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Coping with the postponement boundary problem: an empirical investigation in global food supply chains

Abstract

Purpose – The postponement boundary problem entails that duties and cross-border trade complexity can lead companies to geographically postpone operations to downstream global facilities. The present study aims at investigating the problem to provide insights into the drivers behind the choice of different postponement strategies for global food supply chains.

Design/methodology/approach – A single case study was conducted considering an Italian company exporting olive oil toward the United States. Two global postponement strategies, previously formalized in the literature, were tailored for food supply chains. A multi-methodological approach was adopted, combining data obtained through exploratory case research with empirically-grounded analytical modeling. A sensitivity analysis was also performed, to investigate outcomes related to the considered problem when changing key parameters.

Findings – Bulky and heavy packing materials account for a big percentage of finished products' volume and weight, and this can deeply affect strategies' cost-effectiveness. Postponing packaging operations could allow for taking advantage of lower tariffs levied on bulk goods, contributing to significantly lower duties to be paid. However, important trade-offs could arise related to the required investments, and the fiscal regulatory frameworks must be carefully examined.

Originality/value – This study offers an empirical investigation of the postponement boundary problem, which is largely unexplored in the current literature. It also tackles an understudied empirical context as global food supply chains. It summarizes the drivers behind and explores the costs related to the implementation of different strategies, offering an original quantitative approach that could support practitioners' decision-making. Lastly, it formalizes five propositions that could pave the way for further research inquiries.

Keywords: postponement boundary problem, food supply chains, duties, case study, analytical model

Paper type: Research paper

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Introduction

In recent decades, companies have increasingly looked beyond domestic markets and supply sources, stressing the importance and complexity of global supply chains (Meixell and Gargeya, 2005). Global operations entail a significant increase in uncertainty (Cohen and Lee, 2020), and postponement progressively emerged as an effective strategy to increase responsiveness to customer demands while containing supply chain costs (Boone *et al*., 2007; Jafari *et al.*, 2021). By deferring in time a product's final configuration or time of movement down the channel, firms delay commitment to a specific customer or market, thus reducing uncertainty and consequently costs (Zinn and Bowersox, 1988; Pagh and Cooper, 1998; Yang *et al*., 2004).

A global perspective on postponement is not new to the research agenda (van Hoek, 2001), but new opportunities for global postponement strategies are emerging nowadays (Zinn, 2019). The location where operations take place, as well as the place and form in which stock is held, can have a major impact on the companies' overall performance (van Hoek, 1996). Increasing protectionism and cross-border trade complexity can also motivate companies' decision of undertaking some operations downstream in distribution facilities (Cooper, 1993; Lee, 2010). Consequently, a spatial perspective must be taken into account when designing postponement strategies for global downstream supply chains, along with the conventional temporal one (Prataviera *et al*., 2020). Specifically, determining what downstream activities could be performed in the global distribution network, rather than in the centralized factories, has been termed the "postponement boundary problem" (Lee, 2010).

Although a growing body of literature is available about postponement and its global implications, the postponement boundary problem represents an original research issue within the broad research stream, and recent contributions acknowledged its current under-examination in the academic literature (Prataviera *et al*., 2020). Promising research directions exist, related to the identification of the key enablers and inhibitors of postponement (Boone *et al*., 2007; Kisperska-Moron and Swìerczek, 2011), and to the study of different strategies in relation to cost-effectiveness and fields of application including different regions and industries (Zinn, 2019). In particular, global postponement studies mainly focused on high technology products with a modular structure (Lee and Billington, 1994; Choi *et al*., 2012). However, some scholars proposed postponement as a valuable strategy also in the food industry (van Hoek, 1999; Ferreira *et al*., 2020). Although products' non-modularity offers additional challenges, in the food industry postponement may lead to significant cost savings (Abukhader and Jonson, 2007; van Kampen and van Donk, 2014) due to potential inventory carrying and transportation costs reduction (van Hoek, 1997; Bandaly and Hassan, 2020). Also, trade agreements may result in lower customs duties if specific requirements are met and some activities take place in the country where the goods are sold (Henkow and Norrman, 2011; Cheptea and Huchet, 2019). With increasing trade barriers and trade conflicts worldwide (Handfield *et al*., 2020; Roscoe *et al*., 2020), the food industry represents thus a relevant industry in which to analyze the geographical reconfigurations related to the postponement boundary problem.

From a methodological viewpoint, case study research has been recommended to investigate postponement (Zinn, 2019) as it can provide profound insights into complex, multifaceted phenomena, especially when the

boundaries between a phenomenon and its context are not clear (Yin, 2009). However, there is a lack of quantitative studies about the cost-effectiveness of different strategies, and this calls for building ad hoc models to compare available alternatives (Choi *et al*., 2016). Previous scholars highlighted the need for a methodological upgrading of postponement-related research (van Hoek, 2001; Zinn, 2019) and suggested that multi-method approaches could create complementarity that adds richness to problem understanding (Sanders and Wagner, 2011). Based on these premises, the present study aims at elaborating previous contributions by addressing the following research questions (RQs):

RQ1: What strategies could be adopted to cope with the postponement boundary problem in global food supply chains?
RQ2: What drivers could affect companies' decisions on postponement strategies?

To address these RQs, a single case study was conducted concerning an Italian company exporting olive oil to the USA, and a multi-methodological approach was adopted (Choi *et al*., 2016). Data obtained through exploratory case study research led to formalizing two postponement strategies tailored for global food supply chains, and empirically grounded analytical modeling followed to quantitatively compare such strategies.
From an academic viewpoint, this study aims at extending the current postponement theory by exploring an understudied empirical context (i.e., food supply chains) for the postponement boundary problem. For this purpose, it offers a qualitative formalization of the postponement strategies in the application field and a quantitative assessment of the strategies' cost-effectiveness. It also deepens the decisions drivers to shape global postponement strategies and identifies some propositions that could boost future research in the field. Moreover, the study can offer a contribution to supply chain professionals, providing pragmatic insights to consider when approaching global postponement and a model that can enhance decision-making.
The paper is organized as follows: related literature review, and the resulting research gap, are first proposed. Then, the methodology is described, followed by the illustration of the two formalized postponement strategies. The model to compare them is proposed hereinafter, followed by the results arising from its real-world application. Lastly, results are discussed, and conclusions and directions for future research are presented.

Related literature

The postponement boundary problem

In 1988 Zinn and Bowersox classified postponement strategies according to what activities (manufacturing, assembly, packaging, labeling) could be postponed and to the delayed movement of inventories along supply chains. In their wake, several authors studied postponement, distinguishing between upstream and downstream supply chains (van Hoek, 2001; Boone *et al*., 2007).
Heretofore, the mainstream perspective on postponement asserts that it centers around deferring in time supply chain activities until real information about the markets is available (Pagh and Cooper, 1998). However, for global supply chains, the postponement boundary problem (Lee, 2010) requires to include also a spatial

perspective (Prataviera *et al*., 2020). Specifically, upstream activities (i.e., manufacturing) can be centralized in one or a few factories, while downstream operations (i.e., assembly, packaging and labeling) can take place in facilities closer to the end customers (Notteboom *et al.*, 2017), thereby involving an international transport stage (van Hoek, 1996). Initially introduced with respect to the assembly operations only, the postponement boundary problem could be extended to the whole final manufacturing/distribution process (Choi *et al*., 2012; Guericke *et al*., 2012). Recently, Prataviera *et al*. (2020) developed a framework to conceptualize the related strategies. A group of 12 strategies for global downstream supply chains was identified by combining the first activity to be geographically postponed (i.e., assembly, packaging, labeling, or finished product distribution) with the corresponding region where it takes place (i.e., Home region, Third-country region, or Destination region).

Global postponement drivers

Many drivers can influence the choice among different postponement strategies, including Product-related, Market-related, and Process-related ones (Pagh and Cooper, 1998; Boone *et al*., 2007). Export volumes (Lee *et al*., 1993; Weskamp *et al*., 2019) and demand uncertainty (Zinn and Bowersox, 1988; Yang *et al*., 2004) have been acknowledged as important drivers behind any postponement strategy, along with product value density (Brun and Zorzini, 2009), obsolescence rate (Twede *et al*., 2000), value profile (Pagh and Cooper, 1998), customization degree (Zinn and Bowersox, 1988), delivery lead time requirements (van Hoek, 1996), required knowledge and/or capabilities (Cooper, 1993; Jafari *et al.*, 2021), and process modularization (Guericke *et al*., 2012). Despite being relevant for both domestic and global postponement strategies, these drivers were mainly considered when dealing with domestic supply chains (Kisperska-Moron and Swìerczek, 2011). In a global landscape, Product-, Market- and Process- related drivers are still important, as widely acknowledged by the existing literature (Lee and Billington, 1994; Choi *et al*., 2012; Varsei *et al.*, 2017). However, they cannot fully address the postponement boundary problem (Lee, 2010). A global dimension entails relevant tax implications related to the geographical distribution of value-adding activities, due to customs duties (Miller and De Matta, 2008) and corporate income taxes (Henkow and Norrman, 2011; Shunko *et al*., 2017).

Customs duties includes taxes on imports and exports of goods (Lee, 2010). It is often computed as a percentage of the product value that crosses the border, but it may also be levied based on other parameters, such as weight or volume (Sawhney and Sumukadas, 2005). Product value increases along supply chains because of the additional activities performed to manufacture/transport/handle goods (Miller and De Matta, 2008). When geographically postponing operations to destination markets, duties normally decreases, thanks to lower dutiable value and lower duty rates charged on semi-finished products (Lee, 2010; Choi *et al*., 2012). Also, customs duties depends not only on the customs value but also on the goods classification (i.e., the tariff code) and the origin of the imported goods (Arntzen *et al*., 1995; Cohen and Lee, 2020).

Furthermore, different corporate income tax (CIT) rates for different jurisdictions entail different tax liabilities for companies (Lee, 2010). Important issues related to Permanent Establishment (PE) creation could emerge

(Miller and De Matta, 2008). Specifically, PE is a fixed place of business generally giving rise to tax liabilities in a particular jurisdiction (Henkow and Norrman, 2011). Performing specific value-adding activities in different countries could have PE implications, thus influencing where and how much tax should be paid (Joseph *et al*., 2017).

While in domestic environments postponement strategies can be compared based on costs, in a global environment they should be evaluated based on the resulting profits, considering the effects introduced by applying different tax rates (Miller and De Matta, 2008) and eventually considering also transfer price (TP) definition (Vidal and Goetschalckx, 2001). TP is the price for a product or service related to a transaction between parties belonging to the same firm (Fernandes *et al*., 2015), and different methods to determine TPs exist (Vidal and Goetschalckx, 2001). The most popular one is the cost-plus method, according to which TPs are determined by adding to unitary product costs a pre-determined mark-up (Fernandes *et al*., 2015). In general, transfer pricing is based on the "arm's length principle", requiring that the transaction should occur as if it had taken place between independent parties (Vidal and Goetschalckx, 2001).

Postponement in the food industry

Postponement literature mainly focused on high technology products with a modular structure, like computers, cars, and workstations (Lee and Billington, 1994; Lee, 2010; Ferreira *et al*., 2020). Nevertheless, some scholars investigated postponement applications also in the food industry, considering wine manufacturers (van Hoek, 1997), soluble coffee producers (Wong *et al*., 2011), and orange juice producers (Ferreira and Alcântara, 2015; Bandaly and Hassan, 2020). This industry is characterized by non-modular products with relatively short shelf-life (Yang *et al*., 2004; Abukhader and Jonson, 2007). Postponement can provide benefits related to lower uncertainty (van Hoek, 1999; Brun and Zorzini, 2009), entailing inventory carrying and transportation costs reduction (Bandaly and Hassan, 2020).

On the one hand, inventory cost savings can emerge from holding inventories of undifferentiated products (Van Hoek, 1997). Product value density is the main driver for postponement in this industry and, the higher the product value, the higher the inventory cost reduction due to postponement (Wong *et al*., 2011; Bandaly and Hassan, 2020). Then, higher duties charged on finished products than on semi-finished goods can significantly impact the overall distribution costs, especially for high-value density products with short required delivery lead times (Cholette, 2009; van Kampen and van Donk, 2014).

On the other hand, if packaging operations are postponed closer to end customers, huge savings in transportation costs can be achieved (van Hoek, 1999; Varsei *et al*., 2017). Such savings would emerge from the avoidance of shipping the heavy and bulky packing materials, usually adopted in this industry, that significantly increase the weight and/or volume of the transported goods (van Hoek, 1998; Twede *et al*., 2000). For instance, some wines are transported in bulk and bottled at regional distribution centers, since it is much less expensive to ship the product in bulk, without the heavy glass bottles (Cholette, 2009; Varsei *et al*., 2017). To this end, the use of specific containers for liquid products, termed flexitanks, appears to offer significant savings (Harris *et al*., 2018). Nevertheless, when goods are shipped bulk, it may not be possible to include

multiple products in the same container (Van Hoek, 1997), which could affect the number of containers yearly shipped as well as inventory levels and management policies.

Therefore, in the food industry, postponement opportunities are mainly related to deferring packaging and labeling activities (van Hoek, 1998; Bandaly and Hassan, 2020), also because of the importance of private labeling (Cholette, 2009) and the proliferation of promotional packaging (Wong *et al*., 2011). Moreover, in most food production processes, assembly is replaced by blending, which entails mixing two or more ingredients to create final recipes and thus offers original applications for postponement (Van Kampen and Van Donk, 2014; Ferreira and Alcântara, 2015; Ferreira *et al*., 2020). While blending entails significant scale economies in production, packaging (e.g., bottling) requires "medium" scale economies, with scale advantages from centralized operations lower than those in capital-intensive industries such as aluminum, cement, oil, gas, petrochemical, and power plants (Varsei *et al*., 2017).

Methodology

Research design

The present study aims at investigating the postponement boundary problem for global food supply chains, exploring the drivers behind the choice of different strategies and providing a quantitative assessment of the strategies' suitability to support managerial decision-making (Figure 1).

-Take_in_Figure_1-

A single case study was conducted considering an Italian company exporting olive oil to the United States. Case studies are recommended for inductive exploration of yet unknown phenomena (Gammelgaard, 2017), whereas case selection should be driven by the expected information thickness rather than generalization properties (Flyvbjerg, 2006). Although a single case approach might limit the study's external validity, it was deemed appropriate to investigate a currently under-explored phenomenon and develop in-depth understanding (Flyvbjerg, 2006; Yin, 2009). While the review of the previous literature contributed to providing substantive justification for the study (Mentzer and Kahn, 1995), case research contributed to strengthening the research motivation highlighting its real-world relevance, designing the study, and validating if the insights were logical and applicable in the real world (Sodhi and Tang, 2014). Then, a multi-methodological approach was adopted (Choi *et al*., 2016), combining data obtained through exploratory case study research with empirically grounded analytical modeling (Sodhi and Tang, 2014). This approach helped yield a more scientifically sound and multi-perspective solution to existing problems, strengthening the research rigor (Sanders and Wagner, 2011) and increasing the practical relevance (Stentoft and Rajkumar, 2018). Given that analytical models are usually constructed based on a set of restrictive assumptions, the resulting insights might be criticized as being not practical enough (Choi and Guide, 2012). Nevertheless, the use of real-world empirical data from case research supports the validity of the inquiries emerging from analytical modeling (Sodhi and Tang, 2014). It improved the study's rigor, simultaneously highlighting its applicability and strengthening the resulting

managerial insights (Choi *et al*., 2016). Lastly, quantitative modeling allowed for performing a sensitivity analysis to investigate outcomes when changing key parameters, thus partially addressing the external validity limits that intrinsically characterize single case research.

Case selection

Postponement strategies entailing a geographical reconfiguration of downstream operations were considered as units of analysis (Yin, 2009). Consequently, food producers with significant export activities were acknowledged as potential cases. As the postponement boundary problem encompasses the importance of duties and trade barriers, we looked for cases that could have allowed for explicitly investigating the related impact. Cases were identified from a list of companies available through contacts activated by two Italian universities, and case selection was driven by the potential to maximize conceptual insights and understanding (Caniato *et al.*, 2018). Purposeful sampling was used to maximize information thickness rather than generalization properties (Flyvbjerg, 2006). The selected case (named ItalOil to guarantee anonymity) was chosen due to its broad experience with duties management worldwide, and also because of its availability to extensively share experience and data.

ItalOil is a medium-sized Italian olive oil producer, employing more than 100 people and with a single production facility located in Northern Italy. Choosing an Italian company was deemed appropriate for the study's purposes, as food supply chains account for a large percentage of national exports (Istat, 2021). Furthermore, Italian products are appreciated worldwide, but significant trade barriers exist when importing in several countries (Banterle *et al*., 2016). Born as a flaxseed oil artisanal producer, ItalOil has grown over the 20th century as a private label manufacturer for Italian retail trade chains. Since 2010 the company has started to re-focus its brands. It experienced significant growth in revenues (about € 200M in 2018), driven by the introduction of new products and by the simultaneous increase in export volumes that accounted for about 20% of ItalOil total revenues in 2018. In addition, exports toward the USA were expected to increase significantly in the next ten years. ItalOil used to operate in the US market as a private label producer for well-established retail chains. Then, exploiting its relationship with US retailers, the firm planned to introduce its brands in the US market. Moreover, new big private label contracts were signed. Therefore, the company was evaluating to re-design its global supply chain by geographically postponing some operations to the US market, to cope with increasing exports and take advantage of tariff differences between finished (i.e., bottled) and semi-finished (i.e., bulk) products. As also acknowledged by previous studies in other contexts (e.g., Cholette, 2009), bottled olive oil is usually subject to higher duties than bulk imported one.

Data collection

All the necessary data were primarily gathered through weekly visits over a period of four months, from August 2019 to December 2019. Weekly semi-structured interviews were conducted (Voss *et al*., 2002), involving managers from different departments (Supply Chain Planning, Purchasing, Manufacturing, Sales, Logistics and Finance/Accounting), supported by the analysis of available archives, financial statements, internal plans,

and accounting documents, accessed through the company's ERP system. To ensure a strategic vision about the considered problem, the company's logistics manager and export manager played the role of key interviewees, allowing for the reconstruction of events and the understanding of issues resistant to observation (Voss *et al*., 2002). The interviews (approximately 90 min long and, when agreed by the informant, recorded and transcribed) helped limit the study's scope and increase focus, hence increasing conceptual and legitimative relevance (Stentoft and Rajkumar, 2018). Every interview was based on a list of open questions, built upon previous academic contributions (e.g., Pagh and Cooper, 1998; Lee, 2010), which became more and more detailed with the progression of the work (Appendix A). Moreover, every time a piece of information was collected, it was written off from that list and included in a calculation sheet and/or in a text document, where all details were reported. Interviewees were consulted when any doubt emerged through follow-up questions. In this way, the construct validity and reliability of the study were strengthened. Data triangulation was also an integral part of the process: industry reports, annual reports, news articles, and other public documents were consulted, thus corroborating the findings and also increasing the internal validity (Yin, 2009). Due to the sensitive nature of the topic, confidentiality was guaranteed to interviewees and, therefore, neither company nor individuals will be revealed.

Qualitative data analysis

The first phase of the research was inductive in nature, aiming to formalize the system under study. Despite this being similar to theory building (Yin, 2009), the end result was not a testable theory but an analytical model from which to deduct further insights (Choi *et al*., 2016). The study is directly built upon recent literature contributions (e.g., Lee, 2010; Varas *et al*., 2018; Prataviera *et al*., 2020), and this increased internal validity and contributed to improving the study's theoretical calibration (i.e., the degree to which theory is captured within research design – Craighead *et al*., 2019). Data collected during the interviews were processed and abstracted, so that literature-based global downstream postponement strategies were tailored for global food supply chains. A preliminary understanding phase characterized the first meetings, which allowed for capturing the informants' perceptions about the problem in focus and for improving the study's theoretical contextualization (i.e., the degree to which theory is adapted to the industry situation being studied (Craighead *et al*., 2019). Emerging findings and reflections supported the conduction of the following interviews, and collected data were openly coded to compare similarities and differences with previous contributions, strengthen existing constructs, and develop new categories (Ellram, 1996). For example, blending operations were deepened since they replaced the assembly ones that characterize modular products like computers or cars. Open coding paved the way for axial coding, to connect the identified categories and examine their interactions (Ellram, 1996; Gioia *et al*., 2013). Some cost items had an impact on others (e.g., duties to be paid over inventory carrying costs), and this had to be properly addressed. Nevertheless, open and axial coding occurred as iterative processes, rather than pure sequential ones, and the emerging patterns and results were systematically compared with the additional information collected from the informants (Gioia *et al*., 2013).

Iteratively sharing the findings with informants characterized by heterogeneous backgrounds also led to reducing misunderstandings and better interpreting and reconciling field data (Voss *et al*., 2002; Yin, 2009).
As a result, two strategies were considered (namely, Global Logistics Postponement – GLP, and Global Packaging Postponement – GPP) since they were deemed the most relevant ones by the company. This was also coherent with previous contributions (e.g., Twede *et al*., 2000; Varsei *et al*., 2017). According to GLP, the production process is completed in the Home region and finished products are distributed from warehouses located in the Destination region. Conversely, for GPP, goods are packaged and labeled in the Destination region, from where demand to final customers is also fulfilled.

Quantitative data analysis

A model to assess the cost-effectiveness of the two identified strategies was developed according to an analytical approach, chosen due to its flexibility (i.e., changes and variations can be applied to each single modeled activity with limited effort) and transparency (i.e., assumptions are clearly stated in advance) (Mangiaracina *et al*., 2016). In order to compare the two strategies, profits were considered, rather than only costs, as taxes can have a significant impact on the overall company's performance (Miller and De Matta, 2008). Revenues, transfer prices definition, and corporate income tax rates were thus included (Fernandes *et al*., 2015) to determine Net Income After Taxes (NIAT). Profits were computed as the difference between revenues in the export market and the differential costs between the two alternatives, also considering the CIT difference due to different tax rates in different countries. As the postponement boundary problem is limited to downstream supply chains (Lee, 2010), upstream stages were not considered. Consequently, upstream production costs were excluded from the model formulation.
The modeling phase required the identification of three main elements: inputs (data and contextual parameters needed to run the model), model algorithms (mathematical formulas to assess the cost functions related to each activity), and outputs (tables and graphs to display the results). The following cost items were included: transportation, handling, downstream operations (i.e., packaging and labeling), customs duties, materials purchasing costs (related to packaging and labeling), inventory carrying costs, and CIT (Lee, 2010; Choi *et al*., 2012; Weskamp *et al*., 2019). In addition, for GPP not only distribution but also downstream manufacturing operations took place in the facility abroad. Therefore, for GPP an investment cost in the Destination region was introduced, related to production facilities and equipment purchase, inbound handling systems and tools purchase, warehouse and storage equipment purchase, start-up costs for the destination region subsidiary, and any additional expense required to perform activities in the Destination region. The investment cost was then factored into the model by calculating the Net Present Value, i.e., by analyzing the profitability of the investment with respect to the present value of cash outflows over a given timeframe.
Cost functions were developed by combining literature review and data collected from the interviews for each cost item and each postponement strategy. General analytical functions were imported into Microsoft Excel, and calculation sheets were filled with the company's data. Once entered input data in Microsoft Excel, the model returned the NIAT estimation for each configuration, allowing for separately examining any cost item.

Since data collection and model construction phases were parallel, the model was progressively revised and populated with data and information (e.g., CIT rates) gained from the interviewees. They were later involved to validate research, by triangulating the model's results with the company's outcomes through extensive use of face validity. This validation strategy may be argued, as the mathematical rules are well-validated (logical validity) whereas the parameters are less so (data validity). However, this should not affect the reliability of the study, as the research is aimed at exploring the phenomenon rather than providing normative guidelines. Indeed, the case study offered a way to understand subtleties within the specific research setting, where prior knowledge is limited, by providing the data for generating further insights (Eisenhardt, 1989; Ellram, 1996). As an output, the model provided a final spreadsheet containing: (i) costs related to each above-mentioned cost item and NIAT for both alternatives; (ii) pay-back time related to GPP implementation.

Lastly, analytical modeling enabled to perform a sensitivity analysis, simulating the model's outcomes when changing contextual parameters. Coping with uncertainty represents a central argument when making strategic decisions (Cohen and Lee, 2020). Such analysis allowed for studying the impact of those drivers that the literature or the interviewees proposed as key drivers behind global postponement strategies design (Choi *et al.*, 2016). On the one hand, export volumes were considered because demand uncertainty has been widely acknowledged as the main driver for postponement (Yang *et al*., 2004; Weskamp *et al*., 2019). On the other hand, the impact of duties was explored. The company deemed it a critical element to cope with when defining its postponement strategy, because of the increasing protectionist laws and the erection of trade barriers between nations in recent years. This is also in line with the general theory about the postponement boundary problem (Lee, 2010; Prataviera *et al*., 2020). By means of the sensitivity analysis, it was possible to get a richer understanding of the situation and to test the contextual effects on the developed model in order to generate knowledge without expensive real-life implementation. Moreover, it improved the paper's practical relevance by investigating a problem that practitioners consider relevant to improve understanding of their business situation (Stentoft and Rajkumar, 2018).

Postponement strategies for global food supply chains: GLP and GPP

This study addresses global downstream supply chains, from factories to final customers' sites (Harris *et al*., 2018). The target company highlighted that, independently from where manufacturing operations take place, shelf-life requirements require that finished products inventories be kept close to final markets. This is to guarantee an acceptable service level to customers, in line with the existing literature (e.g., Cooper, 1993; Pagh and Cooper, 1998). Consequently, with respect to the strategies formalized by Prataviera *et al*. (2020), this study focuses on those strategies that entail at least one operation to take place in the Destination region, as this enables companies to keep finished products inventories there.

Moreover, blending activities offered scarce opportunities for postponement, because they required special capabilities and knowledge. In the considered case study, due to customs requirements in terms of the rules of the origin, blending has to take place in Italy to keep the Italian origin for olive oil. Labeling postponement was also excluded, as it resulted subordinate to packaging operations. Therefore, GLP and GPP strategies were

identified as the ones offering the largest business opportunities. Table I summarizes the drivers behind global postponement strategies characterizing the present case study.

-Take_in_Table_I-

Figure 2 and Figure 3 exhibit the illustration of GLP and GPP, respectively, according to the conceptual framework offered by Prataviera *et al*. (2020).

-Take_in_Figure_2-

-Take_in_Figure_3-

According to GLP, blending is completed in the Home region. Finished products, already packaged and labeled in the Home region, are packed in boxes, stacked onto pallets, loaded into containers, and shipped to warehouses located in the Destination region, from where finished product distribution occurs. Conversely, for GPP blending activities are also carried out in a centralized facility in the Home region, but then unpackaged goods are shipped bulk through flexitanks fitted inside ordinary dry containers to final markets (Destination region). There, they are packaged and labeled according to product differentiation requirements by customers. Hence, higher investments are required for GPP rather than GLP, since it is necessary to equip proper facilities to carry out operations in the destination market.

It was also assumed that GLP strategy is managed through an importer/intermediary in the Destination region so that the company can sell its products in the foreign market without formally opening any legal entities there. Conversely, GPP implementation requires creating a company's subsidiary abroad, which entails being subject to tax liability in the Destination region due to the creation of PE (Shunko *et al*., 2017). According to the company interviewees, they also evaluated GLP along with a foreign subsidiary, thus bypassing any intermediary. Nevertheless, the operations to take place in the Destination region would not have justified the creation of a PE abroad. Moreover, such a solution would have introduced a rigidity not justified by the operations to take place in the Destination region. As claimed by the company's export manager, "for pure distribution of finished products, an intermediary is just fine for our purposes. Opening a subsidiary would imply additional investments and require specific knowledge that are not justified by the marginality we might achieve with our customers".

Model formulation

This section presents a generic model to quantitatively compare the two identified postponement strategies for global downstream supply chains in the food industry. The model is based on previous literature as well as on insights and data from the interviews, incorporating tax rates as exogenous parameters (Fernandes *et al*., 2015). It evaluates NIAT (Vidal and Goetschalckx, 2001), taking into account only differential costs between the two alternative strategies. The following assumptions were introduced:

1. A multi-product model is proposed, and *k* finished products are included;
2. Both finished (packaged and labeled) and semi-finished (unpackaged) goods are considered, although it is assumed that outbound flows from the warehouse in the Destination region can involve only finished products;
3. Inventories are managed through a periodic review model;
4. For both strategies, customer orders are fulfilled from stock kept in a warehouse in the Destination region. Downstream operations, including packaging and labeling, are performed based on forecasts. The decoupling point is placed before final distribution, thus considering a make-to-stock system configuration (Yang and Burns, 2003);
5. The value-adding facility (Notteboom *et al.*, 2017) in the Destination region where products are packaged, labeled, and stored for GPP is the same facility where goods are stored for GLP, thus having invariant delivery lead times to customers;
6. Due to the limited incidence of the export to the Destination region on the overall production volumes, scale economies related to the operations taking place in the Home region are not affected by the selected postponement strategy;
7. Due to the different operations required to supply goods to customers, the increase in goods' value along the different supply chain nodes is explicitly considered (Miller and De Matta, 2008);
8. GLP strategy is managed through an importer/intermediary in the Destination region (avoiding any PE creation), while GPP implementation entails the creation of a company's subsidiary abroad, thus making the company subject to tax liability in the Destination region;
9. Selling prices to customers are considered as fixed, not affected by the chosen postponement strategy or the ensuing cost structure. Therefore, revenues are invariant between the two strategies (Miller and De Matta, 2008);
10. As a requirement for the justification of TPs to tax authorities, all transfer prices are properly defined in accordance with the arm's length principle (Miller and De Matta, 2008). The cost-plus method is applied (Fernandes *et al.*, 2015) and it is also assumed that TPs include transportation and duties cost (which, therefore, are entirely charged to the subsidiary for GPP) (Vidal and Goetschalckx, 2001);
11. For the sake of simplicity, all costs and revenues, as well as monetary parameters and variables (presented in the following section), are expressed in a single currency.

The model formulation is different for the two strategies. In line with Vidal and Goetschalckx (2001), the model determines Net Income Before Taxes (NIBT) by subtracting cost items from revenues; then, by applying corporate income tax rate (γ, different between Home and Destination regions), NIAT is calculated. NIAT calculation for GLP and GPP is proposed in Equations 1 and 2, respectively. In line with the model's assumptions, the firm is subject to tax burden in the Destination region only when GPP is adopted.

$$NIAT_{GLP} = NIAT_{Home} = NIBT_{Home} - CIT_{Home}$$
$$= (1 - \gamma_{Home}) * \sum_{k} (REVENUES_{k}^{external} - \sum COSTS_{k,GLP}) \quad (1)$$

$$NIAT_{GPP} = NIAT_{Home} + NIAT_{Destination}$$
$$= (NIBT_{Home} - CIT_{Home}) + (NIBT_{Destination} - CIT_{Destination})$$
$$= (1 - \gamma_{Home}) * \sum_{k} \left(REVENUES_{k}^{internal}\right) + (1 - \gamma_{Destination}) \quad (2)$$
$$* \sum_{k} (REVENUES_{k}^{external} - \sum COSTS_{k,GPP})$$

First, revenues are to be distinguished whether intra-company $\left(REVENUES_{k}^{internal}\right)$ or collected from external customers ($REVENUES_{k}^{external}$), related to each of the *k* products considered. Intra-company revenues are generated by the company in the Home region by selling unpackaged goods to the subsidiary in the Destination region at a transfer price. Revenues from external customers are related to finished products and are collected either in the Home region (GLP) or in the Destination region (GPP), according to the model's assumptions. The considered cost items are expressed in Equation 3; although the cost items are the same for both strategies, they are properly modeled for each strategy *s*.

$$COSTS_{k,s} = TC_s + HC_s + ICC_s + DOC_s + MPC_s + CDC_s \quad (3)$$

Transportation costs (TC_s) consider sea freight as the only transportation mode. It is assumed that different finished products (already packaged and labeled) can be grouped in the same Full Container Load (FCL) shipment in the case of GLP. Instead, for GPP it is not possible to include multiple semi-finished products in the same container. TC_s depend on the shipment frequency and the unitary transportation cost per container, whose quantity depends on the overall yearly demand for all the *k* products, the inventory management policy adopted by the company, the container capacity, and goods' volume or weight. Inland transportation is also included, referring to the goods' transportation from the Home region plant to the port of loading and from the port of discharge to the facility in the Destination region. The related costs are driven by the traveled distance and by the goods' weight or volume (depending on the goods volume density).

As per Handling costs (HC_s), both outbound and inbound activities are modeled through determining a unitary cost per container, taking into account: labor cost of personnel, handling systems rental/lease fees, equipment energy consumption, and equipment maintenance. It is assumed that energy and maintenance costs are directly proportional to the machine utilization rate.

Inventory carrying costs (ICC_s) are related to cycle, safety, and in-transit stocks. Cycle stocks are determined based on the inventory management policy, while safety stocks are related to both demand and lead time

variability (Lee and Billington, 1994). As regards the value of goods at stock, for GLP inventories belong to a third party (i.e., the distributor/wholesaler), and a unitary holding cost is thus introduced. Conversely, for GPP inventories are assumed to be owned by a company's subsidiary. Hence the unitary value of unpackaged goods is equal to the TP applied in the intra-company sale between the parent company in the Home region and the subsidiary in the Destination region, plus duties and transportation costs not included in the TP (Miller and De Matta, 2008). Lastly, in-transit stocks are proportional to the average flow shipped from one node to another, multiplied by the lead time due to transportation and customs clearance procedures.

Downstream operations costs (DOC_s) refer to packaging and labeling activities. For GLP the whole production process is completed at the Home region facility, where the exported goods share packaging/labeling production equipment and resources with other products. For this reason, the related production costs are considered variable costs. For GPP, instead, the Destination region facility is dedicated to the exported products, so that yearly packaging and labeling operations costs can be calculated as the sum of the costs of all resources employed in these activities: personnel, rented/leased buildings, and equipment and overheads.

Regarding materials purchasing costs (MPC_s), a local sourcing strategy was modeled. Consequently, for GLP packaging/labeling materials are sourced in the Home region, while for GPP materials are purchased in the Destination region. This entails reduced purchasing lots and quantity discounts for GPP, as purchased materials are meant to supply the only Destination region market (and not any market abroad as for GLP).

Customs duties costs (CDC_s) are determined by distinguishing between ad valorem duties, related to goods' value, and specific duties, which can refer to goods' weight or volume. In addition, indirect costs to be paid for each customs operation and administrative activity are included (Sawhney and Sumukadas, 2005).

Once all differential costs are determined, the model subtracts them from revenues to calculate NIBT. Then, applying corporate income tax rates to NIBT, corporate income taxes (CIT_s) are calculated, and NIAT can be determined for each region. Since GPP strategy entails moving some operations to the downstream supply chain nodes, an investment cost is also introduced (as previously explained in the Methodology section). The model calculates differential Net Present Value between the two strategies, assuming a discount rate equal to the Weighted Average Cost of Capital (WACC). Hence, the model determines the number of years required to pay back the investment.

Model application

The two identified strategies were compared to determine their cost-effectiveness and profitability in the current ItalOil scenario, for which Table II exhibits the values of the input data.

-Take_in_Table_II-

ItalOil exported to the USA 4 different branded extra-virgin olive oils. They differed in terms of olives farming methods, organoleptic properties (taste and smell), and origin. Three different packing formats were considered

for each product, corresponding to different bottle volumes to be sold in the USA: 500ml, 750ml, 1000ml. Hence, 12 SKUs were overall considered.

Numerical results

Although the model is meant to compare the strategies according to NIAT, revenues were supposed to be invariant with the two alternative configurations. Therefore, in addition to profit considerations, results referring to cost differences are displayed to improve the understanding of the underlying cost dynamics (Figure 4). To assure the required confidentiality, all data were properly adapted and transformed into relative measures (in percentage, using as basis the profits and costs related to GLP); such assumptions did not disturb the results, as the same proportions were maintained (Fernandes *et al*., 2015).

-Take_in_Figure_4-

GPP outperformed GLP, with a profit higher by almost 4.8% thanks to a cost reduction close to 8%. Nevertheless, when looking at single cost items, GPP had contrasting effects. On the one hand, geographically postponing packaging and labeling operations to the US facility led to higher downstream operations and materials purchasing costs in the Destination region. This was due to opening a new facility, fully dedicated to the postponed operations, whereas fixed costs were split over lower production volumes than in the centralized facility in Italy. Moreover, material purchasing costs were significantly different between GLP and GPP. For GPP, all materials were purchased from American suppliers; thus, unitary costs increased due to smaller purchasing lots. In addition, the average market price of glass bottles was higher in the USA than in Europe, where glass production is centralized. On the other hand, GPP increased efficiency related to the logistics operations (i.e., transportation and inventory holding). Indeed, inventory carrying and handling costs were lower for GPP due to the bulk shipping of olive oil. Avoiding the creation of the unit load in the Italian facility lowered handling costs, and most inventories were kept as semi-finished olive oils, with a lower unitary value than bottled olive oil. Shipping bulk instead of bottled finished products in GPP also reduced the overall weight shipped per year, avoiding paying for the shipment of a huge amount of glass bottles. This entailed savings in both transportation and customs costs because US customs levies tariffs based on the goods' weight, and the dutiable weight diminished by almost 40%. In fact, for GLP, bottled products underwent customs clearance operations, and the dutiable weight was the sum of olive oil and glass bottles weight. Moreover, the tariff rate applied on bulk olive oil was lower than the one levied on bottled products, thus implying additional savings compared to GLP. Lastly, the CIT rate in the USA was lower than the Italian CIT rate, so that profits accumulated in the US and accounted to the US subsidiary were subject to lower fiscal pressure.

Nevertheless, GPP implementation required additional costs related to running up a new facility for packaging and labeling operations. Yearly savings in place between GPP and GLP were thus compared with required investments. Investments accounted for almost 2.5 million €, and about 80% of the total was due to production line and auxiliary systems (piping, hydraulic pumps, and refrigerating systems). According to the company's

financial statements, WACC was set equal to 11.21%. Net Present Value for GPP strategy was thus calculated and allowed for determining the related pay-back time, equal to 4 years. The useful life of the considered equipment ranged from 10-12 years for some parts of the production line to more than 40 years for piping. Even assuming 10 years as the useful life of the entire investment, GPP emerged as a more profitable strategy than GLP.

Impact of export volumes and duties

A sensitivity analysis was performed to understand the robustness of the identified results (Miller and De Matta, 2008) by modifying export volumes (i.e., yearly demand in the USA) and duties levied on olive oil. Increasing export volumes allow for splitting fixed costs of downstream operations over a higher denominator, thus reducing unitary cost per finished product bottle in the USA. Three possible values for export volumes were considered, equal to "current demand" (3 M liters/year), "high demand" (6 M liters/year), or "low demand" (1 M liters/year). While revenues were assumed to be directly proportional to selling volumes, total costs for the two alternatives varied differently, thus leading to different profitability for the two strategies. In addition, required investments for GPP were not considered directly proportional to selling volumes. They were deemed 40% higher in the case of "high demand" and invariant in the "low demand" case. As concerns duties, possible changes in trade policies were introduced.

GLP and GPP entail different tariffs according to finished or semi-finished products. Therefore, the gap between tariffs levied on finished products (current level: 0.042 €/kg) and those levied on bulk ones (current level: 0.028 €/kg) was considered. Three possible values for tariff gap were introduced: "current gap" (0.014 €/kg), "increased gap" (0.055 €/kg), and "no gap" (0 €/kg). Results are summarized in Figure 5, showing the two strategies' cost-effectiveness.

-Take_in_Figure_5-

GLP was preferable for low export volumes and a low tariffs gap between finished and semi-finished goods. GPP, instead, emerged as the best solution when export volumes or tariffs gap increased. Moreover, results showed that, *ceteris paribus*, export volumes had a stronger influence than tariffs on the cost-effectiveness of GPP compared to GLP. The impact of tariffs was due to the nature of the products shipped across borders and the related dutiable weight. For GPP bulk olive oil was shipped from Italy to the USA, and duties were computed only on the olive oil weight. For GLP, instead, bottled products underwent customs clearance operations. Thus, the dutiable weight was the sum of olive oil and glass bottles weight. Therefore, GPP would overwhelm GLP for a wide range of export volumes.

Discussion

This study confirmed that geographically postponing operations downstream is valuable (van Hoek, 1996), also concerning the food industry (Ferreira and Alcântara, 2015; Ferreira *et al*., 2020; Bandaly and Hassan,

2020). Varsei *et al.* (2017) and Harris *et al.* (2018) highlighted the sustainability-related positive externalities concerning geographical postponement. Conversely, this study deepens the fiscal-related savings and opportunities, while acknowledging the potential barriers (Lee, 2010; Prataviera *et al.*, 2020). For example, postponing customization to local requirements in a warehouse in the Destination region offers huge benefits (van Hoek, 1998; Twede *et al.*, 2000). However, blending operations are so critical in the food industry that they can hardly be postponed, because of scale economies and the specific capabilities and knowledge required (Ferreira *et al.*, 2020). Moreover, the country where blending operations are carried out can be essential to determine the origin of products, possibly introducing constraints to the implementation of some postponement strategies. Geographically postponing blending to the Destination market could entail a reduction in duties payment (as the product value when crossing the border is lower), but it could also imply that products lose their origin. However, for commercial purposes, it is often highly important to preserve the origin of the product, as in this study concerning the Italian origin for olive oil. These findings highlight that the postponement boundary problem should be limited to a few operations, and a first proposition is proposed:

P1: In the food industry, blending activities should hardly be geographically postponed because of the specific capabilities required and due to the implications related to determining products' origin.

Case-based results provided original quantitative insights about postponement for global food supply chains, showing that a trade-off characterized global postponement strategies' evaluation (van Hoek, 1999; Varas *et al.*, 2018). On the one hand, a higher postponement level (as per GPP) entailed an increase in downstream operations and materials purchasing costs (due to lower scale economies in the Destination region than in the Home region). On the other hand, it resulted in a decrease in inventory carrying, transportation, and customs costs. Inventory cost savings are mainly related to holding inventories of undifferentiated products, with a lower value compared with finished goods (van Hoek, 1997; Bandaly and Hassan, 2020). As concerns transportation costs, the study provides quantitative evidence that postponing packaging operations can lead to huge savings in the food industry, thanks to the bulk transportation of products through flexitanks that reduces volumes and costs (Varsei *et al.*, 2017; Harris *et al.*, 2018). A second proposition follows:

P2: Global Packaging Postponement offers wide benefits to global food supply chains, especially when bulky and heavy packing materials account for a big percentage of the finished product's weight and volume.

The research also confirmed that duties and other tax-related elements play a crucial role in shaping global postponement strategies (Cohen and Lee, 2020). Geographical postponement can result in lower scale economies in downstream operations (Varsei *et al.*, 2017), but the possible fiscal advantages, rising from lower duties and lower corporate tax rates under the meeting of specific requirements (Prataviera *et al.*, 2020), can improve the strategies' cost-effectiveness. In this study, GPP entailed lower tariffs upon the import of goods in the Destination region since semi-finished products (and not finished ones) were shipped across borders.

Moreover, duties upon the import of olive oil in the US was proportional to the dutiable weight, and additional savings were achieved when adopting GPP thanks to the lower weight of the imported products (which did not include heavy glass packaging). Similar considerations could be drawn if duties were assessed according to goods' value, but this study shows that benefits related to tax-related elements depend on the fiscal rules of the considered jurisdiction. A third proposition was formulated:

P3: Any postponement boundary problem investigation needs to carefully consider the peculiarities of the application contexts and the corresponding fiscal regulatory frameworks.

This study empirically confirmed that duties and taxes can entail significant cost reduction and higher profitability (Cohen and Lee, 2020), but global postponement strategies could require significant investments that could offset operational and fiscal benefits. In the considered case study, potential advantages had to be compared with the one-time implementation costs needed to run a new facility in the US and with higher downstream operations costs. Additional investments required for GPP implementation (compared to GLP) were characterized by a pay-back time lower than 4 years. This was deemed acceptable, as it is significantly lower than the expected useful life for this kind of equipment. Nevertheless, GPP is inherently more rigid than GLP, and a 4-years time frame can be critical for some companies, especially given the increasing uncertainty about the future of global economics. Furthermore, the sensitivity analysis showed that the higher are the export volumes, the higher is GPP suitability. This is in line with the previous literature, which largely identified export volumes and demand uncertainty as the main drivers behind any strategy (Yang *et al*., 2004; Ferreira *et al*., 2020). However, this study assumes that scale economies in the factory in the Home region are not affected by the postponement of downstream operations, since export volumes to the Destination region are relatively small compared with the overall volumes. Conversely, if the export volumes were comparable to the domestic ones, any increase in bulk exports would determine an increase in unitary costs in the Home region due to negative effects on scale economies. Future studies could deepen the related dynamics, as scale economies might also differ for different operations. For example, while postponement could encompass a geographical reconfiguration of packaging and following operations, this study highlights that blending should occur in the Home region (P1).

The sensitivity analysis also showed that the higher is the gap between the tariffs levied on finished products and those levied on semi-finished ones, the higher is the cost-effectiveness resulting from the adoption of GPP. Combining the discussion of the two contextual parameters, when either the export volumes or the tariff gap (or both) are high, GPP is more cost-effective than GLP, and thus the geographical postponement of a significant part of downstream operations is an appealing option for companies in the food industry. However, while the export volumes affect all the cost items to be considered for a quantitative evaluation of the strategies' feasibility, the tariff gap concerns only customs duties cost (and, indirectly, inventory carrying costs as goods' value encompasses duties payment at import). Therefore, export volumes have the greatest impact on the

postponement strategies performance, but the tariff rates can either improve or worsen it according to the regulatory framework in place:

P4: When shaping global postponement strategies, the export volumes represent the key decision driver, and duties and tariffs can act as an amplifier of the companies' performance.

Lastly, in line with some recent contributions (e.g., Bandaly and Hassan, 2020), this study empirically illustrates the importance to keep inventories of finished products close to final customers in this industry, not only due to service level requirements (i.e., being able to deliver on time – Abukhader and Jonson, 2007) but also because of shelf-life constraints. Indeed, shelf-life requirements can be so strict to make it impossible to deliver food products from any region other than the Destination one (including the Home region) (Ferreira and Alcântara, 2015; Bandaly and Hassan, 2020). For olive oil, customers usually require products whose residual shelf-life is equal to at least two-thirds of their total shelf-life. When considering other products, e.g., fresh products characterized by short times before expiration, shelf-life requirements become even more important. Moreover, since part of the shelf-life can be spent in transportation, customs operations, and storage, postponing packaging operations can reduce the risk of products obsolescence. Consequently, postponing packaging operations provides producers with the opportunity to enlarge the time window to sell their bottled products, reducing obsolescence risks. Geographically postponing some operations could also enable companies to temporally delay their execution, as the sale to customers would not encompass the international transportation lead time. A fifth proposition follows:

P5: Shelf-life requirements management and the possible reduction in obsolescence risks can determine the (un)feasibility of global postponement strategies in the food industry.

Conclusions

With increasing protectionist laws and the erection of trade barriers between nations, duties and corporate tax rates can have significant implications that require careful managerial considerations when making postponement decisions (Lee, 2010; Prataviera *et al*., 2020). The present study aims at contributing to the postponement research stream by investigating the postponement boundary problem in global food supply chains, focusing on the related strategies and the related key enablers (Boone *et al*., 2007; Zinn, 2019). To address the two identified RQs a multi-methodological approach was adopted. A single case study was conducted considering an Italian olive oil producer exporting to the USA, combining exploratory case research data with empirically grounded analytical modeling.

Two strategies were identified as the most relevant and formalized in the considered application context, confirming the importance of regulatory issues that guide postponement choices. Different regulatory frameworks in different countries have a huge impact on companies' decisions, especially for what concerns the origin of products that can lead to tariff barriers behind the import in foreign markets (Cohen and Lee,

2020). Although some qualitative studies exist, the postponement boundary problem is unexplored from a quantitative point of view. This research also offers a model to quantitatively investigate the cost-effectiveness of two specific strategies. Given the relevance of duties and taxes (Lee, 2010), it combined logistics and fiscal cost functions to identify the strategy with the highest NIAT. A sensitivity analysis was then performed to investigate if and to what extent global postponement strategies were affected by export volumes and tariffs levels.

This study can offer theoretical and practical contributions that could help bridge the gap between academia and the current practice. From an academic perspective, it explores decision drivers related to the postponement boundary problem, considering an innovative and understudied industry as the food one. By specifically formalizing duties and fiscal implications, the paper also advances the concept of geographical postponement in logistics research. Five propositions are offered, paving the way for further inquiries beyond the exploratory case considered in this study. Moreover, the study contributes to addressing the challenge for a methodological upgrading of postponement-related research through the adoption of a multi-method approach. Previous studies mainly encompassed qualitative approaches, while this study also quantitatively explores the suitability of two different strategies. Lastly, the provision of empirical evidence related to the problem through analytical modeling encompasses that the proposed model could be updated and adjusted to adapt to different industries, to investigate the related characterization of the postponement boundary problem.

As concerns practical relevance, the study demonstrates how GPP could represent a worthwhile strategy for food manufacturers while acknowledging that significant investments might be required having strong implications in terms of supply chain flexibility. As academic papers should provide realistic solutions for existing problems (Stentoft and Rajkumar, 2018), food producers could consider this study to gain concrete insights into the importance of the duties in place between different countries and the considered export volumes. Moreover, the proposed model could support their managerial activity when making decisions about global postponement.

Nevertheless, some limitations do exist, and avenues for future research can be recommended. The study focuses on two alternatives to cope with the postponement boundary problem, while new research could address other postponement strategies. Moreover, the postponement boundary problem is largely unexplored in the current literature. This study is one of the first contributions in the field, and the proposed model is characterized by some restrictive assumptions. However, this can open up opportunities to extend the model and the related findings. For instance, the impact of exchange rates or corporate income tax rates could be further investigated, including the impact of different TP policies or the PE implications that emerged in this study. Furthermore, different empirical contexts could be explored, varying the Home region or the Destination region, as well as the considered industry. This study targeted food supply chains as an understudied and promising industry in which to apply geographical postponement, but other industries (including those traditionally considered for postponement as consumer electronics) well deserve to be further deepened.

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Macro-category	Driver	Driver characterization
Product-related	Value density	Olive oil has a high value density compared to the average value density of foods products. Moreover, branded products have a higher value density compared to private label products.
	Obsolescence rate	Olive oil shelf-life, equal to 14-16 months, is counted starting from the date when the product is packaged, and big retailers usually require products whose residual shelf-life is equal to at least two-thirds of their total shelf-life. If products are bottled in Italy and then shipped to a warehouse in the USA, where they are stored waiting for customer orders (GLP), part of the shelf-life is wasted in transportation, customs operations, and storage, thus increasing the risk of products obsolescence. Instead, for GPP products are bottled in the USA, shortly before being shipped to customers.
	Change in size/ weight in downstream operations	All branded olive oil exported to the USA is packaged in glass bottles (primary packaging), which are then put in 6-bottles carton boxes (secondary packaging). This results in a huge increase in the weight of finished products compared with the weight of the olive oil (+43% on average).
	Value profile	Most of the product value is added during the packaging, labeling, and distribution phases. In fact, if olive oil is sold as a branded product in the USA market, the unitary value of a bottled and labeled product delivered to the customer is far higher than the value of the bulk olive oil (from +80% to +160%, depending on the olive oil type).
Market-related	Required delivery lead time	Short and reliable delivery lead times are pre-conditions for the supply of branded products to big retail chains. Therefore, orders are required to be fulfilled from the US warehouse.
	Customization degree	All products exported to the US must have a country-specific label, due to the language (English and Spanish) and to food labeling regulations issued by the US Food and Drug Administration (FDA).
Process-related	Required knowledge/ capabilities	Only the first stage of the production process (blending phase) requires special expertise, on which the company's competitive advantage is based. Instead, the following stages do not require special knowledge or technological capability.
	Process modularization	The blending operation is decoupled from the packaging and labeling activities through a stock of bulk blended oil, conserved in tanks. Instead, packaging and labeling are performed on the same production line and can hardly be decoupled.
Country-related	Customs and duties	Duties charged on unpackaged products are significantly lower. According to US customs regulations, specific duties are levied on olive oil, based on the weight of the imported products [€/kg]. In particular, bottled olive oil is charged by 0,042 €/kg, computed on the weight of the whole product, including oil and packaging. Bulk products, instead, are charged by 0,028 €/kg, which is applied just to the oil weight. Therefore, big savings can be achieved if bulk, unpackaged products are imported into the USA.

Table I – Global postponement strategies' drivers in the considered case study

Input data	**Unit of measure**	**Value**
Annual demand faced by the company in the USA	Liters/year	3,000,000
Number of different SKUs to be distributed in the USA	#	12
Cost to ship one 40’ container from Italy to the USA (Genoa-Baltimore)	€/container	3,050
Cost to ship one 20’ flexitank from Italy to the USA (Genoa-Baltimore)	€/flexitank	3,600
Duties on import of bottled olive oil in the USA	€/kg	0.042
Duties on import of bulk oil in the USA	€/kg	0.028
Weighted Average Cost of Capital (WACC)	%/year	11.21
CIT rate on revenues collected in Italy	%	27.9 %
CIT rate on revenues collected in the USA	%	25 %
Investments required to implement GPP strategy	€	2,610,000

Table II – Model application input data

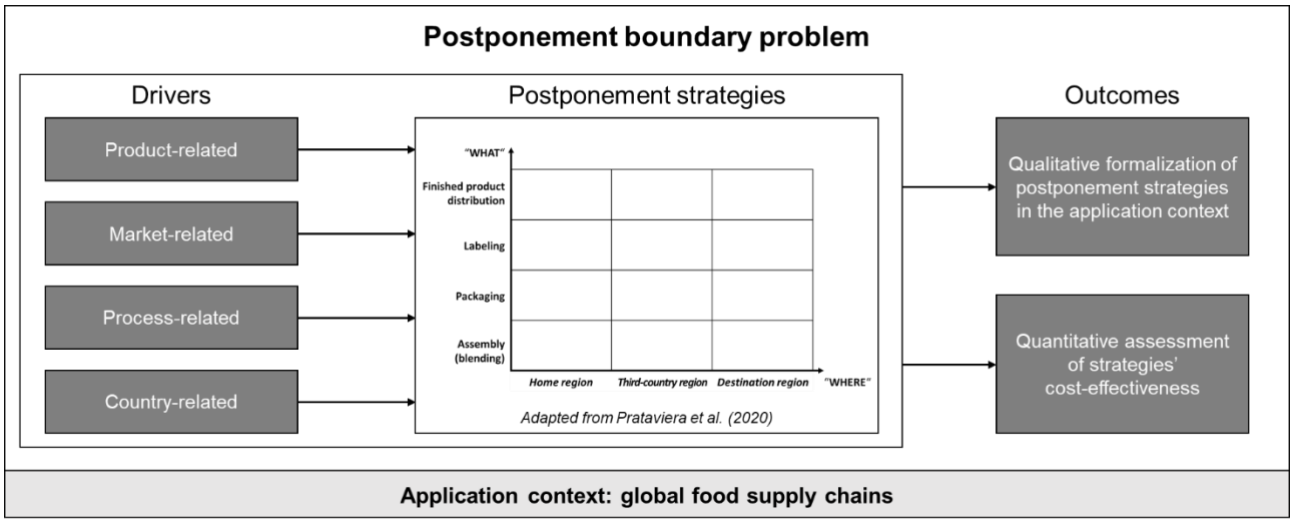

Figure 1 – Research design

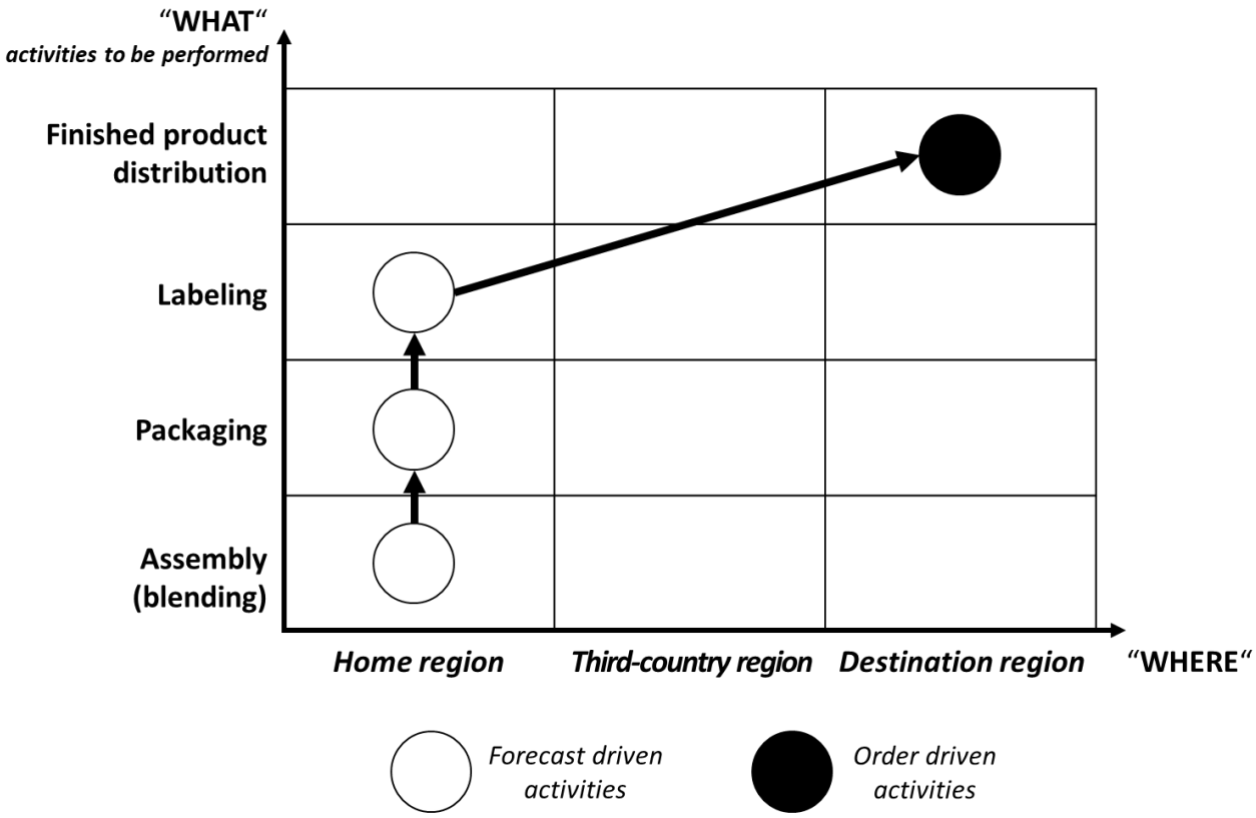

Figure 2 - GLP strategy for the considered case study

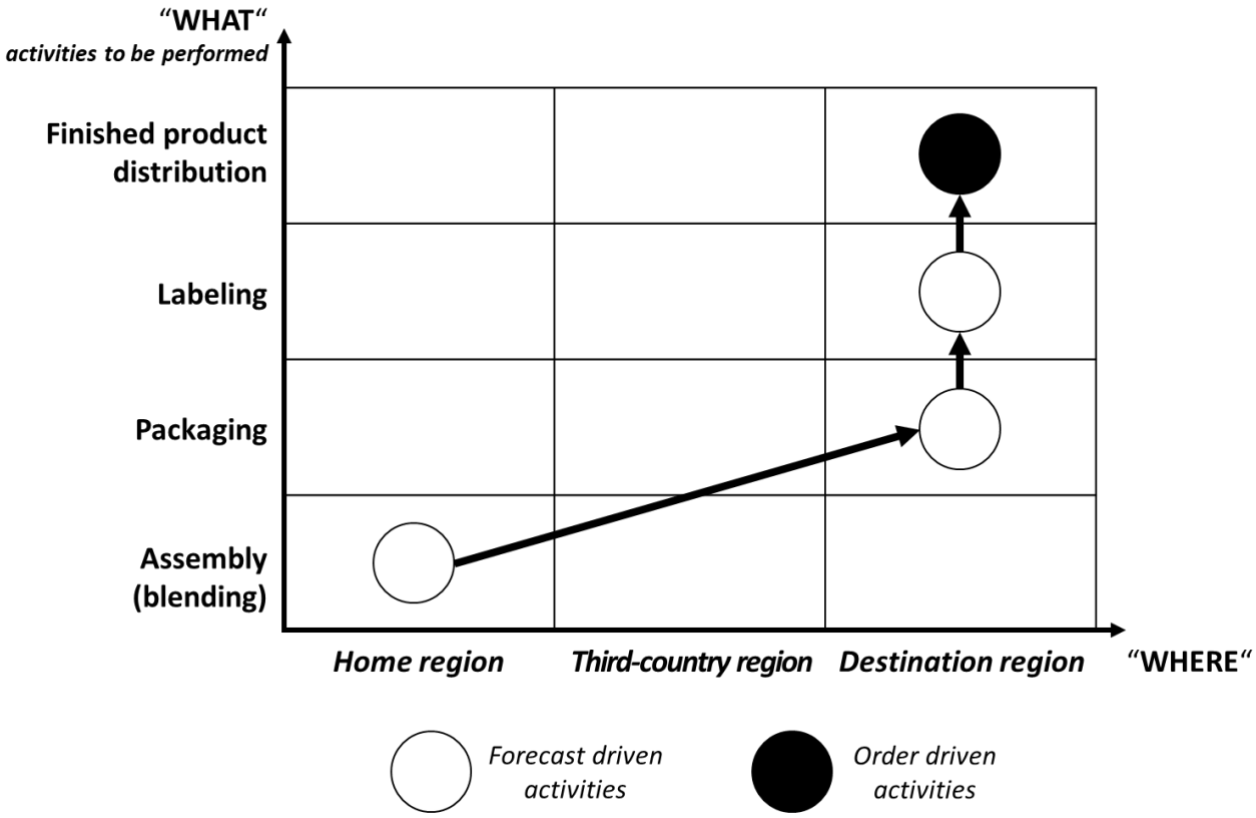

Figure 3 – GPP strategy for the considered case study

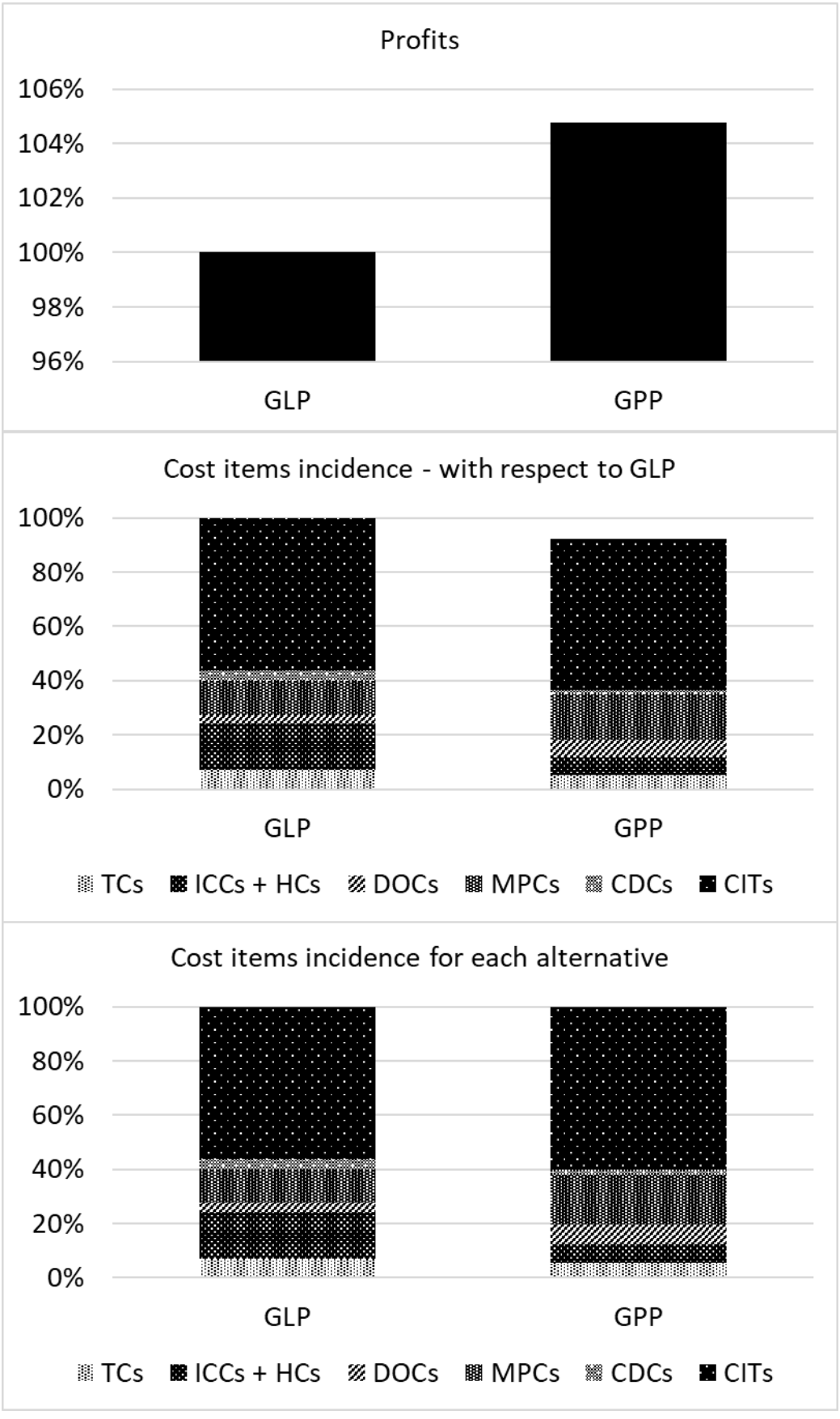

Figure 4 – Model application: results

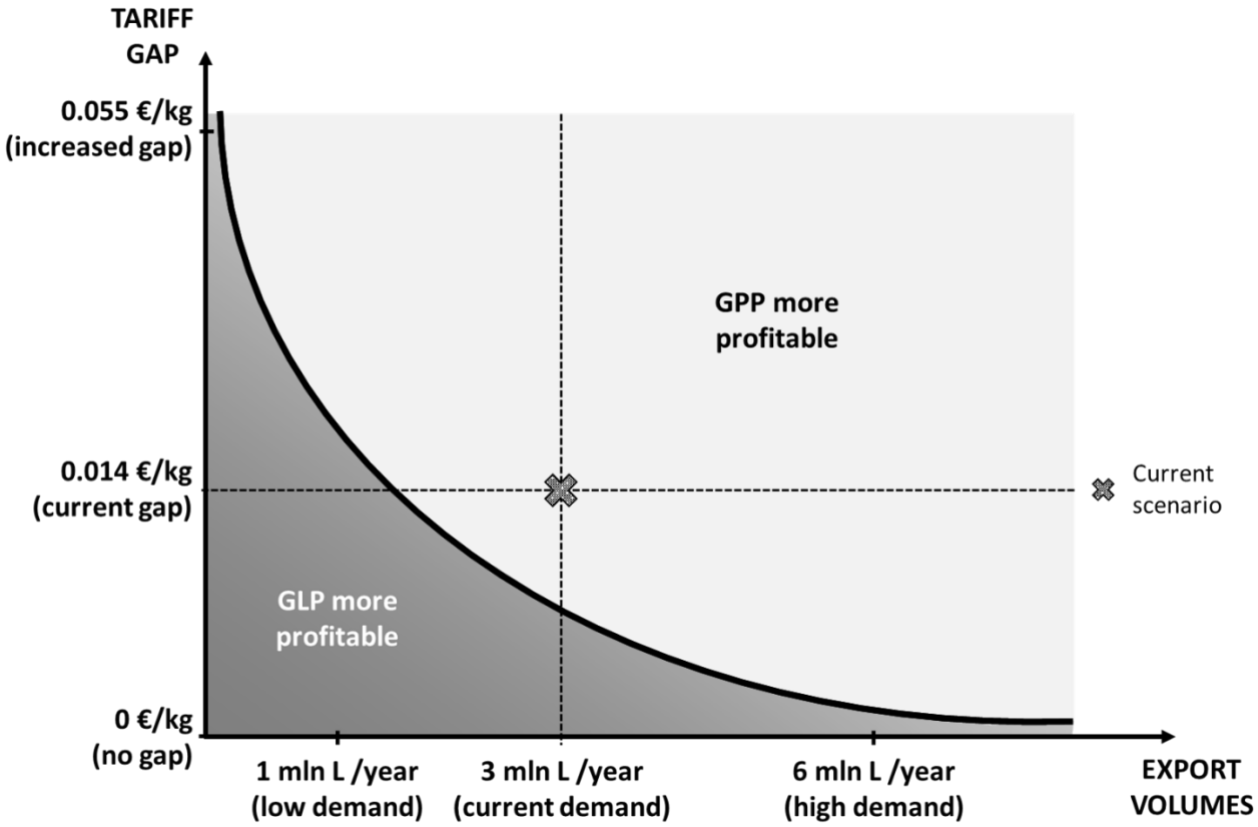

Figure 5 – Model application: sensitivity analysis

Appendix A – Interview guide

1. Company's headquarters and facilities location, and considered foreign markets
2. Products sold by the company, domestically and for each foreign market
3. Operations that characterize the manufacturing process (e.g., assembly, packaging, labeling, finished product distribution, etc.)
4. Manufacturing/logistics facilities abroad? If yes, where are they located?
5. With respect to the US market:
    a. Evolution of the operations in the US, and related motivations
    b. US-based revenues, and average selling price
    c. Global distribution network design from Italy to the US (e.g., which are the available options? How and why would you deem these options different?)
    d. Time and place where different operations occur (i.e., to investigate temporal or geographical postponement)
    e. Involvement of any logistics service providers or other kinds of intermediaries
    f. Inventory and transportation management (e.g., inventories ownership? transport modes? any specific requirement needed (e.g., controlled temperature)?)
    g. Discussion of the relevant decision drivers:
        i. Product-related (e.g., product value density)
        ii. Market-related (e.g., demand volume and uncertainty)
        iii. Process-related (e.g., required knowledge and/or capabilities)
    h. With respect to each product flow directed towards the US market:
        i. Trade agreements in place
        ii. Duties (function of goods origin/goods classification (tax code)/goods value)
        iii. Local content requirements and other regulations
        iv. Taxes impact
        v. Transfer price policies
        vi. Other risks than currency (e.g., obsolescence)
        vii. PE issues and other tax liabilities