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Abstract

Purpose – This research aims to support companies' risk-informed selection of a logistics solution to operate in China via Cross Border B2C E-Commerce (CBEC).

Methodology - Decision theory is applied to the recent field of CBEC. This theoretic setup involves a decision maker who must choose among a set of alternatives, whose consequences depend on uncertain factors (Savage, 1954). The study develops an activity-based model to calculate logistics costs in a deterministic setting. Simulations and probabilistic sensitivity analyses are later performed to evaluate the impact of uncertainty.

Findings – There are four main solutions to enter China, determined by the adopted international transport mean and the presence of a local warehouse. The most important risk factors affecting the choice of the logistics solution are change of CBEC regulation, product value, expected service level, demand level.

Originality – From a theoretical perspective, this study improves CBEC literature, so far characterised by descriptive papers, often lacking industry focus or empirical exploration. It also provides new application opportunities for decision theory, whereas previous contributions have proposed different theoretical approaches, such as transaction cost or institutional theory. From a practical viewpoint, the paper is the first to compare the costs of the main logistics solutions to sell online to China, by taking uncertainty into account. The results can be used to better understand the differences among solutions and identify the most critical parameters. Finally, this research provides some observations for policy implementation.

Keywords: cross border e-commerce, CBEC, logistics, risk, uncertainty, decision analysis

Introduction

China is the largest B2C e-commerce market in the world, valued at over €1000 billion in 2018 and with a market share of almost 40% of global e-commerce (Lee, 2017). Since 2013, it has been attracting numerous foreign companies to set up their online business, mainly facilitated by large players such as Alibaba's Tmall or JD.com (Giuffrida et al., 2018) and by the emergence of Cross Border E-Commerce (CBEC). This model allows foreign legal entities to sell online in China without a local physical presence, partly simplifying internationalisation processes. However, CBEC has also brought new challenges, especially in the logistics domain. These are related to the increasing demand for advanced service features, including quick delivery to designated locations, tracking of delivery status or possibility to return goods. The urge to meet such needs has led to the creation of innovative and collaborative business models characterised by a strong coordination between logistics service providers and e-commerce operators.

In an effort to foster CBEC growth, in the beginning, China has encouraged the adoption of this trade model by issuing supportive policies within the "Belt and Road" development plan. However, the Government has started to discuss the introduction of a new regulatory regime in 2016 (Chan et al., 2016) and has released new e-commerce rules in the beginning of 2019 (Zhang, 2019). These elements, coupled with the ongoing trade tensions between China and the USA, have contributed to produce a great amount of uncertainty regarding the future of CBEC.

Regulatory aspects are not the only sources of uncertainty in this field. CBEC has several complexities, including communication in a foreign language, payment currency and terms. One of the most complex issues, however, is logistics, due to long distances and delivery times, quality of delivery, higher service level expectations, returns management, and stronger dependence on local service providers (Cho and Lee, 2017; Kawa and Zdrenka, 2016; Yang and Shen, 2015, Giuffrida et al., 2017a). Furthermore, China presents specific challenges, being a country full of local and unwritten rules, such as Confucianism, strongly tied to the value of trust among logistics service providers and users (Lai et al., 2008; Huo et al., 2017).

In such a context, identifying the most suitable logistics solutions to implement a CBEC initiative can be burdensome for companies interested in this market. In the rest of the paper, we refer to the selection of a logistics solution to support CBEC as the "decision problem". Understanding the sources of uncertainty of online internationalisation is vital for the sustainability of companies operating in this field (Pezderka and Sinkovics, 2011) and can provide valuable information, relevant to our decision problem. Nonetheless, very little research has been conducted so far specifically investigating CBEC logistics uncertainty.

Therefore, this paper aims to explore the main CBEC logistics solutions in China and evaluate the effect of uncertainties on the overall costs of each solution, thus identifying their convenience for companies in different industries. Costs here considered do not only relate to efficiency issues, but also to effectiveness. In fact, also the service level is considered and modeled in terms of stock-out cost.

We propose the application of decision theory, centered around a decision maker who must choose among a set of alternatives whose consequences depend on uncertain factors beyond his control (Savage, 1954). Given that CBEC logistics is characterised by high levels of uncertainty, this theoretical setup seems particularly appropriate to study the problem at hand.

On a practical level, the major aim of this study is to provide insights that can support companies in addressing the decision problem previously defined. On the academic side, we are confident to contribute to the advancement of CBEC logistics literature, that is still nascent and relatively underdeveloped (Giuffrida et al., 2017a), but is receiving increasing attention by the scientific community.

This research addresses two Research Questions (RQs):

- RQ1: How does uncertainty affect the costs of the logistics solutions supporting CBEC in China and their importance?
- RQ2: Which logistics solution should a company select based on the information regarding its uncertainty?

The remainder of this paper is organised as follows. The next section presents a review of CBEC logistics literature with a focus on China and on the theories that have been used in this field. The third section details the methodology and the features of the models built to quantify the costs of the CBEC logistics solutions, the fourth section presents and discusses the main findings. The fifth section details the implications of this study, while the sixth section concludes.

Literature review

CBEC logistics in China: main challenges and logistics models

The advent of e-commerce has profoundly affected logistics in China. The online market has grown so rapidly that the logistics industry could not keep the pace, rather becoming a bottleneck for e-commerce development (Hensher et al., 2015; Hou 2014; Giuffrida et al., 2017a). However, being such an essential driver both for cost reduction and the correct fulfilment of orders, logistics is gradually becoming the core competence Chinese e-commerce companies focus on (Jiao, 2014).

Logistics is a fundamental aspect of CBEC. It is important to customers since it affects the service level. Nonetheless, it can be challenging for firms, especially SMEs, due to high delivery costs, typically limited volumes and consequent inability to negotiate with logistics operators (Kawa and Zdrenka, 2016; Gessner and Snodgrass, 2015). Additional problems of CBEC logistics are the excessive length of the order cycle (Shuyan and Lisi, 2013), inadequate taxation rules, regulations from different public departments, poor market supervision, slow custom clearance, demanding after-sales service, and low efficiency of distribution networks (Yue et al., 2017; Fang, 2017; Yang et al., 2017).

Despite the difficulties of CBEC logistics, some solutions are spreading to enable CBEC sales in China. Some authors have specifically studied the available logistics models. For instance, Giuffrida et al. (2017b), state there are three main logistics solutions to support CBEC logistics, namely (i) distribution from a warehouse in the country of origin through express couriers, (ii) distribution through sorting hub(s) located in China and (iii) distribution from warehouses in China. Other contributions simplify the classification (e.g. Ballering, 2017) by stating that companies selling via CBEC can either opt for a "B2C" or a "B2B2C" delivery model. The "B2C" model implies a direct shipment relying on express couriers or postal operators. The "B2B2C" model allows bulk shipment of multiple products to a bonded warehouse within one of the CBEC pilot zones in Mainland China. More recently, Giuffrida et al. (2018) revise their previous findings and show that companies adopt at least four CBEC logistics solutions in China. These are described by combining two main variables, namely the transport mean used to cover the international route and the use of logistics infrastructures in China. Based on these variables, the solutions can be named "Ship and Warehouse" (S+W), "Plane and Warehouse" (P+W), "Plane and Hub" (P+H) and "Direct distribution" (D) from the country of origin.

Regarding the evaluation of available solutions, Wang et al. (2015) suggest that the choice of a specific configuration is influenced mainly by transaction costs and to a less extent by other factors, such as strategic considerations. Su and Xu (2016) propose a logistics mode selection evaluation system. They consider the size and strength of the company, logistics costs, service performance and product characteristics and discuss that big companies typically ask for a high level of autonomy of the logistics system. Conversely, SMEs prefer third-party operators and cheaper solutions for transport. Similarly, Yang et al. (2014) suggest that the logistics capabilities of a company affect the selection of the entry mode to China. Their study shows that companies who are too weak at cross-border operations and logistics typically opt for selling through third-party e-commerce platforms. Pang and Lodewijks (2014) design a cross-border parcel handling information infrastructure, which aims at providing a more accurate tracking and tracing of parcels, by relying on RFID and GPS technologies. Similarly, Zhang (2017) proposes a logistics information platform based on big data, that can improve the logistics service level and its efficiency. Hsiao et al. (2017) suggest that cross-border logistics service providers should pay significant attention to aspects that have positive influence on customers, for instance 24/7 service, free and detailed packaging service, proper tracking information. Qiao et al. (2017) recognise that the diversification of product categories and consumers' needs create a multi-level demand for cross-border logistics services. For instance, the demand for low-value consumer goods usually requires ordinary postal services, while consumers of luxury goods typically ask for international air express service. Therefore, logistics companies need to establish a comprehensive service system. Feng et al. (2017) point out that cost control is particularly important for e-commerce because costs largely impact on logistics and distribution. Finally, Jiao (2015) identifies the main problems and challenges of CBEC logistics in China. These are related to unstable service quality, high logistics costs, complex returns management and customs issues.

CBEC logistics in China: theoretical approaches in current literature

CBEC is a recent literature field with many gaps to fill (Giuffrida et al., 2017a) and a lack of understanding of the phenomenon (Su et al., 2017). Nonetheless, in recent years, several authors have tried to analyse the topic proposing alternative theoretical settings.

In 2015, Wang et al. offer a transaction cost theory approach to explain the causes of CBEC development with respect to traditional commerce. They find that the reduction of transaction costs in CBEC is the major driver for its diffusion. However, while the total transaction costs of CBEC decrease with respect to traditional cross border activities, the ones related to logistics increase in CBEC. Furthermore, the authors acknowledge that, given the complexity of the phenomenon, relying only on transaction costs does not explain the issue completely. Similarly, Wang et al. (2017) investigate the impact of CBEC on international trade in the context of China, mainly from the perspective of transaction cost economics in conjunction with the traditional comparative advantage model.

Conversely, Ai et al. (2016) apply the two markets theory to develop an e-commerce logistics performance evaluation model. They find that robust legal system, logistics barcode technology, effective electronic clearance and international payment systems are needed to support CBEC. Guo et al. (2015) then apply the principles of signalling theory and trust theory to build a conceptual framework of seller-buyer trust in CBEC. Huo et al. (2018) specifically adopt an institution-based view and underline the importance of institutional support for companies involved in CBEC. Lu and Yan (2017) suggest that an application of complex network theory would be beneficial to study the distribution network of the major e-commerce players in the Chinese CBEC sector. Finally, only Su et al. (2017), recognising the relevance of uncertainty in this field, propose the application of grey systems theory to predict the future evolution of CBEC import and export flows in China.

Although multiple theoretical approaches have been attempted to analyse CBEC, most of the existing papers analyse CBEC as a phenomenon and apply theories to explain its development. There are a few papers specifically using theory to analyse the logistics aspects; moreover, very few of the existing contributions incorporate uncertainty in their analyses. These are descriptive and do not provide tools to support decision making for CBEC logistics. Nonetheless, the use of e-commerce in a global environment brings a certain amount of uncertainty that should not be disregarded (Sinkovics et al., 2007). Therefore, we put this topic at the centre of the present research.

Methodology

Research framework

Given the scarcity of contributions simultaneously analysing the features of logistics solutions for CBEC and the impact of uncertainty, we aim to fill this gap by proposing a study that preliminarily identifies possible uncertainty factors and later calculates their effects on logistics by means of a quantitative uncertainty analysis, as common in a decision theory setting. This helps address RQ1

Based on the results obtained addressing RQ1, the paper aims to suggest paths for decision making by relying on a decision tool, in our case expressed in the form of a decision tree. This part addresses RQ2. The complete research framework is represented in Figure 1 and hereafter described

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Insert Figure 1: Research Framework

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The proposed framework clarifies that RQ2 relies upon the results of RQ1 and specifies the main factors that are needed to address RQ1. More specifically, in order to assess the impact of uncertainty on our decision problem, three elements have to be considered: the logistics solutions supporting CBEC, the main cost and service level indicators for the solutions and the uncertain variables that may influence them. The main theory that drives uncertainty-based contexts is decision theory. The key elements of this theory are of statistical nature, namely:

- a set of uncertain factors
- a set of consequences influenced by the uncertain factors
- a set of functions that connect the uncertain factors to the consequences

In our case, the uncertain factors are the logistics-related risk variables (e.g. cost factors, demand, regulations); the consequences are represented by the total logistics performances of all the logistics solutions; the functions are probability measures of the uncertain factors.

Components of the framework

Starting with the logistics solutions, we follow the work of Giuffrida et al. (2018) and consider the four solutions reported in Figure 1 and mentioned in the literature review:

•Solution "S+W" (ship + warehouse): this model implies the international route is performed via ship and products are delivered in bulk to one or more warehouses located in a Chinese CBEC pilot zone. By using the ship, international transport takes 30 days on average. Therefore, a warehouse in China is necessary to decouple the phases of the logistics process.

•Solution "D" (direct shipment): this solution operates without logistics infrastructures in China. Single orders are sent directly from the country of origin via express couriers or normal postal service. This model is costly but allows outsourcing the complete logistics process, thus reducing the organisational effort of the selling companies;

•Solution "P+H" (plane+hub): this model implies international transport is performed via plane with logistics intermediaries collecting orders from multiple sellers until a full load travel can be arranged. The solution makes use of a logistics hub in China, i.e. a logistics node with only sorting functions and very limited storage activities;

Solution "P+W" (plane + warehouse): this solution uses a local warehouse with a plane-based transport and is used because of product characteristics (e.g. obsolescence of fast fashion items) or because demand is not easy to forecast, therefore shipments cannot be adequately planned. For e-commerce, this method is recently becoming preferred to sea-fright with warehousing in China, due to reduced turnaround time (de Bie, 2015).

As mentioned in the introduction, these solutions are particularly interesting to investigate because they are developed thanks to synergic actions of logistics and CBEC service providers with the goal to provide adequate service to final consumers. It must also be noted that, while we analyse these solutions separately, there are some companies that are starting to experiment a hybrid use of the solutions with models consisting of a direct shipment (solution "D") to a third country where a bonded warehouse is established (solution "P+W" or "P+H") and final shipment to Mainland China by truck or other transport means, depending on the distance.

As a second element of our framework, we detail the main types of logistics performance indicators, in terms of costs and service level, that are relevant in a CBEC logistics environment. The considered costs are linked to the main logistics activities. According to Jiao (2015), these are transport (from country of origin to the door of the Chinese consumer), inventory management (including the inventory carrying cost of cycle, safety and in-transit stock), handling (the operational costs of handling goods in port/airport or within the hub/warehouse), and customs clearance (import tariffs and final taxes). In addition, the stock-out cost is used as an indication of service level.

Finally, we consider a set of uncertain variables impacting the entity of the logistics costs.

In its basic formulation, the overall cost of a logistics solution is determined by multiplying the unit cost of each logistics activity by the volume, i.e. the number of units, for which the activity is performed. Estimating cost factors in this context is particularly complex. Indeed, according to Badurdeen at al. (2014), the single logistics cost factors depend on a set of drivers, e.g. delays, fares, labour prices, forecasts, break-downs, that are hard to assess and interconnected to each other. However, they all contribute to make the cost factors uncertain. Similarly, demand volumes are uncertain and represent a typical risk of global supply chains (Manuj and Mentzer, 2008). Another driver affecting logistics costs and the service level is the value of the product (Mangiaracina et al., 2015). Last, environmental factors, especially CBEC regulation changes and quality checks, are recognised to produce high levels of uncertainty in literature (Jiao, 2015; Yue et al., 2017; Fang, 2017; Yang et al., 2017; Giuffrida et al., 2018). The mentioned variables are classified into external, market- related or company-related in the suggested framework. Company-related variables are at least partially under the control of the company, the others are not. While other risk factors are available in traditional global logistics literature (e.g. see Vidal and Goetschalckx, 2000; Vilko et al., 2014), in this paper we include only the variables that are mentioned in specific CBEC literature.

How to address RQ1: Quantitative risk assessment

In order to answer RQ1, the costs of the four logistics solutions need to be compared under two specific cases; the first implies the absence of uncertainty, while the second involves uncertainty. To serve this scope, two models, named "deterministic model" and "probabilistic model" are developed and described below

Deterministic model architecture

To calculate logistics costs in a deterministic setting, an activity-based cost model is developed. The model returns the unit logistics costs, i.e. the logistics cost associated to a single piece for each solution by considering all the relevant logistics activities proposed in the research framework, i.e. transport, inventory management, handling, customs clearance. Service level features are considered through the stock-out cost, i.e. the cost of missed sales. While service level can be also expressed in a time unit of measure (i.e. days between order receipt and fulfillment) we translate it in monetary terms so that it can be added to the costs, and overall comparisons among all solutions' performances are possible. The model is applied to two base cases, namely the fashion industry, and the food and beverage industry. The returned unit costs represent the average costs of the solution.

The activity-based cost model consists of four main building blocks, herein described:

- *Inputs:* these refer to (i) the characteristics of the exported product, e.g. product category, weight, variable production cost, and (ii) the logistics features, e.g. number of units per carton, number of cartons per pallet, service level expressed as item fill rate;
- *Context data:* they refer to the external environment, e.g. exchange rate, demand, transport fares, warehousing costs;
- *Computation algorithm:* the model's algorithm calculates the total costs for each solution. It must be noted that, for solutions adopting a local warehouse in China, most of the costs associated with forecast-based activities depend on the frequency through which goods are sent out to China. For such reason, these solutions require the determination of an optimal frequency. In order to fix it, the costs corresponding to a set of frequencies are calculated and the frequency associated to the lowest costs is considered the optimal one. The costs returned by the model are, therefore, the ones linked to the optimal frequency;
- *Output:* the output of the model is the unit logistics cost, split by type of activity, per each solution.

Probabilistic model architecture

To assess the effect of uncertainty on the costs of each logistics solution, we rely on the construction of a probabilistic setting, as common in quantitative analyses (Apostolakis, 2004; and Paté-Cornell and Dillon, 2006). We develop a probabilistic model that receives the output of the deterministic model as inputs. These data are used as mean values of a probability distribution, then a Monte Carlo simulation (Hazen and Huang, 2006) is run. We use @Risk to assign distributions and generate a Latin hypercube sample of 5000 iterations per each case (food, fashion) and each logistics solution. The result is the Probability Distribution Function (PDF) of the total unit logistics cost for each solution.

In defining the probabilities, we opt for the triangular distributions for all cost items. This distribution is commonly used in literature because it is manageable and useful when a distribution cannot be determined, due to missing, difficult to obtain or costly to collect historical data (Glickman and Xu, 2008). Due to novelty of the phenomenon, historical data are not sufficiently available, therefore the triangular distribution seems appropriate to our case. Regarding the demand volumes, we opt for a lognormal distribution that can take values ranging from 0 to +∞, recognising that in such an environment it is difficult to identify minimum or maximum levels for the demand. Once distributions are assigned and simulations run, the data of the simulation are inputted and processed in Matlab to derive the importance measure β^{Ku}, based on Kuiper's metric. This sensitivity measure can determine a ranking of the most important risks to consider for each logistics solution. It can be calculated by running algorithms in standard software packages which are available in literature. This analysis identifies the most critical uncertain factors in each solution. We apply it similarly to Baucells and Borgonovo (2013).

Finally, the introduction of a new regulation and taxation policy is modelled as a discrete uncertain variable, leading to different cost scenarios depending on the verification of two main uncertain events that will be described in the results section. The base case corresponds to the old regulation. We add the VAT and consumption taxes to the logistics costs borne by the company despite they are paid by the customers. We proceed in this way because when the change in CBEC regulation was first proposed in April 2016 players such as Kaola.com, were forced to offer discounts at the cost of their profits, to ensure that consumers could purchase goods at the same price as before (Jiang, 2018). Under the "old" regulation, an average rate of 20% of product value is applied to most fashion items and 10% to food ones. All the data and assumptions embedded in both models are based on interviews with companies operating in CBEC and secondary sources.

Figure 2 displays the main features of the two models. A more detailed description of the models' structure, data sources and formulas is offered in Appendix I.

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Insert Figure 2 – Model architecture

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The Appendix also shows that the data inputted in the model are all specific of the Chinese context, given the geographical focus of the research. More specifically, we use transport fares, warehousing and handling costs applicable in the considered first and second tier cities. Furthermore, we consider GDP and population of each city when distributing demand volumes within China. Last, we use data related to the tariffs and taxation policy valid for Chinese CBEC until December 2018, as well as the expected tariffs announced for the new regulation.

How to address RQ2: Decision analysis tool

In order to use the information derived from RQ1 to guide companies in their decision process, we use the decision tree approach. The tree consists of several branches. Each of them represents an option of the decision problem, i.e. in our case a different logistics solution. Along each branch, all the possible uncertainties (chance nodes) and the cost associated to their realisation (value nodes) are represented and used to determine the best alternative, i.e. the one with the lowest expected cost. Following this method, we are also able to calculate the Expected Value of Perfect Information (EVPI), i.e. the maximum amount a company should pay to eliminate uncertainty from the decision problem.

Results and discussion

RQ1: How uncertainty affects the costs of the logistics solutions and their importance

In order to determine the relevance of the different types of logistics costs under the four logistics solutions, a preliminary base case is developed. For the purposes of this paper, we identify two scenarios, one for the fashion and the other for the food industry. Each case is evaluated for the four logistics solutions, leading to eight alternative scenarios. The results are first calculated in a deterministic setting and then translated into a probabilistic one to record the effect of uncertainty

Deterministic case

The following Table 1 lists the base case features of the model applied to the fashion industry. The unit costs associated to each variable are the ones returned by the deterministic activity-based model.

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Insert Table 1 - Base case (Fashion) – Yearly values

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Please, note that the variable "stock-out cost" is defined as the cost of missed orders in case of stock-out. This cost is inversely related to the service level, defined as item fill rate (i.e. the probability of satisfying customers' demand with available stock).

By looking at the different types of cost we can observe that results are in line to what suggested in current literature. In fact, as suggested by Kawa, 2017; Ballering, 2017; Giuffrida et al. 2018, among others, transport cost grows with the speed of the transport mean, inventory costs depend on the number of levels in the distribution network and the value of the items. Moreover, customs clearance costs are found to be very burdensome and often represent a barrier to international expansion (Boyd et al., 2003). Similarly, we find that transport cost is preminent for solutions using planes, inventory costs prevail in case of local warehouses (because inventory is duplicated) and customs and taxes are the highest source of cost for any solution. Also stock-out costs are reduced for solutions with a local warehouse, thanks to higher fill rates.

By looking at the line "total unit logistics cost" we can desume that the optimal solution for the hypothesised fashion case is "P+H", i.e. the use of a consolidation hub in a Chinese Free Trade zone, served via air. In this case it is possible to note that inventory management costs have a major impact on both solutions "S+W" and "P+W", due to the high value of the item, which makes these alternatives less efficient than the one considering the hub. Solution "D" is by far the most expensive. However, it should be noted that this is a valuable solution in case the aim of the company is not only linked to cost minimisation. This solution allows facilitating the overall logistics process since most of the organisational and operational burden is outsourced.

The following Table 2 lists the base case features of the model applied to the food industry. The unit costs associated to each variable are, again, the ones returned by the deterministic activity-based model.

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Insert Table 2 - Base case (Food) – Yearly values

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In this case, we face a partially different result with respect to the fashion case. In fact, we find that higher transport cost and inventory costs are again associated to solutions that involve faster transport means and local warehouses respectively. Nonetheless, customs and taxes are not the highest cost items, although being equivalent regardless of the solution. This is due to the particularly low tariff and the lower value of the product with respect to the fashion case.

Generally, by looking at the line "total unit logistics cost" we can desume that the optimal solution for the hypothesised food case is "S+W", i.e. the use of a bonded warehouse in a Chinese Free Trade zone, served via ship, due to the typically low value of food items. The rationale here is that the low value of the products do not justify an expensive delivery by plane. At the same time, keeping these products on stock is not excessively costly, as it would be in the case of a high fashion garment. Solution "D" is again the most expensive. However, it must be noted that in this paper we are considering the case of dry food, for simplicity. Higher costs linked to the need of refrigerating transport and storage systems, as well as shelf life issues, should be considered for fresh products. Therefore, the optimal solution might change for the fresh food or grocery industry.

In conclusion, we can observe that while the magnitude of costs in a deterministic setting is in line with what suggested by literature, results also depend on the industry, the type of product and the applicable import tariffs.

Probabilistic case

In order to assess the impact of uncertainty, in all scenarios we consider nine uncertain factors that are built as a measure for the ones proposed in Figure1. These are (i) the value of the product (expressed as its production cost); (ii) the transport cost; (iii) the inventory carrying cost; (iv) the in-transit stock cost; (v) the handling cost; (vi) the customs clearance cost; (vii) the stock-out cost (expressed starting from the item fill rate); (viii) the markup, i.e. the overprice applied to the value of the product, important to determine the lost margin in case of stock-out; and (ix) the demand level. After assigning the probability distributions to each factor under the four different solutions, as described in the methodology, Monte Carlo simulations are run. Figure 3 graphically shows the effect on the output, i.e. the total unit logistics cost in the fashion case.

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Insert Figure 3 - PDFs of total unit logistics costs for each solution (Fashion)

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By looking at Figure 3, we can notice that the curves represent the PDF of the total unit logistics cost for each solution in the fashion industry. The x-axis reports the possible unit costs and the y-axis reports the corresponding probability of occurrence. In general, we can notice that curves shifted to the right correspond to more expensive solutions. Since some of the curves partially overlap, it is clear that the optimal solution might undergo a change in the fashion industry because of the effect of uncertainty.

Figure 4 graphically shows the effect of inputs uncertainty on the unit logistics cost under the four logistics solutions in the food case.

By looking at the graph, we can notice a more drastic divergence of solutions with respect to the fashion case. “S+W” is the cheapest solution in any condition, with unit logistics cost hardly exceeding 5 €/item. Solutions “P+H” and “P+W” provide similar results, while the reliance on direct shipment (solution “D”) is prohibitive in the dry food scenario due to high cost with respect to the average value of the products in this industry. This was already anticipated in the deterministic scenario (Table 2) where the stock-out cost of this solution is negative.

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Insert Figure 4 - PDFs of total unit logistics costs for each solution (Food)

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The presented graphs give us a broad idea of the effect of uncertainty. We do understand that the final cost is not a fixed number as in the deterministic case, but that it can range over a wide set of options. However, some information is missing to fully evaluate the effect of uncertainty.

In our RQ1, we are also interested in investigating what are the key variables under uncertainty. Therefore, a probabilistic sensitivity analysis is proposed to isolate the effect of single variables, while Figures 3 and 4 consider the effect of all the inputs varying together. Results of this analysis are reported in Tables 3 and 4 respectively for the fashion and food cases. Both tables list all the uncertain inputs on the rows and the value of the β^{Ku} sensitivity metric for each logistics solution on the columns. If little or no variations in the output are registered when a given uncertain variable changes, the metric will take a value closer to zero. Conversely, higher values of the metric imply higher importance of the input in each logistics solution.

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Insert Table 3 – Sensitivity analysis – Kuiper importance measure (Fashion)

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By looking at results of Table 3, we can derive some interesting insights. First, the risk of regulation change is the most important variable for every solution, thus confirming the results presented in Giuffrida et al. (2018). The regulation change is reported in the table in substitution of the customs clearance cost because it mainly affects these aspects, as it will be explained in the next section.

Similarly, the value of the product is the second most important variable. We can therefore observe that the convenience of each solution is highly dependent on the type of product. Then, uncertainty in demand, i.e. volumes, is a key parameter especially for solutions not relying on local logistics infrastructure (solution "D"). Regarding the cost factors, inventory carrying costs importance increases with warehouse-based solutions; in-transit stock and handling costs are the least influential variables in all solutions, while service level, tied to the value of the item fill rate, is equally relevant in every solution. Last, despite accounting for a relevant part of the logistics costs in an international distribution setting, transport cost is not among the key variables in this case. This result leads us to observe that not all the cost factors reflect the importance they had in the deterministic scenario.

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Insert Table 4 – Sensitivity analysis – Kuiper importance measure (Food)

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Regarding the food industry, some of the observations made for the fashion case are replicable. The regulation change and the value of the product are again the most influential variable, confirming results retrieved in literature. Demand volume uncertainty is relevant especially when there are no warehouses. A possible explanation could be that the sellers without a local warehouse might not be able to face a substantial increase in the demand incurring in stock-out costs or be able to satisfy it at very high cost. Also, handling and in-transit stock costs are again the least influential. We can, however, notice some differences with the fashion case, i.e. a lower criticality of service level and an increased criticality of transport costs for plane-based solutions. These results do not reflect completely the order of magnitude calculated in the deterministic case.

Considering both cases, the results overall suggest that the regulation change, with its impact on taxation and customs issues, is the most uncertain and critical variable for CBEC. Following, the value of the product is the second most influential variable for the cost and effectiveness of the logistics solutions. Indeed, this variable acts as a constraint on suitable solutions. For instance, in the dry food industry, expensive solutions such as the direct or plane-based delivery are not convenient.

Prioritisation of uncertain factors is important because it suggests that if resources are available for further modelling or data collection, companies should prioritise those linked to the most influential variables. For instance, a company adopting solution "D" should focus on producing a precise demand forecast to reduce uncertainty on this important variable. Conversely, it would not be worth investing time in modelling in-transit stock or handling costs due to their limited impact on the total logistic cost.

RQ2: supporting risk-informed decision making

Finally, in order to adress RQ2 and help companies select a proper logistics solution, we rely on the foundations of decision theory and propose a decision tree to compare the convenience of the investigated solutions under uncertainty. As demonstrated in the previous sections of the paper, regulation is a sensitive topic in the CBEC sector. Therefore, in addressing RQ2, we need to clarify the events and conditions that make CBEC regulations critical. In 2016, the Chinese government released new policies for CBEC, whose main impact is two-fold:

- Introduction of a new taxation policy: while direct imports are still treated as personal use products with the application of postage tax, storage in a bonded warehouse implies application of higher value added taxes. Tax rates change in both cases;
- Institution of a positive list system: not every product is allowed to enter China via CBEC models, but only those included in the positive lists. These goods are exempted from submitting an import licence to Customs. However, products subject to China Food and Drug Administration (CFDA), e.g. cosmetics, baby milk and medical devices, require filing or registration, which are lenghty procedures, before being imported.

The main aim of this new regulation is to shape a more balanced system, where CBEC is treated similarly to traditional trade. Moreover, this regulation forces a further differentiation between the direct shipment models (B2C) and the ones based on the use of a bonded warehouse in China (B2B2C) (Chan et al., 2016). Following an uprise from CBEC players for the tightened requirements, a transition period was initially granted until the end of 2017. The grace period has then further been extended and, at present, most people think the new policy will come into place soon.

The following paragraphs analyse the solutions under the old and the new taxation policy. For semplicity reasons, we assume the analysed products are included in the positive lists and are not under the CFDA regulation, therefore they can be traded with any type of CBEC model.

Fashion industry

As a first case, we examine the fashion scenario and we assume there is a high probability for the new regulation to become effective (80% chance), rather than stay the same (20% chance). The corresponding decision tree is represented in Figure 5. As it can be noted from the picture, the decision analysis evaluates the expected unit logistics costs under the four logistics solutions. The regulation change cost is reflected in a change of the taxation rates. Under the "old" regulation, an average rate of 20% of product value is paid for most fashion items regardless of the adopted solution. With the new regulation, taxes are set at 70% of both VAT (17%) and consumption tax (30% for most fashion items), i.e. 0,7* (0,17+0,3) = 32,9%. This value holds for solutions "S+W", "P+H" and "P+W", while for solution "D" a postal tax for personal import of 30% applies (Chan et al., 2016; de Bie, 2015; Ballering, 2017). Each solution is rapresented by a branch of the tree. In branches "S+W", "P+H" and "P+W", there is only one chance node, i.e. the one expressing the probability of the new regulation coming into place. Conversely, in branch "D", an additional uncertain event must be taken into account, i.e. the actual check of the parcel by the authorities. With bonded warehouse (or hub) solutions, the taxes are 100% payable, while in case of direct shipment not every parcel will be inspected and taxed (Chan et al., 2016). The probability of the parcel being checked is normally lower than 100%. In this scenario, we fix it at 50%.

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Insert Figure 5 – Decision tree (Fashion)

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As it can be noted from the picture, the actual convenience of the solutions is dependent on the parcel check from authorities. Since branches “P+H” and “D” have similar costs, whether the parcel is taxed in solution D makes a difference. More precisely, for probabilities of the parcel not being checked at least equal to 50%, solution “D” becomes the optimal choice in the considered scenario, with an expected cost of 46.14 €/piece. The fact that the optimal solution changes under different realisations of uncertain events with respect to the deterministic scenario (where the optimal solution for fashion was “P+H”) suggests that an EVPI analysis could provide additional interesting insights. According to Howard (1966), when changes in the problem inputs do not only cause a change in the value of different alternatives, but also affect the preferred alternative, decision-sensitive measures should be considered. The Value of Information is appropriate for taking both value and decision sensitivity into account (Borgonovo, 2017). This measure represents the maximum amount a decision maker should pay in order to access a status of perfect information. It is obtained as the difference between the decision tree previously calculated and a new tree where uncertainties are eliminated and substituted by the best possible choice under different realisations of the uncertain events. The expected cost of a tree where uncertainty about regulation change is eliminated is 43.14 € /piece, i.e. 3 € less than the corresponding case with imperfect information. The saving of 3€ is the value of knowing with certainty about the change of regulation in this case (EVPI). If we intend to eliminate also the uncertainty about the parcel check, a new tree can be calculated, whose expected cost is 38.42 €/piece, with an EVPI of 7.72 €/piece. This result highlights that getting to know about parcel check is more costly because this information embedds the information about regulation change itself.

Food industry

As in the previous case, we examine the scenario where there is a 80% chance for the new regulation to become effective. The corresponding decision tree is represented in Figure 6. In this case, under the “old” regulation, an average rate of 10% of product value is paid for most food items regardless of the adopted solution. With the new regulation, taxes are set at 70% of VAT (17%) and consumption tax (15% for most food), i.e. 0,7* (0,17+0,15) = 22,4% (Chan et al., 2016; de Bie, 2015; Ballering, 2017). This value holds for solutions “S+W”, “P+H” and “P+W”, while for solution “D” the postal tax for personal import is 15%. Again, we set the probability of the parcel being checked at 50%.

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Insert Figure 6 – Decision tree (Food)

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Under this scenario, the solution that minimises the expected logistics cost is “S+W”. Therefore, no changes occur in the optimal choice suggested by the tree with respect to the deterministic case, differently from the fashion case. Solution "D" is so costly for the food industry, that even in the tax-free option, it exceeds the costs of the ship and warehousing solution. Given the convenience of "S+W" under all the scenarios, we do not consider worth performing an EVPI in the food case. The optimal solution would not change, even in a state of perfect information. However, we must underline that these results are only indicative, as the exact rates to apply depend on the specific product and industry.

Implications of the research

Implications for theory

This paper investigates the effects of uncertainty on logistics supporting CBEC. This topic is analysed by comparing the performances of four main logistics solutions under probabilistic and deterministic scenarios. In order to do so, the paper applies two quantification models to industry cases and relies on the principles of decision theory. To the best of the authors' knowledge, this study is the first to provide a detailed assessment of logistics costs for CBEC and show implications for two of the most purchased product categories in China, i.e. fashion and food. Indeed, a very general approach has been predominantly reserved to CBEC so far, with very descriptive papers, lacking industry focus or empirical exploration.

The first theoretical insight derived from this research is that the chosen model may influence results. If we do opt for a deterministic model, the optimal solution changes with respect to the one suggested by the probabilistic model in one of the hypothesised cases (the fashion industry), while stays the same in the hypothesised food case.

Second, the fact that the result is case-dependent stresses that generalisation is hard to achieve in this field. Industry effect is very relevant and overcomes the model effect. This suggests that another theoretical lens worth applying in the future to this field is contingency theory (Woodward, 1965; Lawrence and Lorch, 1967), strongly rooted in the hypothesis that situational aspects and context factors have an influence on the strategy that companies implement to set up a project. In this sense, additional context variables, beyond industry, should be identified and their effect on CBEC uncertainty and the consequent strategy to apply should be assessed.

The paper also contributes to the ongoing academic debate on the effect that digitalisation has brought to international business. In fact, while some authors state that CBEC helps to reduce costs related to international payments, logistics, and language, and that e-commerce has the potential to facilitate exporting processes (e.g. Karadvic and Gregory, 2005; Hameri et Hinsa, 2009; Hsiao et al. 2017), this paper finds additional costs are created. More specifically, in this field, uncertainty has a "cost" that should not be neglected, given that it may cause optimal solutions to change.

Implications for practice

In our view, the main value of this analysis for practitioners is given by the risk prioritisation exercise. In fact, this can guide managers towards the identification of the most critical parameters to monitor under uncertainty. As shown in tables 3 and 4, this paper finds that (i) regulations are a key uncertainty source, (ii) product value is the second most important driver, (iii) the demand volume is determinant to decide whether to establish a local warehouse, but fluctuations in demand are more critical when the warehouse is not present, (iv) handling and in-transit stock cost are the least influential variables and (v) the importance of uncertain factors is not necessarily linked to their magnitude in a deterministic setting.

First, the fact that regulations are the greatest source of uncertainty suggests that companies should enact strategies to counterbalance possible negative effects. The general tax rate deduction is an encouraging sign for brands who want to invest in the Chinese market. However, the regulation is going to be stricter for CBEC (Walk the Chat, 2019). Therefore, companies need to make sure to follow the rules and stay compliant, avoiding ambiguous methods like the *Daigou*, i.e. local importers buying on behalf of a larger multitude of clients, often for tax evasion purposes. One of the most appropriate ways to manage regulatory issues in this field is to avoid autonomous initiatives and cooperate with local and international logistics service providers, whose information systems are typically connected to the CBEC platforms and to the customs systems. This way, tracking and customs clearance services are offered easily.

Second, with reference to the impact of product value, this can be partially controlled by the selling company through the selection of an appropriate product mix to sell to China. It is important to note that, typically, Chinese e-commerce platforms tend to highlight individual products rather than the brand or company behind them. Very often, in fact, they launch promotional campaigns to promote a selection of references offered by different companies. The main driver of cost for a company that sells and delivers through a Chinese platform is the single product. The more references available, the higher the costs (Digital Export Observatory, 2018). Therefore, it is advised to start focusing on higher-margin products when volumes are low and then gradually expand the product range as volumes grow.

Third, the criticality of demand volumes suggest companies should invest into a local warehouse only in the medium term, after they reach a critical mass and enough historical data to support their demand forecast processes.

Finally, regarding the selection of the optimal solution under uncertainty, results show that the optimal solution is dependent on the actual probability of the parcels being checked and taxed in the fashion case. The event that the parcel is checked under the new regulation, therefore, increases the cost of uncertainty in the decision problem. Such result pushes for performing a value of information analysis, that returns the maximum amount a company should pay to know future events with certainty and take decisions accordingly. We find that the information about the possible implementation of the new tax policy should be paid between 3€/piece and 7.72€/piece. The application of the EVPI is hard to explain practically because, of course, perfect information does not exist. However, calculating this value gives an indication of the real cost and impact of uncertainty in the field.

Implications for policy

From a policy point of view, this study stresses how promising yet challenging CBEC in China is. We find that the effects of new policy implementation highly depend on the sector and type of product. However, by looking at the results, some interesting and hopefully useful observations can be made. In the proposed fashion case, solution "D" does not become optimal for real convenience, but for the possibility that the parcel is not checked. This ambiguity may tempt the decision maker to use this solution only to bet on tax elusion. This does not look reasonable, neither ethical. Therefore, it is important to correctly shape regulatory interventions that eliminate this ambiguity and properly support the development of CBEC. Beyond parcel checks, also tariff fluctuations can play a role in determining the convenience to trade via e-commerce. China has supported the online business with lowered tariffs so far. Moreover, the Chinese Government has released a new policy effective since January 2019 that affects CBEC. The main novelties include (GB Times, 2019):

- Extension of the positive list: 63 product categories will be added to China's duty-free list, covering consumer goods such as beer, electronics and healthcare products;
- Increase of the annual quota on cross-border e-commerce purchases for individual buyers: it is raised from 20,000 to 26,000 yuan. The limit on a single transaction is raised, from 2,000 to 5,000 yuan

However, these facilitations might be hindered in the future, especially in the light of the recent trade tensions with the USA. After withdrawal from the Trans-Pacific Partnership (TPP), in October 2018, the USA has announced a withdrawal also from the Universal Postal Union (UPU) because major economies like China are still considered emerging and benefit from lower shipping rates (The Guardian, 2018). In addition, the USA has imposed billions of dollars of tariffs on Chinese imports, inciting China to do the same in return. Since then, the two economies have engaged in tit-for-tat tariffs on a growing range of products.

The consequences of these actions do not only affect the two involved countries, but international trade at large (International Monetary Fund, 2018). Indeed, a considerable portion of intermediate products are produced in China, which hosts parts of the value chain of most economies in the world. Changes in the tariffs for Chinese products will inevitably affect trade and investment decisions of third countries. From an e-commerce perspective, the main impact will be on the prices of products. These will possibly rise because of increased tariffs.

In the models presented in this paper we have assumed the variation in CBEC tariffs and tax rates to be an additional cost that the selling company bears in order to keep the final price constant and not affect final consumers' buying decisions. However, in the long run, the expected effect is a rise of final prices, if companies do not want to compress their margins too much. In this regard, tariffs are an influential factor in a customer's decision to purchase goods abroad. However, these are not the only factors that buyers consider relevant. In fact, quality and accessibility of new products are ranked with similar importance to price and tariffs among the drivers for CBEC (Paypal, 2018). Therefore, price increase should not be necessarily seen as a barrier for CBEC development.

Nonetheless, policymakers could still hinder CBEC by enacting too protectionist regulations. A good initiative for governments to lower trade barriers and facilitate procedures is the creation of special trade zones, as the pilot CBEC zones China has been establishing for years.

An additional possible consequence of the trade war between China and USA is the decision related to the location of warehouses to support cross border operations. Many logistics players, for instance, have their warehouses in Hong Kong. Although located in the Mainland China territory, Hong Kong has a separate regulatory system that is more beneficial. Therefore, many companies willing to reach China, including US ones, opt for using Hong Kong as a gateway (Digital Export Observatory, 2018).

Regarding the impact of tariff trade on the optimal logistics solution for CBEC, theoretically, the effect should be an increase in the cost of each solution as new tariffs apply regardless of the chosen channel. Nonetheless, uncertainty may play a role in case of the "D" solution, as per the calculations illustrated in this research, since it is more difficult to check the parcels. The increase in the costs of the solutions will be dependent on the type of products. The sectors that are currently most heavily affected by the tariff increase are electronics, food and automotive (Bloomberg, 2019).

Conclusion

The overarching aim of this research is to help companies solve the "decision problem", here defined as the risk-informed selection of an appropriate CBEC logistics solution. This topic is analysed through two RQs that compare the performances of four main logistics solutions under probabilistic and deterministic scenarios.

Firstly, RQ1 aims to identify the most relevant logistics costs in deterministic conditions and then quantify the effect of uncertainty on these costs. An activity-based model is first developed to evaluate logistics solutions in a deterministic scenario for two of the most popular consumer categories sold in China via CBEC, i.e. fashion and food. Simulations are then run on the results in order to derive the risk profile of logistics costs under different solutions with all uncertain inputs varying together. Later, by calculating a specific sensitivity measure, the most influential variables for each solution are detected.

Secondly, RQ2 proposes a decision tree to identify optimal solutions in uncertain conditions, with a focus on regulatory changes. In the last part, implications of this research on theory, practice and policy are discussed, also considering the tariff wars currently in place between the USA and China.

Despite being focused on China, the study provides insights on a phenomenon that could similarly develop in other countries in the future. As suggested by Amling and Daugherty (2018), innovative logistics practices in China should be studied as they may be applied in the western world as well.

CBEC is one of the biggest and most innovative trends in China. While many consider it simply as a new sales channel, this study agrees with Wang (2017) in stating that CBEC brings changes not only in the sales channels but at various levels in foreign trade. These include changes in the main market players, in business operations, in business models (more and more oriented to the establishment of strategic collaborative relations between different actors), and even in global business rules and legal environments. Uncertainty plays a big role in this new scenario, increasing the costs of doing business. Therefore, it should not be underestimated, but faced with appropriate risk mitigation approaches. One of the biggest causes of uncertainty is linked, however, to regulations and possibly protectionist trade policies. Carefully monitoring the evolution of renegotiations, especially regarding the USA-China relations, will be key to guide companies in better drafting their internationalisation plans.

References

Ai, W., Yang, J. and Wang, L. (2016). "Revelation of cross-border logistics performance for the manufacturing industry development", *International Journal of Mobile Communications*, Vol.14, No.6, pp.593-609.

Amling, A. and Daugherty, P.J. (2018) "Logistics and distribution innovation in China", *International Journal of Physical Distribution & Logistics Management,* https://doi.org/10.1108/IJPDLM-07-2018-0273.

Apostolakis, G.E. (2004), "How useful is quantitative risk assessment?" *Risk Analysis*, Vol.24, pp.515–520.

Ballering, T. (2017) "China Cross Border e-commerce guidebook". Consulate-General of the Kingdom of the Netherlands in Shanghai, *[online report],* available at: https://bit.ly/2xxhGer (accessed 03 August, 2018).

Baucells, M., and Borgonovo, E. (2013). "Invariant Probabilistic Sensitivity Analysis", *Management Science,* Vol.59, No.11, pp.2536-2549.

Borgonovo, E. (2017). "Sensitivity Analysis. An introduction for the management scientist", Springer International Publishing, Cham, Switzerland.

Boyd, S. L., Hobbs, J. E., and Kerr, W. A. (2003). "The impact of customs procedures on business to consumer e-commerce in food products", *Supply Chain Management: An International Journal*, Vol. 8, No. 3, pp. 195-200.

Bloomberg (2019), “A $600 Billion Bill: Counting the Global Cost of the U.S.-China Trade War”, available at: https://www.bloomberg.com/graphics/2019-us-china-trade-war-economic-fallout/ (accessed 10th August 2019).

Chan, W.C., Wouters, I., and Wu, R. (2016), “Shopping without boundaries china cross-border e-commerce: an opportunity not to be missed”, Oliver Wyman *[online report],* available at https://owy.mn/2vkqWRp (accessed 05 August 2018).

Cho, H., and Lee, J. (2017). “Searching for Logistics and Regulatory Determinants Affecting Overseas Direct Purchase: An Empirical Cross-National Study”, *The Asian Journal of Shipping and Logistics,* Vol.33, No.1, pp.11-18.

De Bie, R. (2015) “China Cross Border e-commerce, opportunities for Dutch companies”. Consulate-General of the Kingdom of the Netherlands in Guangzhou, *[report].*

Fang, Y. (2017). “Current Situation, Obstacles and Solutions to China’s Cross-Border E-Commerce”, *Open Journal of Social Sciences*, Vol.5, No.10, pp.343-351.

Digital Export Observatory (2018), “Export digitale, a ciascuno il suo canale”, research report, School of Management of Politecnico di Milano, Milan, March 2018 [report]

Feng, L., Ma, J., Wang, Y., and Yang, J. (2017). “Supply chain downstream strategic cost evaluation using L-COPRAS method in cross-border E-commerce”, *International Journal of Computational Intelligence Systems*, Vol.10, pp.815–823.

GB Times (2019), “China to adjust cross-border e-commerce import policies”, available at https://gbtimes.com/china-to-adjust-cross-border-e-commerce-import-policies (accessed 5th August 2019)

Gessner, G.H. and Snodgrass, C.R. (2015). “Designing e-commerce cross-border distribution networks for small- and medium-size enterprises incorporating Canadian and US trade incentive programs”, *Research in Transportation Business and Management*, Vol.16, pp.84-94.

Giuffrida, M., Mangiaracina, R., Perego, A., and Tumino, A. (2017a). "Cross-border B2C e-commerce to Greater China and the role of logistics: a literature review", *International Journal of Physical Distribution and Logistics Management*, Vol.47, No.9, pp.772-795.

Giuffrida, M., Mangiaracina, R., Perego, A., and Tumino, A. (2017b). “Logistics Solutions to Support Cross Border E-Commerce Towards China: The Case of the Apparel Industry”, in *Business Models and ICT Technologies for the Fashion Supply Chain. IT4Fashion 2016. Lecture Notes in Electrical Engineering*, edited by Rinaldi R., Bandinelli R., Vol.413, pp.163-177. Cham: Springer.

Giuffrida, M., Mangiaracina, R., Perego, A., and Tumino, A. (2018) “Entering China via Cross Border E-Commerce: logistics solutions and related challenges”, Proceedings of the Summer School Francesco Turco, 12-14 September 2018, Palermo.

Guo, Y., Le-Nguyen, K., Jia, Q., and Li, G. (2015). “Seller-Buyer Trust In Cross-Border E-Commerce: A Conceptual Model”, *Twenty-first Americas Conference on Information Systems,* Puerto Rico, 2015, pp. 1-7.

Glickman, T., and Xu, F. (2008). “The distribution of the product of two triangular random variables”, *Statistics and Probability Letters*, Vol.78, pp.2821–2826.

Hameri, A.P. and Hintsa, J. (2009),"Assessing the drivers of change for cross border supply chains", *International Journal of Physical Distribution and Logistics Management*, Vol. 39, No. 9, pp. 741 – 761.

Hazen, G.B., and Huang, M. (2006). “Parametric sensitivity analysis using large-sample approximate Bayesian posterior distributions”. *Decision Analysis*, Vol.3, No.4, pp.208–219.

Hensher, D.A., Zhang, Z. and Rose, J. (2015), “Transport and logistics challenges for China: drivers of growth, and bottlenecks constraining development”, *Road and Transport Research*, Vol.24 No.2, pp.32-41.

Hou, X.F. (2014), “Analysis on the situation of China’s e-commerce logistics”, *Advanced Materials Research*, Vols 926-930, pp.3750-3753.

Howard, R. (1966), “Information value theory”, *IEEE Transactions on Systems Science and Cybernetics,* Vol.2, No.1, pp.22-26.

Hsiao, Y.H., Chen M.C., and Liao, W.C. (2017). “Logistics service design for cross-border E-commerce using Kansei engineering with text-mining-based online content analysis”, *Telematics and Informatics,* Vol.34, No.4, pp.284-302.

Huo, B., Liu, C., Chen, H., and Zhao, X. (2017). “Dependence, trust, and 3PL integration: an empirical study in China”, *International Journal of Physical Distribution and Logistics Management*, Vol.47, No.9, pp.927-948.

Huo, D., Ouyang, R., Hung, K., and Sun, B. (2018), “Effect of Cross-Border E-Business Policy on the Export Trade of an Emerging Market: A Dynamic Study of Institutional Support to Cross-Border E-Business at Chinese Pilot Cities” *Emerging Markets Finance and Trade,* Vol. 54, No., 14, pp. 3153 – 3167.

International Monetary Fund (2018) “World Economic Outlook Update” [online report] available at: https://www.imf.org/en/Publications/WEO/Issues/2018/07/02/world-economic-outlook-update-july-2018 (accessed 10th August 2019).

Jiao, Z. (2014), “Development of e-commerce logistics in China”, in Liu, B., Wang, L., Lee, S., Liu, J., Qin, F. and Jiao, Z. (Eds), *Contemporary Logistics in China: Consolidation and Deepening*, Springer, Berlin, pp.1-14.

Jiang, K. (2018), “Retail Cross-Border E-Commerce in China: Will New Tax Policies Interfere with the Strong Growth Trajectory?”, *Speeda,* 31 January 2018, available at: http://bit.ly/2Rt6hak (accessed 25 August 2018).

Karadvic, M., and Gregory, G. (2005) “Integrating e-commerce into existing export marketing theories: A contingency model”, Marketing Theory, Vol. 5, No. 1, pp. 75-104

Kawa, A., and Zdrenka, W. (2016). “Conception of integrator in cross-border e-commerce”, *Scientific Journal of Logistics*, Vol.12, No.1, pp.63-73.

Lai, F., Li D., Wang Q. and Zhao X. (2008), "The information technology capability of third-party logistics providers: A resource- based views and empirical evidence from China." *Journal of Supply Chain Management*, Vol.44 No.3, pp.22-38.

Lawrence, P. R., and Lorsch, J.W. (1967). "Differentiation and Integration in Complex Organizations." *Administrative Science Quarterly*, Vol. 12, pp.1-48.

Lee, C. (2017). “China accounts for 40 percent of global ecommerce transactions”, *ZD Net,* 30 May 2017, available at: http://www.zdnet.com/article/china-accounts-for-40-percent-of-global-ecommerce-transactions/ (accessed 30 July 2018).

Mangiaracina, R., Song, G., and Perego, A. (2015). “Distribution network design: a literature review and a research agenda", *International Journal of Physical Distribution and Logistics Management*, Vol. 45, No. 5, pp.506-531.

Manuj, I., and Mentzer, J.T. (2008). “Global Supply Chain risk management”, *Journal of Business Logistics*, Vol. 29, No. 1, pp. 133-155.

Pang, Y., and Lodewijks, G. (2014). “Design of electronic commerce infrastructure for cross-border postal operations”, *IEEE International Conference on Service Operations and Logistics, and Informatics (SOLI),* October 2014, pp.406-411.

Paté-Cornell, M.E., and Dillon, R.L. (2006). “The respective roles of risk and decision analyses in decision support”, *Decision Analysis*, Vol.3, pp.220–232.

Paypal (2018), “Cross Border Consumer Research” [online report], available at: https://www.paypalobjects.com/digitalassets/c/website/marketing/global/shared/global/media-resources/documents/PayPal_Insights_2018_Global_Report (accessed 10th August 2019).

Pezderka, N., and Sinkovics, R.R. (2011). “A conceptualization of e-risk perceptions and implications for small firm active online internationalization”, *International Business Review,* Vol.20, pp.409-422.

Qiao, F. (2017). “Comprehensive Service System of Cross Border E-commerce Logistics Enterprises and Its Empirical Research”, *Boletín Técnico*, Vol.55, No.10, pp.514-521.

Ramanathan, R., George, J. and Ramanathan, U. (2014). “The role of logistics in Ecommerce transactions: An exploratory study of customer feedback and risk” in *Supply Chain Strategies, Issues and Models* edited by Ramanathan, U. and Ramanathan, R., pp.221-233. London: Springer.

Savage, Leonard J. (1954), *The Foundations of Statistics*. New York: John Wiley and Sons

Shuyan, C. and Lisi, X. (2013), “Research on the overseas warehouse construction of cross-border e-commerce”, *Wuhan 12th International Conference on e-Business Proceedings, Wuhan*, 25-26 May, p. 77.

Sinkovics, R.R., Yamin, M., and Hossinger, M. (2007) “Cultural adaptation in cross border e-commerce: a study of German companies”, *Journal of Electronic Commerce Research*, Vol. 8, No. 4, pp. 221-235.

Su, L., and Xu, N. (2016). “Research on Logistics Mode Selection under the Background of Cross-border E-commerce based on Grey Analytic Hierarchy Process”, *International Journal of u-and e-Service, Science and Technology*, Vol.9, No.12, pp.387-396.

Su, Y., Wang, Y., and Mi, C. (2017). “The Forecast of Development Prospects of China's Cross-border E-commerce Based on Grey System Theory”, *International Conference on Grey Systems and Intelligent Services (GSIS),* August 2017, pp. 182-186. IEEE.

The Guardian (2018), “Trump pulls US out of UN postal scheme on China price concerns”, available at:https://www.theguardian.com/us-news/2018/oct/17/trump-universal-postal-union-withdraw-foreign-postal-rates (accessed 8th August 2019)

Vidal, C.J, and Goetschalckx, Marc (2000). “Modeling the effect of uncertainties on global logistics systems”, *Journal of Business Logistics*, Vol. 21, No. 1, pp. 95-120.

Vilko, J., Ritala, P., and Edelmann, J. (2014). "On uncertainty in supply chain risk management", *The International Journal of Logistics Management*, Vol. 25, No, 1, pp. 3-19.

Wang, J. (2017), “Cross-Border E-Commerce in China: An Institutional Explanation” Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH Sino-German Quality Infrastructure Project

Wang, L., Chai, Y., Liu, Y., and Xu, Y. (2015). “Qualitative analysis of cross-border e-commerce based on transaction costs theory”, *IEEE 12th International Conference on e-Business Engineering (ICEBE)*, October, pp.166-172.

Wang, Y., Wang, Y, and Lee, S. H. (2017). “The Effect of Cross-Border E-Commerce on China's International Trade: An Empirical Study Based on Transaction Cost Analysis”, *Sustainability*, Vol. 9, No.11, pp. 2028 - 2041.

Woodward, J., (1965). “Industrial Organization: Theory and Practice”, Oxford University Press, London.

Yang, N. (2017), "Study of the Impact of the Cross-border E-commerce Model Based on the Belt and Road on China's International Trade System", *Revista de la Facultad de Ingeniería*, Vol.32, No.8, pp.490-496.

Yang, J., Yang, L. and Yang, N. (2014), "The factors affecting cross-border e-commerce development of SMEs: an empirical study", *Wuhan 13th International Conference on e-Business Proceedings*, Wuhan, 30 May-1 June, pp.12.

Yang, Z. and Shen, Q. (2015). "Current status and trend analysis of China's import cross-border e-commerce development", *Proceedings of the International Conference on Education Technology, Management and Humanities Science (ETMHS 2015)*, pp.133-137.

Yue, H., Wu, J., and Yao, L. (2017). "Analysis on the Development and Bottlenecks of China's Cross-Border E–Commerce", *Studies in Asian Social Science*, Vol.4, No.2, pp.26-35.

Zhang, D. (2019) "New cross-border e-commerce regulations". *China Business Law Journal,* available at: https://www.vantageasia.com/new-cross-border-e-commerce-regulations-2/ (accessed 02 August 2019)

Zhang, H. (2017), "Study on Cross-Border E-Commerce Logistics Optimization Platform based on Big Data", *Revista de la Facultad de Ingenieraí U.C.V.,* Vol.32, No.4, pp.329-335.

Table 1 – Base case (Fashion) – Yearly values

Uncertain factor	**Solution S+W**	**Solution D**	**Solution P+W**	**Solution P+H**
Product value	100 €/piece	100 €/piece	100 €/piece	100 €/piece
Transport cost	2 €/piece	20 €/piece	6 €/piece	6 €/piece
Inventory carrying cost	6 €/piece	1 €/piece	6 €/piece	1 €/piece
In-transit stock cost	2 €/piece	1 €/piece	1 €/piece	1 €/piece
Handling cost	2 €/piece	1 €/piece	1 €/piece	1 €/piece
Customs clearance cost	20 €/piece	20 €/piece	20 €/piece	20 €/piece
Stock-out cost	2.64 €/piece	3.85 €/piece	2.58 €/piece	4.5 €/piece
Item fill rate	97%	95%	97%	95%
Markup (on product value)	100%	100%	100%	100%
Demand	10,000 units	10,000 units	10,000 units	10,000 units
Total unitary logistics cost	**34.64 €/piece**	**46.85 €/piece**	**36.58 €/piece**	**33.5 €/piece**

Table 2 – Base case (Food) – Yearly values

Uncertain factor	**Solution S+W**	**Solution D**	**Solution P+W**	**Solution P+H**
Product value	5 €/piece	5 €/piece	5 €/piece	5 €/piece
Transport cost	0.5 €/piece	20 €/piece	3 €/piece	5 €/piece
Inventory carrying cost	1.25 €/piece	0.05 €/piece	1.25 €/piece	0.05 €/piece
In-transit stock cost	0.15 €/piece	0.1 €/piece	0.05 €/piece	0.05 €/piece
Handling cost	0.4 €/piece	0.05 €/piece	0.4 €/piece	0.05 €/piece
Customs clearance cost	0.5 €/piece	0.5 €/piece	0.5 €/piece	0.5 €/piece
Stock-out cost	0.381 €/piece	(0.26) €/piece	0.309 €/piece	0.49 €/piece
Item fill rate	97%	95%	97%	95%
Markup (on product value)	200%	200%	200%	200%
Demand	10,000 units	10,000 units	10,000 units	10,000 units
Total unitary logistics cost	**3.18 €/piece**	**20.44 €/piece**	**5.51 €/piece**	**6.14 €/piece**

Table 3 – Sensitivity analysis – Kuiper importance measure (Fashion)

	Solution S+W		Solution D		Solution P+W		Solution P+H	
Uncertain factor	**Beta (Ku)**	**Rank**	**Beta (Ku)**	**Rank**	**Beta (Ku)**	**Rank**	**Beta (Ku)**	**Rank**
Regulation change	0.4530	1	0.5944	1	0.4797	1	0.5003	1
Demand	0.0901	6	0.3601	3	0.0912	6	0.1011	5
Value of product	0.4202	2	0.4500	2	0.4101	2	0.4603	2
Markup	0.2104	3	0.0604	5	0.1033	5	0.1217	4
Transport cost	0.0401	7	0.0472	6	0.0602	7	0.0750	6
Inventory carrying cost	0.1102	5	0.0221	8	0.1500	4	0.0562	8
In Transit stock cost	0.0351	8	0.0311	7	0.0401	8	0.0621	7
Handling cost	0.0202	9	0.0201	9	0.0304	9	0.0503	9
Stock	0.1301	4	0.0802	4	0.1901	3	0.1302	3

Table 4 – Sensitivity analysis – Kuiper importance measure (Food)

	Solution S+W		Solution D		Solution P+W		Solution P+H	
Uncertain factor	**Beta (Ku)**	**Rank**	**Beta (Ku)**	**Rank**	**Beta (Ku)**	**Rank**	**Beta (Ku)**	**Rank**
Regulation change	0.4132	1	0.4467	1	0.4789	1	0.4914	1
Demand	0.0869	6	0.2700	3	0.0370	7	0.2102	3
Value of product	0.3302	2	0.3501	2	0.4010	2	0.3700	2
Markup	0.0903	5	0.0870	6	0.0601	5	0.0961	5
Transport cost	0.0711	7	0.0921	5	0.2902	3	0.1620	4
Inventory carrying cost	0.1403	4	0.0250	9	0.1700	4	0.0650	7
In Transit stock cost	0.0271	9	0.0740	7	0.0310	8	0.0510	8
Handling cost	0.0341	8	0.0401	8	0.0201	9	0.0361	9
Stock-out cost	0.2302	3	0.1102	4	0.0461	6	0.0820	6

Figure 1 – Research framework

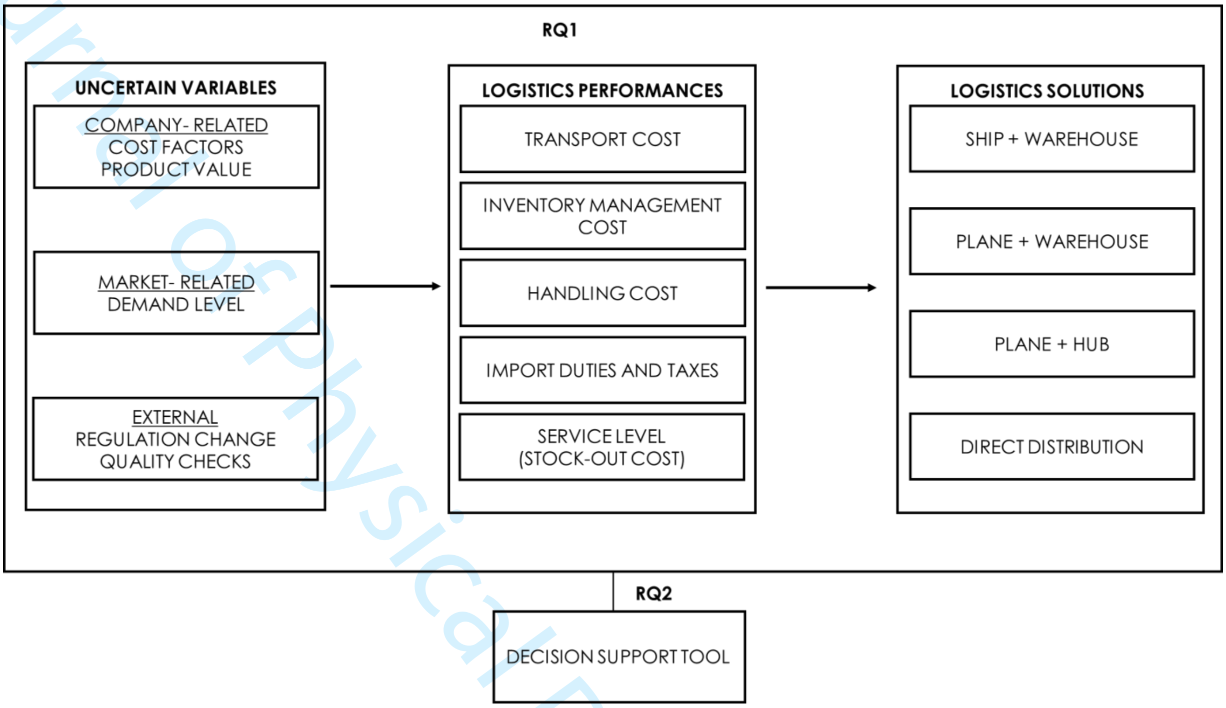


Figure 2- Model architecture

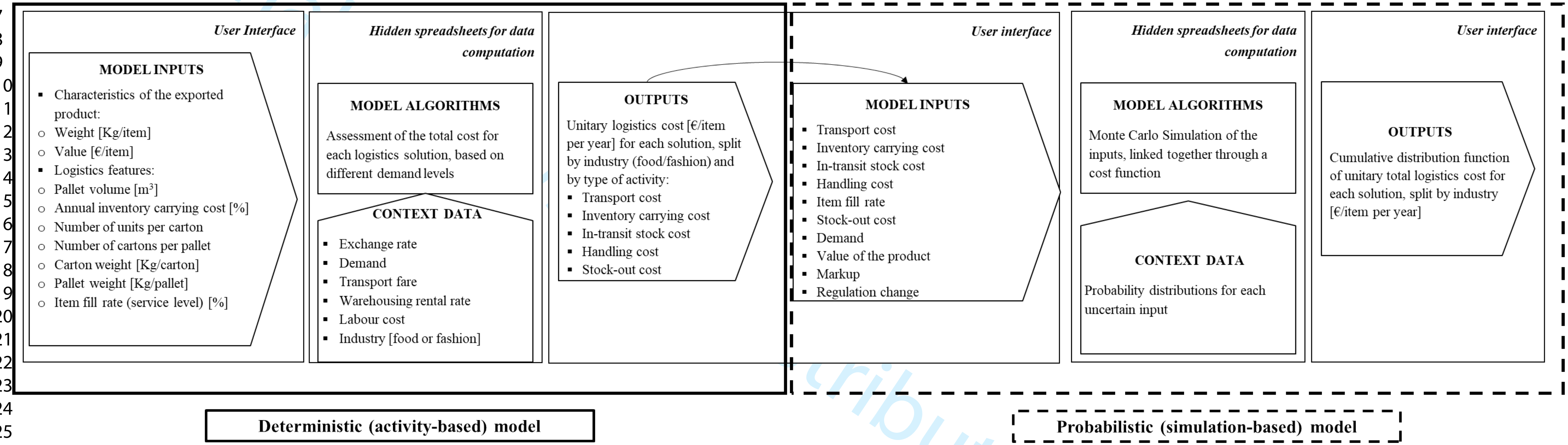


Figure 3 - PDFs of total unitary logistics costs for each solution (Fashion)

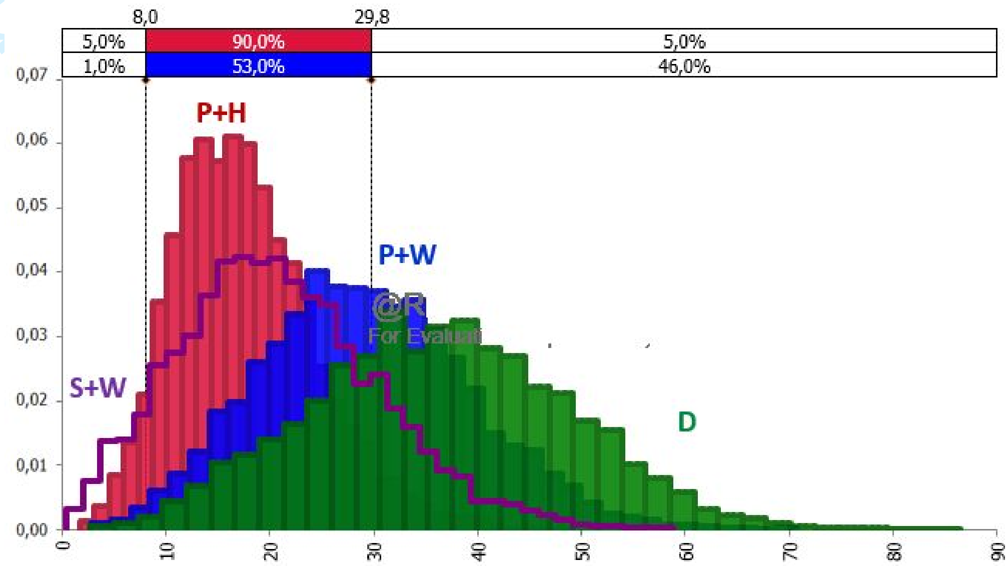


Figure 4 - PDFs of total unitary logistics costs for each solution (Food)

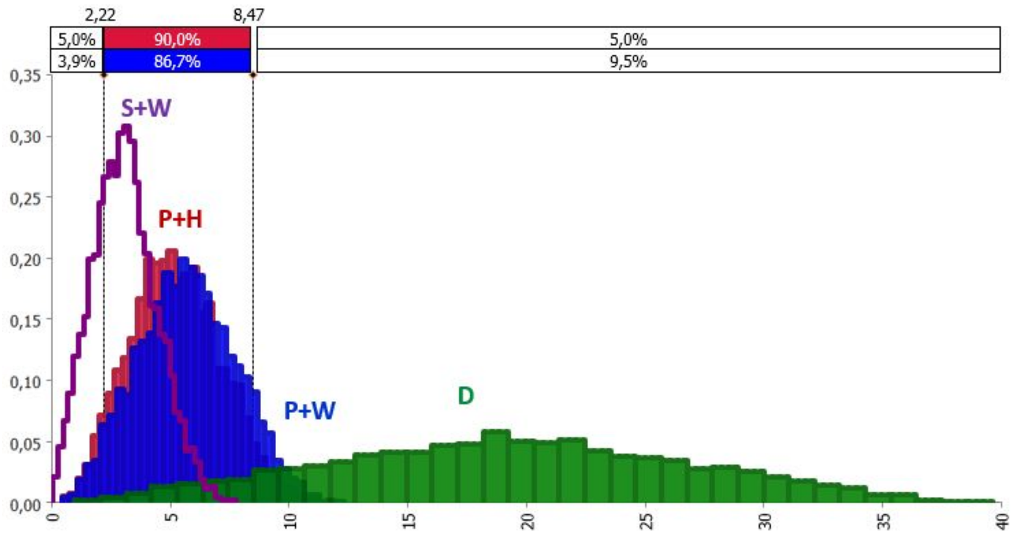


Figure 5 – Decision tree (Fashion)

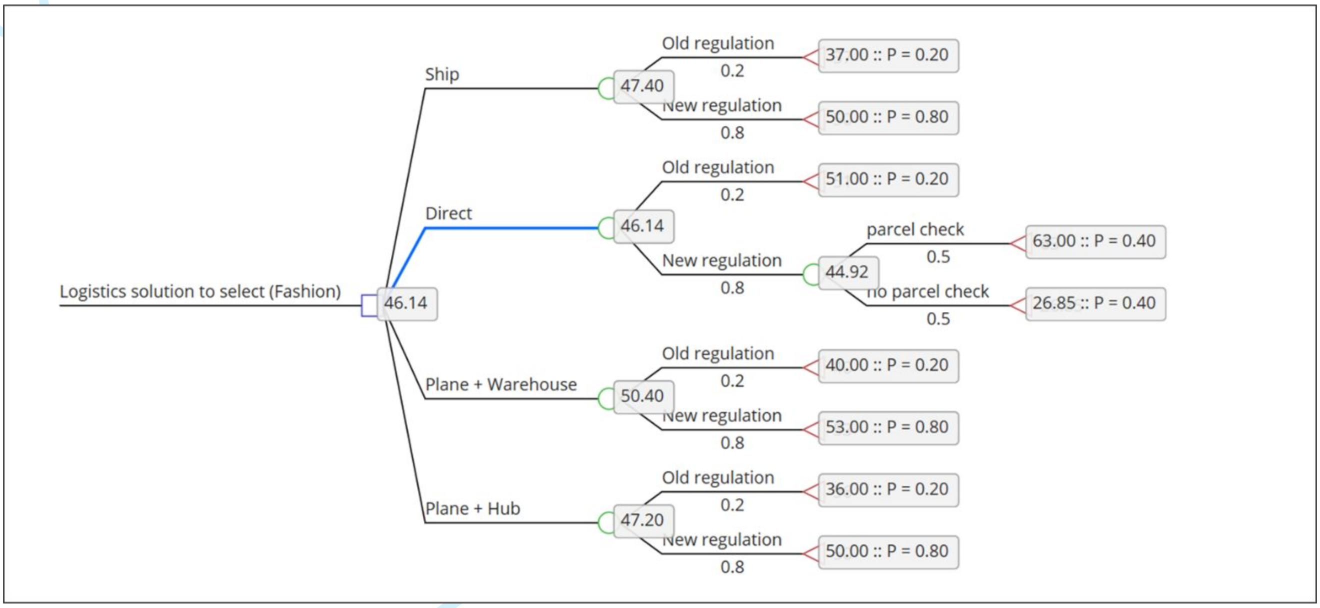
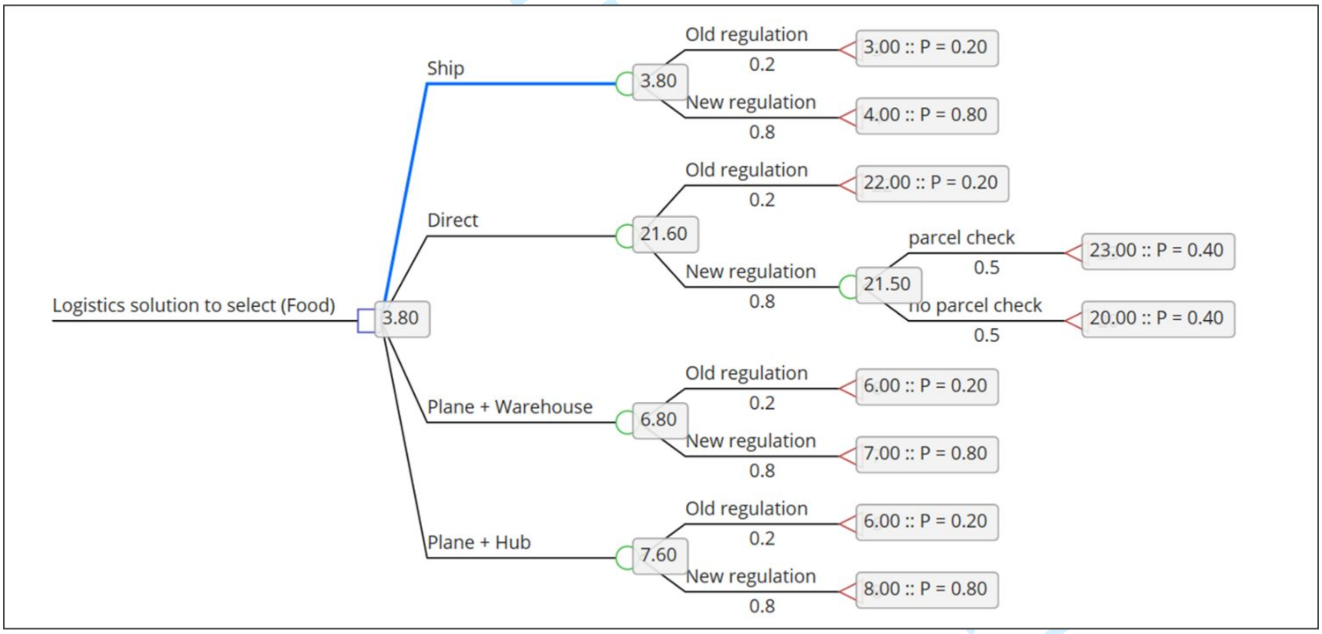


Figure 6 – Decision tree (Food)



Deterministic model – Main data and assumptions

The proposed model is composed as follows:

Inputs: these refer to (i) the characteristics of the exported product, e.g. product category, weight, variable production cost, and (ii) the logistics features, e.g. number of units per carton, number of cartons per pallet, service level expressed as item fill rate, location of the home country warehouse

The inputs can be inserted by the user and tailored to better reflect its condition. As an example, the input section for the presented fashion case is filled as follows

Input	Value
Weight (kg/unit)	0.25
Pallet volume (cubic meters)	1.152
Maintenance rate (Chinese warehouse)	0.3
Number of units per carton	3
Carton weight	0.2
Number of cartons per pallet	30

Context data: they refer to the external environment, e.g. demand, transport fares, warehousing costs;

The user can indicate whether (s)he wants to only serve first tier cities (Beijing, Guangzhou, Shenzen, Tianjin) or also second tier ones (Chongqing, Harbin, Wuhan, Shenyang,Changsha, Hohhot, Hefei, Shantou, Zhengzhou, Jinan, Zhuhai, Lhasa, Chengdu, Ürümqi, Changchun, Sanya, Fuzhou, Taiyuan, Dalian, Nanchang, Xiamen, Kunming, Xi'an, Tsingtao, Wuxi, Suzhou, Guiyang, Ningbo, Hangzhou, Lanzhou, Haikou, Nanjing, Nanning).

- **Demand**

The expected demand is allocated to each city proportionally to (1) the population of the city and (2) the GDP of the city. Both factors are assumed to have equal weights in the allocation formula reported below

$$\text{allocation of demand to city } (i) = 0.5 * \frac{population\ (i)}{\sum_{j=1}^{n} population\ (j)} + 0.5 * \frac{GDP\ (i)}{\sum_{j=1}^{n} GDP\ (j)}\ ; \text{ with n = number of served cities}$$

- **Cost data**

The main cost data included in the model are the average fares for: transport within the country of origin, international sea-freight, air-freight or express courier depending on the model, last mile by Chinese express courier, warehouse operating cost (related to the handling of containers from the terminal to the warehouse and to the administrative activities) and rent cost (related to the storage fee to be paid per ton stored in the Free Trade Zone warehouse), import duties and taxes, calculated depending on the industry and based on the Chinese CBEC taxation policy.

The data come from mixed sources: the transport fares within the country of origin and for the international route are collected through interviews with logistics operators. The data are combined, obtaining multiple observations of the average €/km fare for different points of origin and destination. These are clustered and the decreasing pattern of the €/km fare for different km ranges is calculated. The cost for the international express courier and the last mile delivery in China derives from secondary sources, i.e. the fares reported on the UPS and SF express couriers' websites. The rent, storage and unloading fee for the warehousing cost in China are retrieved from Chinese logistics service providers and refer to a warehouse location in Shanghai or Ghuangzhou

Computation algorithm: the final model's algorithm calculates the total costs as the sum of the single types of cost (transport, inventory carrying, in-transit stock, handling, customs, stock-out) for each solution. The calculation of the single components' cost depends on many variables.

As an example, we report the calculation procedure of the international transport cost by sea.

The structure of this cost is:

- Rental cost: the base price, which is made of the rental cost of the container and the travel cost from the origin port to the destination one

- Terminal Handling Charges (THC): a variable cost that is related to the activities to handle the containers in the ports;

- International Ship and Port Facility Security (ISPS): a variable cost, depending on the number of rented containers, which accounts for the security activities carried on at the terminal.

- Agency duty: a fixed cost related to the managerial activities needed to fulfil the service required.

The cost calculation procedure requires the determination of an optimal shipment frequency. Once this is calculated, the cost/kg of each shipment is calculated as follows

$$\textbf{\textit{Fare per kg}} = \frac{(rent\ and\ transport\ cost + THC + ISPS + unloading\ fee + transfer\ from\ terminal}{\max weight\ capacity\ of\ container} * (1+ \text{margin})$$

Therefore, the total international transport cost becomes

$$\textbf{\textit{International transport cost}} = \textit{Fare /kg * Annual demand [kg]}$$

Output: the output of the model is the unit logistics cost, split by type (transport, inventory carrying, in transit stock, handling, stock-out, customs and duties) per each solution.

Probabilistic model – Main data and assumptions

Inputs

In order to account for the effect of uncertainty this model takes the outputs of the previous one as inputs and adds other relevant uncertain factors. These are assigned the probability distribution reported in the table below. Please note that logistics costs are expressed as a percentage of product value. We ask that the demand is negatively correlated with unit transport cost and positively correlated to unit handling and inventory carrying cost during the simulation runs. The parameters are given the average value reported in Tables 1 and 2 of the paper. The minimum and maximum values of the triangular distribution are determined, for each case, as +/- 50% of the average. This range resulted from discussion with practitioners operating in the field and expert of the CBEC sector in China

Uncertain factor	**Probability distribution**
Regulation change	Bernoulli, p = 0.8
Parcel check	Bernoulli, p= 0.5
Demand	LogNormal
Value of product	Triangular
Markup	Triangular
Transport cost	Triangular
Inventory carrying cost	Triangular
In Transit stock cost	Triangular
Handling cost	Triangular
Stock-out cost	Triangular

Simulation

The simulations are run using @Risk, a Palisade software that works as an Excel plug-in. Using the Latin Hypercube method, 5.000 iterations are performed per each of the eight scenarios (four solutions and two industries)

Probabilistic sensitivity analysis

The simulated data are then inputted into Matlab software and processed using the kstest2.m function (Baucells and Borgonovo, 2013). This algorithm returns the ranking of the Kuiper sensitivity metric reported in Tables 3 and 4 of the paper