris et al. (2018)	Packaging	Home region	Pure Packaging	Not specified
U2	UK wine import – alternative case	Harris et al. (2018)	Packaging	Destination region	Global Packaging	Not specified
V	Chilean winery	Varas et al. (2018)	Labeling	Home region	Pure Labeling	Labeling

Table 3 – Main characteristics of the business cases

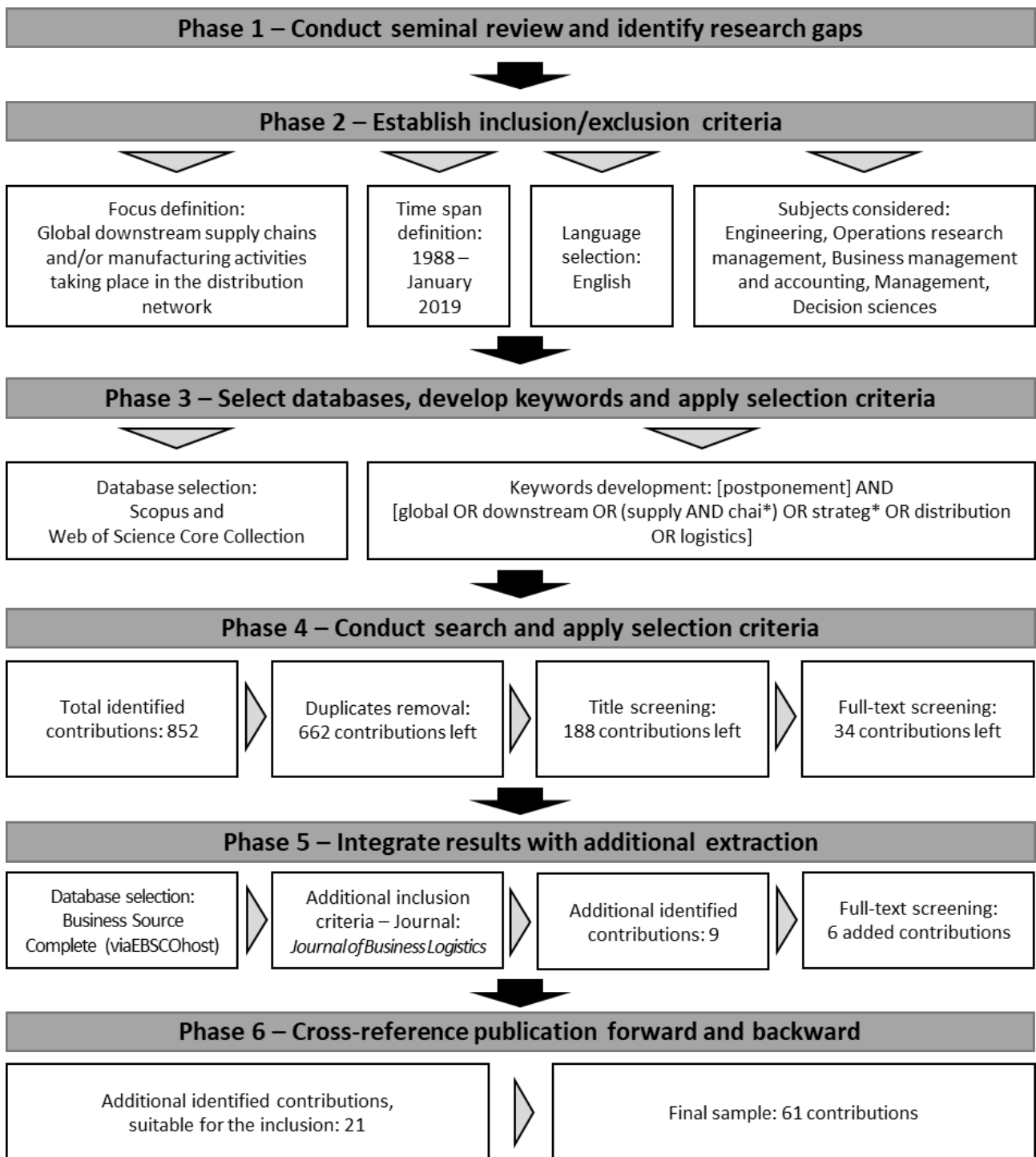


Figure 1 – Overview of the Structured Literature Review (SLR) protocol



Figure 2 - Conceptual framework for postponement strategies in global downstream supply chains

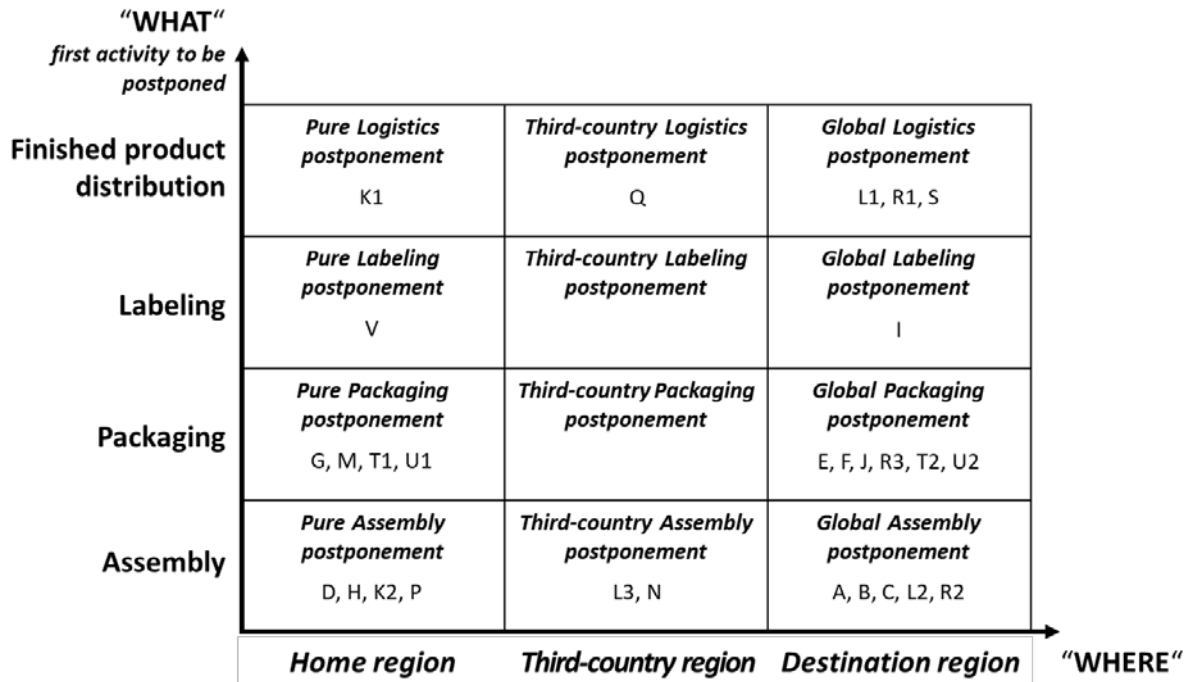


Figure 3 – Classification framework for postponement strategies in global downstream supply chains – Step 1. (Please note that the symbols used for identifying each case refer to cases’ description reported in the Appendix)

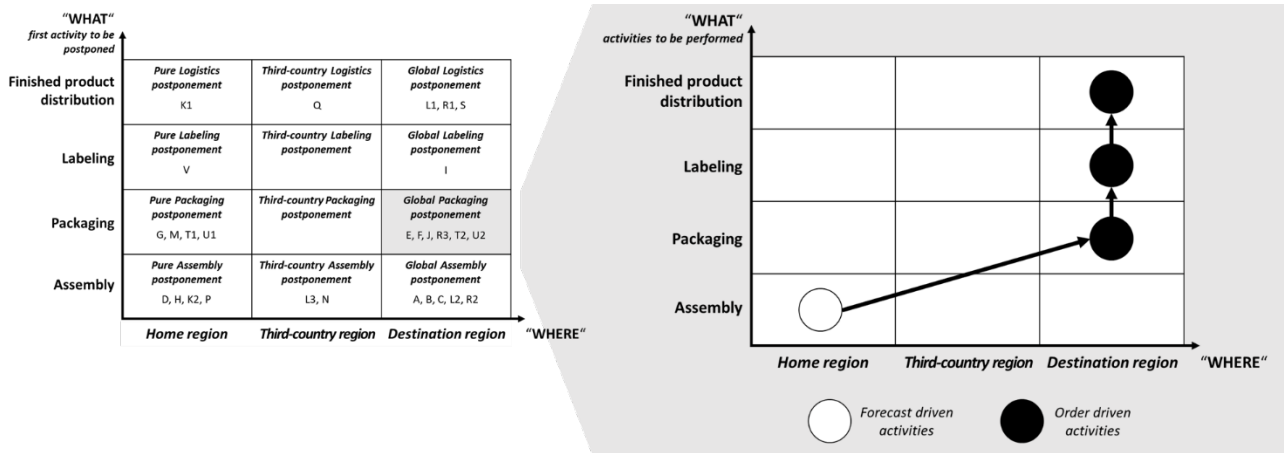


Figure 4 – Classification framework for postponement strategies in global downstream supply chains – Step 2: application for Global Packaging postponement – Packaging on order

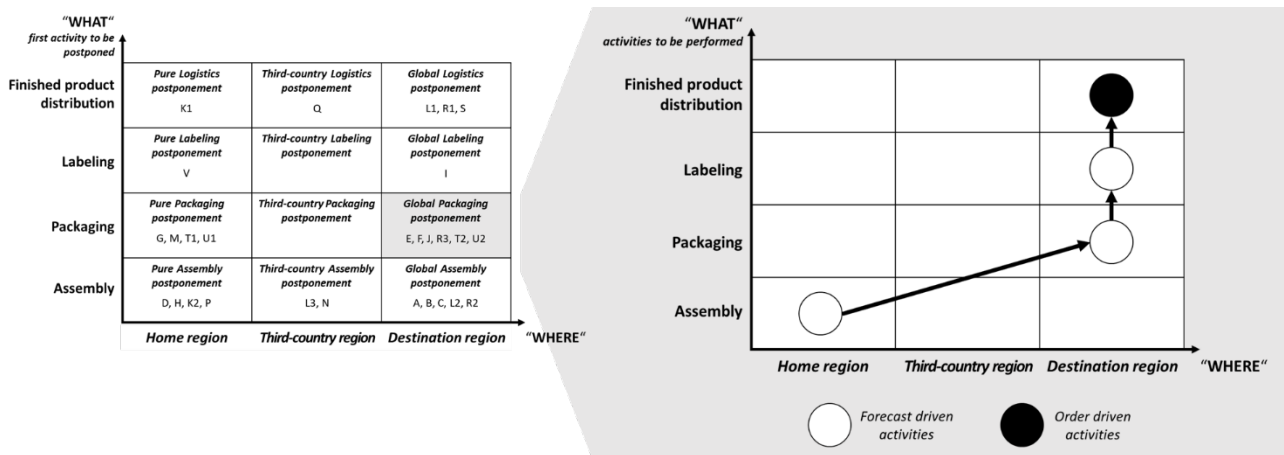


Figure 5 – Classification framework for postponement strategies in global downstream supply chains – Step 2: application for Global Packaging postponement – Packaging on forecast

Appendix: Description of business cases

- *A: HP Deskjet printers* (Lee et al., 1993). This case represents an example of Global Assembly postponement. Standard semi-finished printers are produced in a factory in Vancouver, Washington (United States) (home region). The semi-finished goods, without their power supply modules, instruction manuals, or packaging, are shipped to regional distribution centers globally (destination region). There, a series of operations are carried out according to customer orders, involving the assembly of customer-specific power supply modules, inclusion of instruction manuals, and packaging. The first activity to be postponed is the assembly of the product, as all the previous operations to manufacture the semi-finished product take place in the US factory and all the subsequent operations are managed in the overseas regional warehouses.
- *B: Caterpillar lift-trucks* (Cooper, 1993). As with the HP Deskjet printers, this case also refers to Global Assembly postponement. Components and semi-finished trucks are manufactured in countries with lower production costs (the home region/s), with North America being the destination region. All lift-trucks share a common core component and their distinctive parts are assembled at a warehouse in the USA. Cooper (1993) called this strategy 'deferred assembly'.
- *C: PC Manufacturer* (van Hoek, 1996). In this case, the Asian manufacturing base of the company produces PC housings with disk drives and built-in working memories. Housings, central processing units, and hard disks are shipped to Europe with an average transport time of four to five weeks. PC motherboards are manufactured in the Asian manufacturing base as well but are transported by plane. Semi-finished PCs are stored in a European distribution center, where the final stages of manufacturing take place based on customers' orders. The final stages of manufacturing consist of assembling PC boards, running two quality tests, and screwing the housing on the board and packing the PC, including the documentation. Hence, this case provides an example of Global Assembly postponement.

- D: *Dell* (van Hoek, 1998b; Chiou et al., 2002; Ivanov et al., 2017). This case is a very common example of Pure Assembly postponement, with products assembled by Dell at its facility in Austin, Texas (USA), after it receives the customers' orders. The products are then shipped to customers worldwide.
- E: *BT Health Care Inc.* (van Hoek et al., 1998). In this case, the company has adopted a Global Packaging postponement strategy. Parts are assembled at a USA-based plant and then shipped to a facility in Europe, to be packaged and labeled before the final distribution. The company decided to conduct the assembly and packaging at a facility in Europe (destination region), because approval can be obtained more rapidly in Europe than in the USA for products intended for the European market. Since the replenishment lead time to serve customers is very short (24-48 hours), the company has to use express couriers to deliver its products and, to comply with its strict service requirements, products are packed and labeled in advance on the basis of its forecast and then shipped when the customers' orders are received.
- F: *Polaroid's supply chain strategy for its 'i-Zone' instant pocket cameras* (Twede et al., 2000). This case can be considered as the first example of Global Packaging postponement described in the literature. Manufacturing and assembly are centralized in the home region, and products are then shipped to regional facilities in the Netherlands, Japan and USA (Massachusetts), where they are packaged. Due to country-specific packaging requirements (such as local language or different conventions for displaying information), packaging is the first activity to be postponed, and it is carried out at warehouses in the destination region. The distribution of finished products is managed from these warehouses, and is based on the customers' orders.
- G: *The Wine Company* (van Hoek, 2001). This case provides an example of Pure Packaging postponement. The company stores its table wines in tanks until orders are received (but the concept could clearly apply to all its production). At that point, additives may be added and

the wines are bottled, labeled and shipped. Here, in terms of operation, bottling is equivalent to packaging.

- H: *MCC* (van Hoek, 2001). This is an example of Pure Assembly postponement. MCC assembles cars to order, with car modules being manufactured in a flow shop environment and finished vehicles assembled in batches of one. Process complexity is reduced by working to a modular product design, which provides for car customisation, and the final assembly is both rapid and efficient. By storing the generic modules only, the company avoids any inventory risks arising from changes to quantity or variety, and operations are less complex. As a final benefit of this postponement strategy, the customer can drive off in a customized car after a mere three-week lead time.
- I: *Compal Computers* (Chiou et al. 2002). This case provides an example of Global Labeling postponement, since labeling is carried out at overseas facilities. This Taiwanese IT manufacturer waits for its customers' orders before labeling its products at its facilities in the USA, from where it ships the finished products.
- J: *D-Link* (Chiou et al., 2002). This is an example of Global Packaging postponement. A Taiwanese company ships electronic components (such as Ethernet cards) to local warehouses, located outside Taiwan. Depending on its orders, the company packages its products into appropriate product bundles for delivery.
- K: *Bang and Olufsen* (Appelqvist and Gubi, 2005). Retailers all over the world order products from a facility in Denmark, which sends its finished products to customers according to their transport and/or customisation choices (and these, in turn, are determined by if and when products are customized). The company employs two different strategies, depending on the volume and related variability in demand:
 - a. K1 – Make to stock (MTS): for high-volume variants, the company makes and stocks products, and then waits for customer orders before shipping. This strategy is a Pure Logistics postponement strategy.

- b. K2 – Assembly to order (ATO): for lower-volume variants, the company waits for customer orders before assembling the products. This is an example of Pure Assembly postponement, since distribution is spread worldwide.
- L: “Logan” car by Renault (Lee and Silverman, 2008; Lee, 2010). This product was initially designed for customers in developing markets, such as Colombia, Iran, and Northwest Africa, but is actually sold across Asia, Eastern Europe, Africa, and South America. Until 2006, the components were produced in Romania, meaning that this was the home region. When Romania joined the European Union in 2007, the home region became part of the European Customs Union, so the cars could be assembled at other locations within the global supply chain. The company adopted several different strategies for exporting the car to different countries:
 - a. L1 – Completely built-up units (CBU): The entire manufacturing process is carried out at the central plant in Romania, with the main advantage being the economies of scale. The CBU units are then shipped to the sales regions to serve the local markets (Global Logistics postponement). Since import duties on CBU vehicles is extremely high in some regions, this supply chain configuration was employed only for exports to countries where customs unions or free-trade agreements allowed CBU cars to be imported without duties.
 - b. L2 – Completely knocked-down units (CKD 1): Components manufactured in Romania are bundled and shipped to assembly facilities in the destination countries (Global Assembly postponement). This supply chain configuration is suitable when the duties charged on components are lower than those on the finished products.
 - c. L3 – Completely knocked-down units with transit from a third country (CKD 2): This strategy has been employed for vehicles sold in the European Union after Romania joined in 2007. It provides a practical application of Third-country Assembly postponement. Components are made in Romania (home region), bundled and sent to

Morocco (third country) for final assembly, after which the finished products are shipped to Egypt (destination region). This allows the company to exploit the lower cost of production and high economies of scale in their Moroccan assembly facility without increasing tax duties, as the parts made in Romania are officially European components. Because of the current trade agreements in place (Lee, 2010), the local content of the cars is high enough for them to qualify for duty-free import from Morocco to Egypt.

- M: *Illva Saronno* (Brun and Zorzini, 2009). In this case, the Italian company postpones its packaging and labeling operations when selling to foreign markets. Since packaging is the first task to be postponed, the resulting strategy has been renamed Pure Packaging postponement.
- N: *Spanish appliances manufacturer* (Saiz and Uribechebarria, 2012). This case relates to an unnamed Spanish company that produces several domestic appliances, including the valves for gas ovens. When selling on the Brazilian market, the company ships the components to China where it assembles the valves. The finished products are then shipped to Brazil, where they are stored and later distributed to customers. Although this option is mainly driven by economies of scale within the Chinese facility, it provides an example of Third-country Assembly postponement.
- P: *Dairy food company* (van Kampen and van Donk, 2014). This case presents an example of Pure Assembly postponement strategy. An unnamed dairy processing company sells products to more than 20 countries on four continents. To meet its customers' demands, a number of base components are mixed and processed into more than 100 preparations according to the company's recipes, and then they are transformed into 700 final products using 18 packaging lines, delivering its products in a wide range of containers, wrappings and outer packaging. The order lead-times are relatively long for most products (up to three months between ordering and delivering the products). Depending on the total volume and variability of the

demand, with low volume or high variability, the different preparations are produced after receiving the customers' orders.

- Q: *DIY company* (Fernandes et al., 2015). This is another example of how Third-country Logistics postponement strategy can be applied, with a multinational corporation with a plant in Portugal opening a finished product distribution centre in Switzerland to serve its foreign markets.
- R1/R2/R3: Ferreira and Alcântara (2015) described three different supply chain strategies adopted by various Brazilian orange juice companies exporting their products to USA, Europe and Asia. While the strategy has been classified as Global Assembly postponement, given the peculiarities of the orange juice supply chain, the assembly phase can be taken as equivalent to the dilution/flavoring process. The three strategies differ according to the first operation that is geographically postponed to the destination region. In this case, it relates to the assembly, packaging or distribution of the finished product.
- S: *R&D* (Luo et al., 2017). This case is an example of Global Logistics postponement. Production is managed in China and finished products for the European market are then shipped to a warehouse in Austria and distributed after the company receives the customers' orders.
- T: *WineCo* (Varsei et al., 2017). WineCo (anonymized company name) was identified as one of Australia's major wine companies exporting to overseas markets around 80 per cent of its total production. A sustainability perspective is also introduced, investigating potential trade-offs between economic and environmental elements associated with the bottling location decision, through calculating supply chain cost components, carbon dioxide equivalent emissions and water usage.
 - a. T1: As a first option, wines are produced and bottled in a winery located in Australia (Pure Packaging postponement). Bottled wines are then shipped from Australia to

Europe (export markets mainly in the UK and Germany), and to North America (export markets in the USA and Canada).

- b. T2: Alternative scenarios are developed, in which one or more bottling facilities are located in the destination markets. In line with F and T2 cases, bottling is considered as equivalent to packaging. Thus, this case offers an example of Global Packaging postponement).
- U: *UK wine import* (Harris et al., 2018). In this paper different options are taken into consideration with particular reference to UK wine imports from two regions: Northern Italy and Southeast Australia. Three main type of unitization are taken into account, whose choice is highlighted to be a consequence of where performing the bottling activity, as well as its impact on the supply chain environmental footprint.
 - a. U1: First, it takes into account wine bottling at source (Pure Packaging postponement)
 - b. U2: Secondly, it evaluates bottling at destination (Global Packaging postponement).As per case F, bottling is considered as equivalent to packaging.
 - V: *Chilean winery* (Varas et al., 2018). This case provides an example of Pure Labeling postponement. A Chilean winery with a focus on export supplies its wines to many international customers, meaning that there is often the need for different labels for the same kind of wine. Order forecasts tend to be highly inaccurate, and the winery must be able to react quickly, making lot-sizing an important issue. One way to reduce product misallocation is to postpone product differentiation, and labeling for the winery's premium wine is the natural decoupling point.