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# Global–local supply chain configurations for different production strategies: a comparison between traditional and customized productions

Laura Macchion
*Department of Engineering and Management, University of Padova, Padova, Italy, and*
Rosanna Fornasiero
*STIIMA-CNR, Institute of Intelligent Industrial Technologies and Systems for Advanced Manufacturing–National Research Council of Italy, Milano, Italy*

## Abstract

**Purpose** – Supply chain (SC) configuration has gained increased acceptance as an important issue when evaluating new customization possibilities and this evidence has contributed to the strengthening of the debate between global vs local production locations. This work contributes in enrichment of this topic by studying how local or global SC location decisions influence performances by considering a SC point of view, in terms of cost and time, in traditional and customized productions.

**Design/methodology/approach** – A discrete event simulation approach, based on experimentation through executable configurations, was used to evaluate different SC scenarios for customized as well as traditional products within the footwear industry.

**Findings** – The results indicated that to identify proper SC locations, existing trade-offs between the time and cost performances should be studied, avoiding the evaluation of a single performance independently and, instead, adopting a complete SC point of view while considering these performances.

**Research limitations/implications** – This evidence has contributed to the reinforcement of the discussion between far-shore destinations vs near-shore production locations. Further studies are encouraged to adopt the present model, in which addition of other variables such as specific manufacturing competences to differentiate suppliers, both local and global suppliers, or the possibility of realizing special types of product customization required by final consumers can be done.

**Practical implications** – The paper contributes to the academic and practitioners' debate by proposing a systemic approach to assess SCs' performances in customized contexts and to compare them to traditional collections. Results indicate that cost and time performance must find a balance that does not necessarily correspond to an exclusively local or global production.

**Originality/value** – This work contributes to the SC configuration issue by considering the trade-off between efficiency and effectiveness (i.e. SC costs and SC times) for customized productions by reviving and enriching it with an SC perspective in customization contexts.

**Keywords** Fashion, Personalization, Customization, Supply chain design, Supply chain management, Supply chain configuration

**Paper type** Research paper

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## 1. Introduction

Since many years the literature is interested in debating Supply chain (SC) configuration possibilities (e.g. Beamon, 1998) by studying the factors that push companies to locate manufacturing in different geographical regions and their respective balancing choices between local and global productions (e.g. Ketokiwi *et al.*, 2017). Exploring the manufacturing location decisions still represents today a lively research issue considering the following evidence.

First of all, the sharpening of the backshoring debate (Martínez-Mora and Merino, 2014). Low cost countries introduced in the past years a strong cost competition, which still penalizes companies with production sites located in Western countries (Macchion *et al.*, 2015). As a strategy, Western companies have responded to this pressure by pursuing different globalization strategies (Arlbjørn and Lüthje, 2012; Bals *et al.*, 2016). Against common belief, some contributions (e.g. Kinkel, 2012) supported that not only the location of production to emerging countries is a relevant phenomenon but also the backshoring of once offshored manufacturing activities to the home base. This evidence has contributed to the strengthening of the debate between far-shore destinations vs near-shore production locations.

Second, the growing business and academic discussions related to the possibilities offered by big data since they have the potential to profoundly revolutionize SC dynamics. The growth of this innovation led to data sets larger than what was manageable by the conventional, hands-on management tools. Therefore, to use these large amounts of data appropriately, new methods of data science and new applications in the form of predictive analytics, such as the discrete event simulations, have been developed and applied also to the SC design issue (Waller and Fawcett, 2013).

The SC location issue is also importantly based on the necessity of the company to allocate different types of orders amongst their suppliers. Always more companies are adopting a customer-driven market strategy that takes into consideration customization requirements of their consumers. This implies that the company must be able to address the goal of designing, producing and distributing small series and personalized products, with huge impact on the localization of manufacturing activities. Therefore, the SC must be designed in relation to new customization strategies. In fact, although research on customization has recently advanced at the product level, by identifying and improving the technologies (such as the three-dimensional [3D] printing) useful to customize products, much work remains to be done to identify the SC implications of customized productions (Macchion *et al.*, 2017).

Finally, many studies have emphasized the need to reorganize production processes by encouraging strong performance monitoring of the whole SC in order to provide products, also customized, in the proper amount of time (e.g. Salvador *et al.*, 2004). This implies a change in performance monitoring systems: the transition from the evaluation of the individual supplier' performance to the monitoring of the whole SC performance (Macchion *et al.*, 2017). Selecting the appropriate performance measures is however challenging due to the inherent complexity and interdependence of SCs (Flynn *et al.*, 2010). In particular, two key performances have attracted the attention of previous studies focussing on SC design for customer-driven productions.

(1) Time performance: On the one hand, the literature suggested that SC performance measurement should consider the ability to respond on time to changing environments and new customer requirements (Flynn *et al.*, 2010), in particular when debating the manufacturing location aspects (Acar *et al.*, 2010; Caniato *et al.*, 2013).

(2) Cost performance: On the other hand, SCs incur low costs when changing the locations where their manufacturing processes are realized, mainly in terms of labour and transportation costs (Acar *et al.*, 2010). In fact, the labour cost can be decreased by selecting low labour cost areas, but the transportation costs is always a big (perhaps

the dominant) source of cost for productions located in remote manufacturing areas. Therefore, companies have the necessity to revise the location of their production sites and redesign their SC based on the proper evaluation of these costs.

These phenomena justify a re-examination of the manufacturing location issue, by reviving and enriching it with a SC perspective. In fact, despite the increasing attention placed on this matter, further studies analysing the SC as a whole are encouraged (Klibi *et al.*, 2010) since it is still challenging switching from a traditional production approach to a global and customized based on customers' requirements SC approach (Macchion *et al.*, 2017).

This topic is especially interesting for the footwear industry, in which today the demand for customized collections is growing and the companies should face this challenge also through a redesign of proper SC manufacturing structure. In fact, the footwear industry is currently strongly influenced by variations in products' styles and customers' preferences, thus providing a suitable context to explore the changing nature of supply networks. Important footwear companies, such as Adidas and Nike, demonstrate that customization interest not only aestheticises features but also innovates functionalities such as more comfortable fit and innovative materials customizable based on the use of the shoe. However, from a SC point of view, developing and producing shoes, customized based on new market requirements, may expose SCs to greater risk and vulnerability: in the case of personalized products, supply networks cannot rely on extra inventory as a solution for demand unpredictability, rather they should lever on their responsiveness to satisfy on time any customer's need without ignoring production costs requirements. Generally, the footwear SCs, characterized by many and different actors, can be located in different areas in the world: in local industrial networks or in very far countries. The location of production can however act as lever or obstacle to the achievement of higher levels of customization. Therefore, in the last years, some companies have manifested the need for a back-shoring path, shifting production from countries characterized by low labour costs to Italy or to areas closer to their European headquarters, so that they can both respond more quickly to changing customer requirements and control production times (Kinkel, 2012; MacCarthy *et al.*, 2013; Macchion *et al.*, 2015).

In this scenario, new studies identifying proper global or local configurations for SC are thus required, both from a scientific and an industrial point of views, to consider and increase companies' capability to fast react to variable market demand. This paper examines how local or global production choices impact the performance of the entire SC by considering different SC configurations within the footwear industry. To accomplish this research goal, discrete event simulation is used to compare different SCs' scenarios.

The results highlight that the redesigning of SCs' location requires a proper trade-off between SC cost and time performances.

## 2. Literature review

### *2.1 Supply chain configuration decisions*

Increasingly, global markets are becoming more turbulent, complex and uncertain requiring a growing focus on proper design of SCs (Charan *et al.*, 2008; Purvis *et al.*, 2016; Yao and Askin, 2019). An SC may be defined as an integrated manufacturing process wherein a number of various business entities work together to acquire raw materials, convert these raw materials into specified final products and deliver final products to customers (Beamon, 1998). At its highest level, an SC consists of the activities relating to the production planning process that encompasses the manufacturing, the storage and their interfaces (Beamon, 1998). Figure 1 illustrates these activities and provides the basic framework for the conversion and movement of raw materials into final products.

At the company level, raw materials are purchased based on orders of the sales campaign. Whereupon, raw material arrive typically at the warehouse of the company and are shipped to

manufacturing suppliers dealing with specific production stages or handling all productive activities before returning again as finished products to the company's warehouse. In fact, generally, the focal company of the SC has multiple options to allocate different orders' quantities and typologies to be manufactured amongst its suppliers or owned plants. Therefore, multiple outsourcing or offshoring possibilities can take place. Outsourcing can be defined as the shifting, at the national or international level, of all or a part of the company's internal productive activities to an external supplier, thus transferring externally the control and advancement of these productive activities (Broedner *et al.*, 2009). Offshoring, instead, implies just the movement of production activities to another foreign country (Waehrens *et al.*, 2015).

Nowadays, many companies are relocating their production sites back to the original locations (Garetti and Taisch, 2012). The relocation of manufactures to local lands, mainly driven by the opportunity to take advantage of time compression (even if with a decrease in terms of production costs), is a possibility that companies are taking into consideration also to cope with ever-changing customer requirements that increase market competition based on time responsiveness. This phenomenon is called by the literature insourcing, inshoring, reverse offshoring, backshoring, back-reshoring, reshoring, near-reshoring or near-shoring as opposed to outsourcing/offshoring (Kinkel, 2012; Fratocchi *et al.*, 2014; Huq *et al.*, 2016; Martínez-Mora and Merino, 2014) even if some differences can be identified amongst the different definitions. For instance, reshoring refers to the change in the location of some of the tasks that are part of the firm's value chain that had previously been moved from the home country to another foreign location (Martínez-Mora and Merino, 2014). While, the reshoring is meant to indicate a generic change of manufacturing location, with respect to a previous off-shore country, a significant difference exists between back-and near-shoring (Fratocchi *et al.*, 2014). Backshoring is intended as companies' decisions to reverse previous offshoring by bringing manufacturing back home (at the home country); nearshoring consists in the transferring of production to another country which is geographically closer to the firm's home country (for instance, from China to Mexico in the case of US companies) (Fratocchi *et al.*, 2014; Di Stefano *et al.*, 2018).

Currently, this issue is receiving great attention from the literature that is exploring whether backshoring is a failure of the offshoring initiative or rather the evolution of the firm's competitive and location strategies (Di Mauro *et al.*, 2018). Baraldi *et al.* (2018) highlighted that the nature of this relocation of activities between different supply markets and counties depends more on both the firm's strategy and on the structure of the supply network located in the home and host countries' contexts.

In particular in the footwear sector, many authors are highlighting this trend. Martínez-Mora and Merino (2014) analysed this phenomenon in the footwear industry cluster in the province of Alicante, where the main part of the Spanish footwear sector was concentrated and results revealed that it was a response to changes in both the economic climate (wage differentials have fallen) and changes in the market, which was demanding smaller batches in shorter time frames. Di Mauro *et al.* (2018) focussed on backshoring by exploring motivation for companies operating

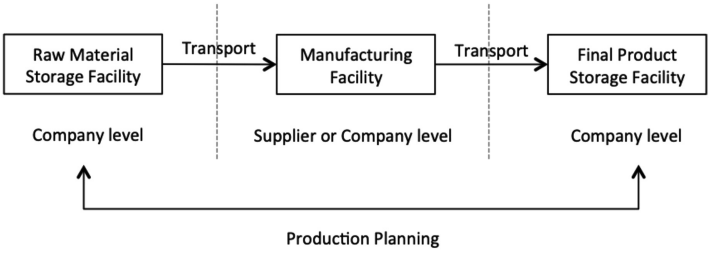


**Figure 1.**
The framework model (adapted from Beamon, 1998)

in the textile, clothing, leather and footwear (TCLF) industry, whose products are often sensitive to the "made in" effect. Fratocchi and da Costa (2018) supported that in recent years, footwear companies have considered backshoring opportunities as a strategic step in their business to maintain competitiveness in the market. Di Stefano *et al.* (2018) explored differences in terms of backshoring and nearshoring amongst footwear companies located in Italy and Spain.

Considering all these manufacturing possibilities, deciding how to allocate production orders and volumes amongst different companies' manufacturing facilities is hence not a simple task and the overall extent of these supply options acts as an additional element of complexity in SC design decisions. To proper manage the SC location problem, a complete overview about these steps is required. In fact, determining which plants will manufacture different orders constitutes an important part of the production planning process that requires proper products' assignment amongst SC partners. Therefore, managers face many decision-making challenges, including supplier selection, facility location and resource planning, which increasingly intensify the complexity of SC location issue. In the footwear sector, these considerations have proven to be essential decisions to achieve a competitive advantage in these markets. Boer *et al.* (2005) debated about the possibilities and problems related to globalization for the textile, clothing and footwear (TCF) industry and underlined how local (Australian) factories should focus on quality and customer service, preferably in niche markets or for specific customer groups and develop technologically advanced products to survive in the international competition. In fact, the Far East has risen to an important position in global manufacturing because of its cost advantages, although there are many differences depending on the area of the Far East under analysis. For instance, Huang *et al.* (2013) compared different area of the Chinese territory and identified considerable logistic benefits for companies working in industrial clustering in the coastal China and manufacturing cost advantages for companies using inland China and Asian countries where labour costs are still relatively low; Hong Kong remains a robust location choice for trade operations because of its favourable tax policies.

### *2.2 The customization challenge*

Despite these contributions, it is still challenging to switch from a traditional production approach to a global SC approach, not only because of the complexity of monitoring the performance of a whole SC (and not just of a company) but also because of the new manufacturing processes that customized productions are imposing to SCs.

Traditional organizations aim to keep their costs low by maintaining mass production of products; thus, they can find it difficult to compete in modern and global markets, where companies must quickly adapt to the new customized requests of their customers in order to be successful. This is particularly relevant within the footwear industry in which customer requirements (for instance, in terms of fit, colours, etc.) can vary widely (Macchion *et al.*, 2017).

By requiring to identify a trade-off between efficiency and effectiveness to respond in compressed times to non-standard requirements of customer, the customization issue creates new productive challenges from an SC perspective. Customization is configured as a strategy based on greater contact with the real needs of customers (Fogliatto *et al.*, 2012), and its potential for fashion companies is growing since always more companies are deciding to offer customization possibilities for some products or to adopt a full customization approach to customize its entire product line (Macchion *et al.*, 2017).

Previous studies have discussed the possibility to design different SCs based on different product typologies (e.g. Christopher *et al.*, 2006; Wong *et al.*, 2006; Puig *et al.*, 2009), but they did not consider the case of customized productions. Some contributions in the customization

field (e.g. Shamsuzzoha *et al.*, 2013; Fornasiero and Zangiacomi, 2013; Macchion *et al.*, 2017) only recently have started the debate on the appropriate SC design for customized productions, but this is still an open issue. In particular, new insights on the possibility to locate customized productions at local or international level are encouraged. In fact, footwear companies have to identify a new trade-off for manufacturing activities locations in order to provide customized products in a short time to customers with adequate production costs since also in customized contexts, SC design must be supported by a systemic monitoring of performances (Liu *et al.*, 2012). The trade-off between cost efficiency and time performance is very strong in customized products, where it is necessary to avoid compromising rapid response to market or impinging upon its need for efficient production (Pine *et al.*, 1993; Fiore *et al.*, 2002; Jiao *et al.*, 2003; Salvador *et al.*, 2004). Obviously, this trade-off will be acceptable only if the quality performance is unchanged, that is when products on a global or local level are qualitatively comparable.

The literature highlights how different types of customization can exist. In the footwear market, the customization consists not just of tailor-made shoes realized by craftsmen but more and more often footwear companies create some collections, customized for end consumers or for their direct first-tier customers, i.e. retailers having direct contact with the final markets that are able to specify the type of product customization that will be offered and appreciated within their shops (Macchion *et al.*, 2015). In fact, most of the footwear companies face the challenge of providing smaller customized orders to their retail customers in order to improve their market diversification strategy, which is necessary in a very fast-changing market, as is the case for the fashion sector. Therefore, further studies embracing a complete SC location perspective should evaluate the implications of this customization possibility on the SC design with a comprehensive monitoring of performances (Liu *et al.*, 2012).

## 3. The research aim

The literature has established an ongoing debate on the importance of SC configurations by bringing in some recent years' evidence on how footwear companies are redesigning their international SC in favour of local manufacturing activities (e.g. Di Mauro *et al.*, 2018; Fratocchi and da Costa, 2018). This research is part of this debate by also adding a focus on the theme of customization aspect that in the literature seems to be a differentiating element for some footwear companies (Macchion *et al.*, 2015). For this purpose, this paper takes into consideration these two research areas: (1) SC configurations and (2) personalization management offered to customers by companies within the footwear sector.

In fact, further contributions are encouraged to deepen the SC location issue by considering either local or global possibilities since nowadays companies are interested in evaluating the impacts of their decision of producing abroad or backshoring their manufacturing activities (e.g. Garetti and Taisch, 2012). Moreover, considering the importance of a complete performance monitoring composed by cost and time measurements to properly design SCs, a discrete event simulation can contribute to identify the impacts of manufacturing location on different SC configurations (Waller and Fawcett, 2013) by analysing not only the performance of single company but adopting a SC point of view.

Finally, because of the growing importance of customization, further insights are required to study the implication on SC design since companies should be able to provide the right customized product without compromising rapid response to market and efficiency within production. In fact, the analysis of SC performance in customized contexts is recognized as an important step in understanding and assessing alternative SC configurations (Macchion *et al.*, 2017).

Thus, this article enriches previous literature by explicitly studying with a discrete event simulation the effect of the customization on SC location decision by considering time and cost performance in the footwear SC.

The following research question is proposed:

*RQ.* How SC configuration decisions (i.e. local or global manufacturing) influence SC performance (cost and time) in customized productions?

## 4. The research methodology

To answer the research question, a simulation model based on a discrete event was developed to study the SC location issue by comparing traditional and customized productions. The simulation model was used since it allowed a realistic observation and evaluation of SCs (Umeda *et al.*, 2006) and offered the possibility to attest the consistency of decision-making policies (Tako and Robinson, 2012; Bisogno *et al.*, 2016). In particular, the production of large quantities of the same product (i.e. traditional production) and the production of small quantities of a larger variance of different products (i.e. customized production) were analysed (Macchion *et al.*, 2017). For each SC location (local or global), the SC performance of cost and time were analysed and used as evaluation parameter of the SC of efficiency and effectiveness. This simulation model is applied to a real SC database collected from an Italian footwear company.

### *4.1 The application of simulation to supply chain configuration problems*

The production location issue has been well established in the firm's strategy and organizational structure literature. However, single firm-based considerations regarding its structural elements may not be adequate in the light of the current market competition that requires providing always better performances, which are achievable only with an SC approach. New studies adopting this SC perspective were therefore favoured by the arrival of new technologies that allow acquiring quickly and completely big data (Fosso Wamba *et al.*, 2015). The literature debate is interested in multistage models for the SC design based on the analysis of these data (Waller and Fawcett, 2013) for which the modelling approach can be different based on the nature of the inputs and the objective of the study. Mainly these modelling approaches can be subdivided into four models: (1) deterministic analytical models – in which the variables are known and specified; (2) stochastic analytical models – where at least one of the variables is unknown and is assumed to follow a particular probability distribution; (3) economic models; (4) simulation models (Beamon, 1998).

In particular, the simulation method is useful for SC studies since it relies on experimentation through executable configurations, which enables the creation of different SC scenarios (Macchion *et al.*, 2017). Simulation represents one of the tools most frequently used to observe the behaviour of SCs in order to highlight their performance and evaluate new management solutions in a relatively short time (Iannone *et al.*, 2007). Some simulation approaches have been proposed for solving different SC design problems. Bottani and Montanari (2010) used the simulation approach to design SCs and support demand forecast based on different information-sharing mechanisms. Previously, Towill *et al.* (1992) used simulation techniques to evaluate the demand amplification based on different SC strategies, such as the modification of the order quantity policies. Ramanathan (2014) applied simulation to SC by considering several performance indicators in collaboration contexts. Persson and Araldi (2009) used a discrete event simulation, particularly suitable to be used when attempting to study the SC from a dynamic perspective by analysing the effect of changes in the SC structure on the resulting performance, while Verma (2006) studied the application of the stochastic inventory model to the three-tier SC. Cigolini *et al.* (2014) applied discrete event

simulation to analyse different SC configurations by evaluating how intermediaries influenced product quality and costs performances. Ding *et al.* (2005) evaluated suppliers' portfolios based on key performance indicators such as purchasing, transportation and inventory costs and total backlogged demands. For what concerns the fashion industry, Zülch *et al.* (2011) used simulation to study different scenarios for customized orders in the garment industry, despite they analysed just the company level instead of considering the entire SC. Macchion *et al.* (2017) described a simulation approach to evaluate the performance of different supply network configurations in customized contexts.

Despite this evidence, further contributions are encouraged to deepen the SC design issue by considering either local or global possibilities (e.g. Huq *et al.*, 2016 investigated the issue in the pharmaceutical industry) since nowadays, companies of the footwear are interested in evaluating the impacts of their decision of producing abroad or reshoring their manufacturing activities accordingly to a customization strategy (Macchion *et al.*, 2017).

### *4.2 Multi-objective models for supply chain performance*

Proper SC location decisions must be related to right measures of SC performance as well (Bhatnagar and Sohal, 2005). When defining a SC performance measurement system, the main trade-off between different performances, such as efficiency and effectiveness, should never be neglected. In fact, multi-objective measurement systems provide more comprehensive measurement of SC performance than traditional, single-measure approaches (Sabri and Beamon, 2000). For instance, Sabri and Beamon (2000) presented an integrated multi-objective SC model including cost and customer service levels. However, effective SC measurements should be determined based on the overall aim of the analysed scenario (Najami and Makui, 2012) and determining proper SC performances belonging to the dominion of SC design.

To this aim, an advantage of simulation models can be found in their capability to provide at the same time valuations of both efficiency and effectiveness of systems by assessing the impact of changed input parameters on the resulting performance, without waiting for the real occurrence of events (Harrison *et al.*, 2007). Therefore, simulation approaches allow the evaluation of performance measures for different SC options by determining the values of the decision variables that yield the most desirable level of performance (Acar *et al.*, 2010).

As suggested by Beamon (1998), quantitative SC performances may be mainly categorized by SC objectives based on (1) time and (2) cost, allowing developing, respectively, effectiveness and efficiency within processes. Effectiveness refers to customers' responsiveness being the ability of a firm or of an entire SC to fulfil on-time customers' requirements, while efficiency refers to the ability to maximize the use of internal resources. Effectiveness is therefore measured in terms of processing times for orders, while efficiency is traditionally related to costs of resources productivity (Beamon, 1998).

In particular, on the one side, the cost performance has been widely used for the optimization of single SC's business units or stages, but recent literature (Liao *et al.*, 2010; Nagurney, 2010) recommends evaluating cost performances of the entire SC to properly address the SC design issue. On the other side, time-based performance related to customers' responsiveness has been mainly described by the literature as the amount of time required starting from when an order is placed until customers receive the order. In addition, in this case such performance requires being studied not only within the boundaries of a single company but with an SC vision (Liao *et al.*, 2010).

### *4.3 Measures*

Previous literature has underlined the importance of time and cost performance to evaluate different SC locations.

(1) First of all, when debating SC location aspects, time performance is important since SC performance measurement should consider the ability to respond on time to customer requirements (Acar *et al.*, 2010; Caniato *et al.*, 2013). In particular, in this study the SC's order lead-time (OLT) is taken into consideration and consists in the time from the reception of the order by the customer (i.e. the focal company's retailer) until the delivery of products to the customer is considered. The OLT is therefore composed by different time components: the time for purchasing activities, the transport, the manufacturing and the queue time required before the beginning of manufacturing activities.

(2) SC cost performance is necessary to verify the SC costs for local or global locations by considering both labour and transportation costs (Acar *et al.*, 2010). The labour cost is assigned based on the cost per hour required for manufacturing activities at local and global levels, whereas the transportation cost is calculated based on the number of pallets shipped and the vector typology.

These performances are particularly relevant in a customization context because of the need to provide the custom product in a short period as well as to control the overall costs within the SC.

Moreover, different order quantities are considered within the model (i.e. number of pair of shoes), which are then allocated to different SCs' locations, local or global, based on the percentage of product volume realized at the national or international level.

Finally, for what concerns the customization measures, the simulation model considers the type of collections by analysing the shift from managing large orders to managing small orders. This means a shift from a large quantity of the same product (i.e. traditional collections) to a small quantity of a larger variance of different products (i.e. customized collections) (Macchion *et al.*, 2017). Therefore, as a proxy for the implementation of customization, the model considers the dimension of the customer order, where the company's customer is the retailer asking for customized products to be sold in shops and stores.

The demand for the production orders, which the focal company will assign to its global or local suppliers, follows a normal distribution where $\mu$ is the mean of the demand and $\sigma$ is the standard deviation. $\mu$ and $\sigma$ depend on the orders' dimension (small or large). Orders are collected at the beginning of the season accordingly to the sales campaign.

### *4.4 The simulation flow*

The simulation flow was structured based on an adaptation of the framework model of Beamon (1998), as summarized in Figure 1, in which three different SC stages are involved in the production planning activities.

As indicated in Figure 2, the local and global manufacturing plans are considered. First, the raw material storage facility at the company level. Within the warehouse of the focal

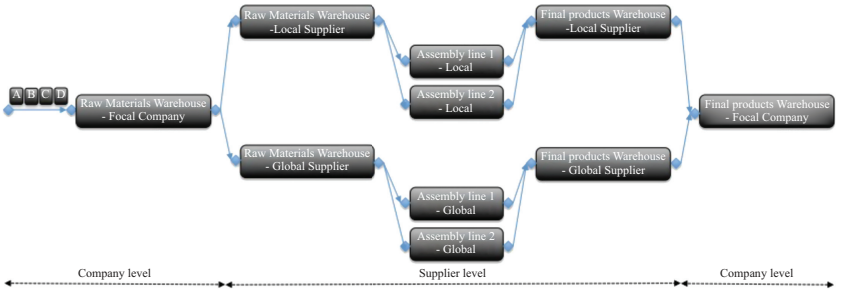


**Figure 2.**
The simulation model

company, the company that rules the entire SC, arrives with main raw materials (i.e. leather) for different product typologies. These different product typologies are shown in Figure 2 as A, B, C and D and reflect the different shapes of shoes composing a collection (such as women's low shoes, women's heel shoes, sneakers and men's shoes).

The purchasing activity of the main raw material (i.e. the leather) is carried over by the focal company. After the arrival of all the leather required for manufacturing activities, the focal company packs the pallets and sends them to the SC actor responsible for production. In particular, when a customer order is received by the focal company's sales office, the availability of leather in the warehouse is checked and if available, then a new production order is assigned to the manufacturing supplier, otherwise raw material will be purchased (implying extra waiting time). Each order waits to be processed until the leather arrives at the focal company's warehouse and until its stock level is adequate to fill a truck or a container to be shipped by boats. It is assumed that a certain percentage of orders need to wait for the leather and the system automatically assigns to some orders the appropriate waiting time. Orders are all collected during the first month of the simulation dedicated to the sales campaign.

Second, the manufacturing activities are assigned to suppliers (local or global) who able to realize the required products (both traditional or customized). The supplier receives the leather for the focal company, stores it into his/her warehouse and purchases other components composing the shoes (such as accessories, soles or heels). Also the purchasing time is simulated with a waiting time. Once all the raw materials necessary for the assigned order are collected, then the production begins. Each supplier has two production lines that can run in parallel to optimize the assembly time associated to different types of products (in Figure 2 assembly lines 1 and 2 for local producer and assembly lines 1 and 2 for global producer). This means that each of the four product typologies can be processed in one of the four assembling lines of Figure 2. The choice between local and global is guided by the creation of the simulation scenarios and after that the choice between assembly lines 1 and 2 is regulated by queueing at the station with the first in, first out (FIFO) strategy. After finishing the manufacturing activity, the shoes wait at the final product warehouse of the supplier until an appropriate number of shoes will be produced to fill the truck or the container before returning to the focal company's warehouse. The simulation model assumes that every supplier, both national and international, is able to produce the product with the adequate quality required.

The transports considered in the model differ based on the location of SC: for the transportation of raw materials and finished products, trucks or ships are used, respectively, for local production and for international productions.

The creation of comparative SC location scenarios (i.e. scenarios 1, 2, . . . *n*) is based on the variations in the order quantity. Table 1 shows the SC scenarios created using the simulation

| SC scenarios | No. of items per season | Allocation strategies | SC OLT [SC $day_i$/best SC day] | SC cost [SC $cost_i$/best SC cost] |
|---|---|---|---|---|
| $SC_{customized}(1)$ | 41,000 | 100%L | ° | 3.66 |
| $SC_{customized}(2)$ | 41,000 | 70%L; 30%G | 1.37 | 2.92 |
| $SC_{customized}(3)$ | 41,000 | 50%L; 50%G | 1.38 | 2.38 |
| $SC_{customized}(4)$ | 41,000 | 30%L; 70%G | 1.41 | 1.85 |
| $SC_{customized}(5)$ | 41,000 | 100%G | 1.48 | ° |
| $SC_{traditional}(1)$ | 125,000 | 100%L | 1.25 | 3.71 |
| $SC_{traditional}(2)$ | 125,000 | 70%L; 30%G | ° | 2.89 |
| $SC_{traditional}(3)$ | 125,000 | 50%L; 50%G | 1.16 | 2.37 |
| $SC_{traditional}(4)$ | 125,000 | 30%L; 70%G | 1.36 | 1.81 |
| $SC_{traditional}(5)$ | 125,000 | 100%G | 1.58 | ° |

**Note(s)**: L = local; G = global; ° = best performance

**Table 1.** The simulation scenarios

and case study data. The proposed SC location model is based on the evidence collected by the literature on the issue debating SC design (e.g. Beamon, 1998) and customization for the footwear context (e.g. Zangiacomi *et al.*, 2017). The model has been formalized using Simio© as a simulation tool.

*4.5 The case study*

The proposed simulation approach was tested and applied to an Italian footwear company. The company had revenues of about 53 m euros, and its target customers were located all over the world and were willing to pay medium–high prices. The company had production licences for shoes of seven prestigious designers of haute couture and it designed and realized its own brand as well. In one year, the production volume was about 440,000 pairs of shoes.

According to the data extrapolated from the company's enterprise resource planning (ERP) system, it was possible to define some initial values for the model's parameters. The simulation considered the case of a customized collections during the year, characterized by a lower number of products (41,000 pair shoes realized in a season) than traditional collections with higher number of shoes (125,000 pair of shoes realized in a season).

In the case of customized collection, the company must be able to handle more than 1,000 variants according to material and colour possibilities required by the customer (i.e. the retailer) and instead for the traditional collection, the customer can order only the products proposed by the company. Also in the case of licensed production, this company chose all suppliers based on its manufacturing necessities: the company had the responsibility of the management of all the suppliers as well as it handled the purchasing activities of leather and other components. The company collaborated with ten suppliers for the manufacturing step operating in multiple nations. For the simulation, we considered the case of their two main suppliers covering most of their manufacturing activities: the first located in Italy and the second in China. For the case that considered the labour cost in China was about the 35% of the labour cost at the local level, whereas the transportation cost at the local level was about the 43% of the international transportation from/to China. Transportation time for trucks, operating at the local level, had a range of 2–3 days to reach the local supplier, while transportation by the container on ships had a range of 30–40 days to get to and from the global supplier.

For both local and global SCs, it was assumed that suppliers to whom manufacturing demand was assigned were able to cover the production capacity and all the manufacturing suppliers could produce all the shoes' typologies (i.e. A, B, C and D). These typologies were differentiated according to the assembly and supply time of raw materials. Daily orders were created within the simulation according to a normal distribution with the quadratic deviation till the achievement of the productive capacity level assigned. The model simulated the production allocated to different SC manufacturing possibilities with a time window of six months (i.e. one entire collection).

Different SC scenarios were proposed (Table 1), for which cost and time performance were calculated. The model compared customized collections (i.e. small batches) to large batches of traditional collections. We simulated five different combination of production location possibilities: 100% of production was realized at the global level; 70% was realized at the global level and 30% was with local suppliers; 50% global and 50% local; 30% of shoes were produced by global SC and 70% by local; 100% of production was realized with local SC. The model contemplated the case of defective products based on the assumption that there is a greater frequency of defects at global suppliers since the company can exercise less control during the production process (and the items produced may not all be made with the required quality). In fact, from the

analysed case study, the quality control occurred only when items were received at the central headquarter and in the case of detection of defective parts, the company usually could implement two strategies: (1) send the defective pieces back to the supplier for reworking and (2) increase the quantity of items to be realized to compensate for any defective parts. The second option was applicable when dealing with international suppliers and therefore impacted on the cost of the supply due to the greater number of items produced.

## 5. Results

The simulation runs were based on the scenarios presented in Table 1. Different scenarios were designed ranging from 100% of local production, mixing the two types of suppliers until to 100% of global production. In this paper, only the results of five scenarios for customized and traditional collections are reported as a summary of the overall results.

### *5.1 The customized production*

The simulation tool allows first of all for an analysis of SC OLT. The analysis of the scenarios for customized production suggests that the best manufacturing solution consists of 100% local production. In fact, in this case a local network allows for improved transportation times amongst different production phases and SC actors. The shipping time, which has a huge impact internationally, in the local case is significantly reduced with benefits on the OLT. Also the queue time of raw materials waiting for manufacturing activities decreases since, thanks to quick transports, all the material arrive in time for the manufacturing activities without delays in production. Finally, final products do not have to wait for a long time to be sent to the central warehouse of the focal company: every shipment is carried out with full load trucks and therefore, in the case of local production, more frequent shipments are made (unlike the international context in which containers have to be shipped by boat with large quantities of final product).

On the other hand, by choosing a fully Far East production, the OLT performance would decrease by 48%. This performance is therefore crucial in promising accurate delivery times to final customers. Also, the intermediate alternatives between local and global production indicate a decrease of such performance compared to the entire local production: the SC OLT decreases about 37%, 38% and 41%, respectively, in the case of 70% local and 30% global, 50% local and 50% global and 30% local and 70% global. The results thus confirm the importance of structuring a local network to respond quickly to consumer' requests in the case of customized production.

For what concerns the cost performance, instead, the results are different as local production presents the highest costs. As many authors suggested (Ketokivi *et al.*, 2017), in fact, usually the production costs associated with a local SC are higher, for example, in Far East countries (in most of the case is the labour cost).

Results indicate that for the specific case, the cost of the local production of customized products is more than three times the global SC. Analysing the results of the other scenarios, it is clear that this extra cost is mitigated in case of activation of both local and global suppliers by shifting part of the production abroad, as it is demonstrated by Figure 4. The variation of the value of these costs is strictly dependent on the labour cost corresponding to each local and global producers and on the cost for the transport. In fact, internationally shipping by boat guarantees low cost as well as large volumes; in the local context, instead, many and frequent shipments are required because of the lower volumes of trucks, impacting the cost efficiency of the entire SC.

*5.2 The traditional collection*

Despite the production volume for the traditional collection was assumed to be three times more compared to customized production, looking at the results of the simulation, the total production time does not show the same increase. As for the customized production, the results indicate that for the case study the best manufacturing solution to improve the SC OLT performance is not the 100% global SC. This simulation methodology indicates a structured and formal way of analysing the best SC location considering specific business constraints. For traditional collections, the case study was considered for the analysis, the best solution in terms of OLT is the allocation of manufacturing activities for the 70% to local SC and for 30% to global SC. Other configurations do not allow for better results in terms of delivery time (Figure 3): the whole local manufacturing denotes a 25% decrease of OLT; the whole global manufacturing indicates a 58% decrease of OLT; the 50% local and 50% global OLT decrease about 16%; the 30% local and 70% global OLT decrease of about 36%. Cost performance instead confirms once again the economic convenience of foreign production even for traditional collections. The worst solution in terms of cost is always represented by the local SC configuration (SC cost increase of about 3, 71 times) and intermediate situations with respect to the exclusively foreign production are represented by a configuration where the percentages of local and global productions are mixed.

Figures 3 and 4 summarize the results for the SC OLT and SC cost performances for both customized and traditional collections.

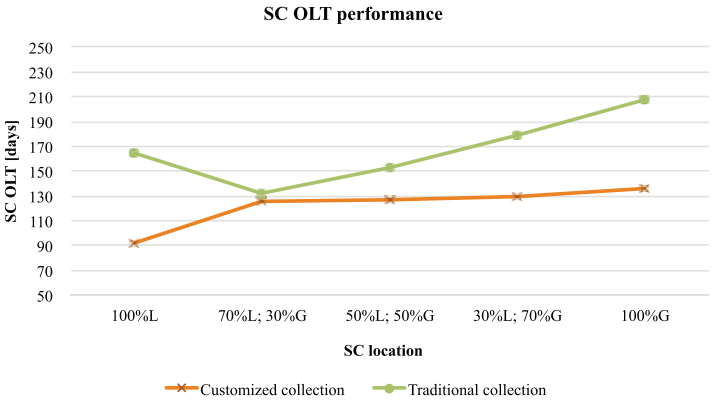


**Figure 3.**
Variation of supply chain order time-lead performance

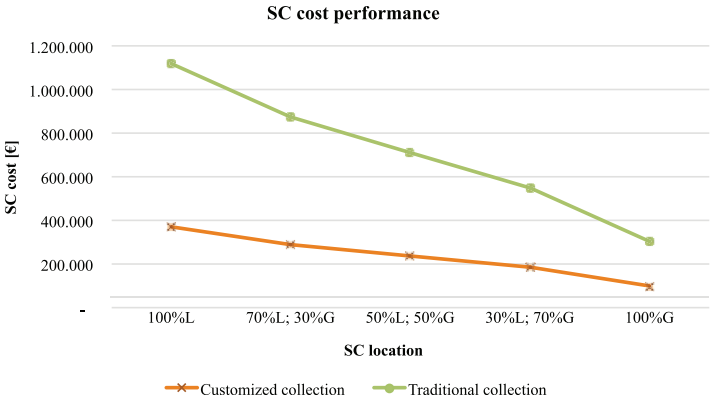


**Figure 4.**
Variation of supply chain cost performance

*5.3 The trade-off between supply chain order lead time and supply chain cost performances*

Considering the results of different scenarios for SC OLT and SC cost performance (see Figures 3 and 4), the identification of a trade-off between these performances is necessary to identify the best SC solution for traditional and customized collections. Figures 5 and 6 therefore show the trade-off results for different SC configurations based on the OLT and cost performances. In particular, this analysis allows for each type of collection to evaluate performances trade-off by identifying the best location for SC.

For customized collections, the best choice for the allocation of manufacturing activities within the SC is the solution where the local supplier manufactures the 70% of the collection and the remaining 30% is assigned to a global supplier. For the traditional collection, the trade-off between SC cost and SC OLT performances is achieved when half of the production is allocated locally and half to the global supplier. The traditional production can be assigned in a larger percentage to global suppliers due to the order dimension and to how much time in advance it is possible to forecast the production compared to the customized production.

For what concerns the quality performance, the model considers the possibility of defects within the production and simulates this circumstance by considering the greater

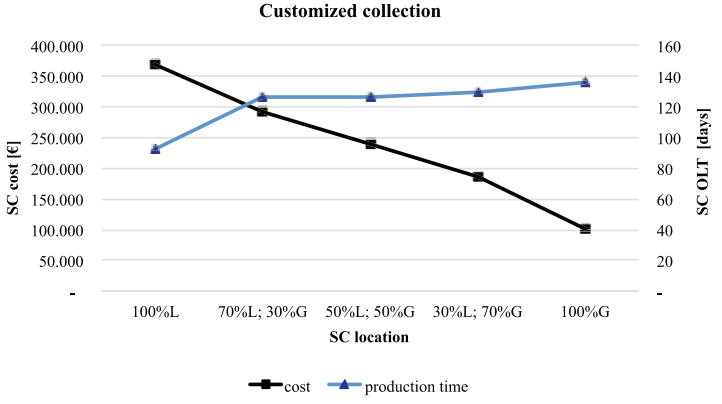


**Figure 5.**
Variation of supply chain cost and supply chain order lead-time for the customized collection

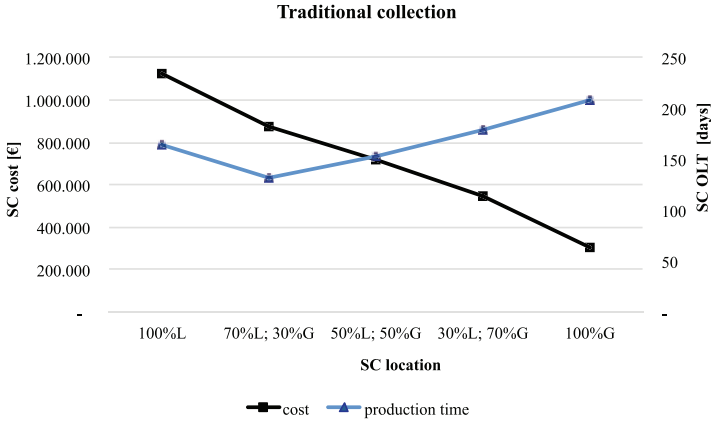


**Figure 6.**
Variation of supply chain cost and supply chain order lead-time for the traditional collection

number of items that must be produced by an international supplier to compensate for defective parts. Due to time constraints, defective items cannot be reworked in time by international suppliers to be sold during the seasonal collection. In fact, fashion products have very short time for their presentation and sale, thus the postponement of their production – even just a few weeks – does not allow companies to sell final products to their customers.

## 6. Discussion

The danger of not being able to realize new customized products in a market where customized demand is growing, such as the footwear context, creates the need for a strong reorganization of SCs, developing more and more a vision based on a network competition. A company cannot think of addressing alone the complexities that customization generates but must adopt an SC approach. In this perspective, the proposed model allows to evaluate at the SC level what are the impacts of customization. Previous papers mainly debated the customization topic adopting a point of view based on the creation of new product design for customization by deepening, for instance, the importance of product modularization (Lampón *et al.*, 2017). But the essence of customization in the fashion context cannot be compared to a mere disassembly of the final product into modules. The fashion industry, in which the predominant aspect that drives sales is the style, it is necessary to consider customization in its highest definition: "customization is configured as a strategy based on greater contact with the real needs of customers" (Fogliatto *et al.*, 2012). This better contact with consumers, translate into better listening to their desires and emerging styles and, as a result, requires a continuous and fast SC relocation in order to fulfil customers' customization requirements on time. In fact, different SC locations can guarantee better time performance. How to design an SC thus opens up a strong debate that compares far manufacturing sites, characterized by long delivery time with local production sites allowing a competitive advantage based on times compression. Indeed, re-evaluating the shift of production previously located in Far East countries (i.e. the backshoring matter) is showing great interest not only in academic literature but also amongst managers who are interested in addressing the challenges of customized productions.

Of course, as already described in the literature debating customization (e.g. Purohit *et al.*, 2016), SC time constraints are balanced by efficiency requirements. Cost containment is an important aspect of every SC management mainly for profits' maximization. Decisions regarding the localization of SC therefore have to deal with the budget available for production activities trying to balance the two major manufacturing objectives of customized productions: costs and time. This work contributes by considering the trade-off between efficiency and effectiveness (i.e. SC costs and SC times) for customized productions.

## 7. Conclusions and future developments

In this work, the impact of customization strategy on SCs' performance in terms of time and cost is studied to deepen the understanding of SC location decisions and the related suppliers' choice.

In particular, this study contributes to this issue by providing new insights on the possibility to locate customized productions at local or international level by analysing performance with a complete SC perspective. In fact, companies have to identify new SC trade-offs to provide personalized products in short time to customers with proper production costs. Companies must achieve customization without compromising a rapid response to the market and an efficient production by combining cost efficiency and time performances (e.g. Salvador *et al.*, 2004). Therefore, this paper contributes to the literature on customization and performance assessment by proposing a simulation model to evaluate in customized

contexts' different scenarios of SC design based on a systemic monitoring of performances (as suggested for instance by Liu *et al.*, 2012). The identification of clear SC performance indicators that can support companies in defining and monitoring their SC configurations for customized productions is a valuable contribution of this work.

This research provides new insights also in the field of SC design by considering either local or global SC locations for customized and traditional collections. Results indicate that cost and time performance must find a balance that does not necessarily correspond to an exclusively local or global production. In fact, for the specific case study considered in this work, the best solution has proven to be an SC location that mixes a local production at 70% with a global manufacturing for the remaining 30%. Conversely, for the traditional collection the optimal SC location consists in the 50–50 allocation of the production volume between local and global suppliers. Thus, this article enhances the literature by explicitly proposing a simulation model to study effect of the customization on SC location decision by considering time and cost performance in the footwear SC.

Despite we have looked at a peculiar case study by taking into consideration its specific SC decisions and possibilities, our analyses can, however, be used as reference model to further research in the field of global/local strategy definition.

The discrete event simulation model can be generalized and used to compare SCs' scenarios based on different manufacturing location possibilities.

These results could widely contribute to both theory and practice since the identification of customization requirements and their deployment into a SC location strategy are key determinants to overcome the ongoing market challenges.

The paper contributes to enrich the current academic debate by combining two areas of research: a first field that explores SC configuration possibilities at both global and local levels in order to guarantee companies a competitive advantage based on cost or flexibility and the theme of personalization, an increasingly current aspect considering the growing customization needs of consumers. The paper contributes by providing evidence to these areas within the footwear sector, for which the aspects of internationalization of the SC and personalization by customers are very strong.

From a practitioner's point of view, the work allows investigating with an SC approach and not just a single-handed company perspective, the challenge of customization and understanding the best SC locations to support customized production. Therefore, this analysis will help identify key suppliers who are able to provide performance suitable to customization contexts, with which to set up close business partnerships. Considering the complexity of the whole footwear production processes, composed by the assembly of many shoe parts realized with different materials and manufacturing technologies, identifying proper SC tools to approach the customization challenge contributes to the development of the sector. Moreover, the proposed tool can be useful for managers also to confirm previous SC internationalization choices or to rethink in a structured way where to locate SCs. In fact, considering reshoring possibilities for companies bears important managerial implications as they are almost never unchanging over time, but on the contrary, a correct management of footwear SCs must periodically re-discuss the advantages in terms of costs and times that global or local SC can guarantee. Furthermore, the proposed tool suggests to managers to reflect on the need to evaluate which activities can be transferred from an international context to a local context, or vice versa, (for example, all activities of the SC or only a part of them) in order to respond appropriately to the challenge of personalization from which footwear companies could gain a competitive advantage.

Future research studies in this field could additionally support the academic and managerial debate. Further works could use the proposed simulation model by a more general approach considering new case studies to evaluate other SC location possibilities not only in the footwear sector but also in other sectors. An interesting analysis might take into

account alternative locations for the production. For example, new evidence could emerge from the analysis of SC located in countries at an intermediate distance between Far East and local manufacturing. In fact, some companies are considering the backshoring theme not only as the return of the whole, or part, of production to the local territory but also as the placing of their plants in neighbouring countries, characterized by less distances (and hence less times) than Far East countries but, at the same time, higher production costs.

Moreover, the present study did not consider the specific manufacturing competences that different suppliers, both local and global suppliers, might have in realizing customized or traditional products since this factor was not relevant for the company considered as case study. Despite this assumption, evaluating also the manufacturing skill level or products' quality realized by different suppliers could enrich the model.

Finally, the model could also be used to evaluate the best SC configurations in the case of product customization required by final consumers. Many companies are actually offering consumers the possibility to customize their own products (for example, the website www.nike.com proposes a customization program). This paper has considered the situation in which customization is required by retailers managing footwear stores that ask for flash collections, characterized by a lower production volume than traditional collections and a strong customization content according to the stylistic trends of the market. Considering the case in which the final customer requires a single and customized product will refine the model and improve the debate. Moreover, the model is also interesting for other sectors, in addition to the fashion sector, where the theme of personalization is becoming relevant for manufacturing companies.

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**Corresponding author**
Laura Macchion can be contacted at: laura.macchion@unipd.it