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Shippers' willingness to use flexible transportation services

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A B S T R A C T

Factors driving the choice of shipper firms for services of logistics service providers have long been recognized in the freight transportation literature. However, the willingness among shippers to choose *flexible* transportation services, where the service package can be adapted during planning and execution, has received less attention. In particular, little is known about the contextual circumstances under which shippers would be inclined to select such flexible transportation service. In this study, experimental scenarios and discrete choice modeling are used to investigate the willingness among shippers to use flexible transportation services. We estimate multinomial logit, mixed logit, and latent class models for a sample of nearly 200 global shipper firms and calculate willingness-to-pay measures for flexibility. The findings indicate that flexible services are essential in demand-volatile markets. Since logistics services may provide external flexibility for shipper firms, we also study which related internal flexibilities in supply chains drive these choices. In particular, our findings show that it is mainly the volume flexibility of shippers that mediates the choice of flexible transportation services.

1. Introduction

Traditionally, shipper firms have regarded transportation services – provided by logistics service providers (LSP)[1] – as a "commodity" or non-differentiated service that is sold primarily on the basis of its price (Coase, 1937). In recent decades, factors like price, time and reliability have also been the core attributes driving the choice of the shipper firms (Da Silveira, 2005; Voss et al., 2006). However, globalization and intensive competition among supply chains have made advances in supply chain management practices, resulting in emerging paradigms like outcome-driven supply chains, which aim to balance and tune cost and service parameters to the needs of end-customers (Melnyk et al., 2010). These changes have also forced LSPs to adapt their services to the needs of shipper firms, and LSPs have begun to offer more customized and differentiated services.

Recently, international LSPs have started to recognize their customers' need for *flexibility* of logistics services (see for example, DB Schenker, 2009; DHL, 2017) (Reis, 2014). For instance, DSV, the Danish provider of worldwide transportation and logistics services, has spread their European logistics network to >135 multi-user warehouses to provide customized solutions that allow their customers to respond quickly to their market changes by reducing or expanding their inventory levels at different locations in their supply chain network (DSV, 2019a). Mason and Nair (2013) report that LSPs' clients e.g., shipper firms, seek flexibility in the logistics services as a

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[1] Throughout this paper, whenever we use a Logistics service provider (LSP), we mean a company that offers an array of logistics services, including transportation, warehousing, forwarding, custom brokerage, cross-docking, return management, distribution of goods and logistics management services. In practice, that includes 3rd/4th Party Logistics (3PL/4PL) and Integrate Logistics Provider (ILP), among others.

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valuable competency for addressing uncertainties in their competitive markets. For example, Marken pharmaceutical company manages its fluctuating demand for drugs through an adaptive distribution strategy, supported by UPS (UPS, 2019). In this study, flexibility is defined as "the capability of a logistics system to provide possible changes in the service components adaptive to shippers' business needs at any point in time, before and after the departure of the freight/goods towards the destination" (Khakdaman et al., 2020). Although successful cases of the application of *LSP-driven flexible logistics services* exist (see case examples from DB Schenker (2019) for the retail/apparel industry and DSV (2019b) for automotive industry), the willingness among shipper firms to use LSP-driven flexible services remains an underexplored area.

While the major factors influencing shipper companies' choice of transportation services have long been identified in the ample literature on freight transportation, only a handful of studies incorporate the flexibility of transportation services as a service component, and none of them have examined *when and under what circumstances shipper firms are willing to choose the LSP-driven flexible logistics services.* Knowing more about the relevant shippers' characteristics e.g., their market environment, which includes, for example, demand volatility, would help LSPs understand to what extent their customers seek a flexible logistics service to address their challenges. Apart from common internal attributes of a service, designing a quality service package would also require a true understanding of its external attributes (Herrmann et al., 2000). A true understanding of shipper firms' business settings, e.g., levels of uncertainty, risk and vulnerability they face in their (everyday) decision-making for the end-to-end supply chain, as well as internal capabilities e.g., internal supply chain flexibilities such as volume flexibility, would help LSPs design customized service packages that truly address their customers' needs. We consider LSP-driven flexible services as an external flexibility for the shipper firms' supply chain (usually, the focal company of a supply chain), complementary to their internal flexibilities, i.e., volume, product, launch, sourcing and postponement flexibility. This study is among the first to explore the impact of these internal supply chain flexibilities on the shippers' choice of flexible transportation services.

In this study, we use discrete choice modeling (Ben-Akiva and Lerman, 1985) to examine the willingness among shipper supply chains to use flexible logistics services. We carried out a comprehensive discrete choice experiment among Global Fortune 500 companies (Fortune magazine, 2017) and major customer firms of the 40 largest global LSPs (Logistics Quarterly magazine, 2011). The main contributions of this study to existing literature are as follows: (i) we identify shipper firms' needs for LSP-driven logistics service flexibility, offering a comprehensive definition of flexible services covering both transportation and inventory management (ii) we show the importance of contextual factors of demand including external and internal factors, such as shippers' own flexibility in the supply chain (iii) we provide empirical evidence from a large, global sample of international supply chain leaders, where earlier studies have been limited in their geographical reach.

In the remainder of the paper, the research questions are discussed in Section 2, along with the associated literature review. Section 3 is dedicated to the research design and methodology, while the empirical results are discussed in Section 4. The final section provides the study's practical implications, conclusions and avenues for future research.

2. Research background

In freight transportation, it is usually the shippers who choose the mode of transportation and LSPs provide the service by booking transportation modes in advance i.e., using their own resources or those of other carriers (Coyle et al., 2011; Tryfleet, 2017). A recent review of the transportation service and mode choice literature concludes that almost all studies consider transportation cost, time and reliability to be the three core attributes of any transportation service, while flexibility is given little or no attention (Reis, 2014). Below, we briefly discuss the relevant literature that has led to our subsequent research questions.

Jeffs and Hills (1990) were the first to empirically identify transportation flexibility as an important factor, within the context of UK firms. Later, Matear and Gray (1993) considered flexibility in the form of the ability to respond quickly to problems, and confirmed its importance for shippers in the UK and Ireland. Norojono and Young (2003) defined flexibility as a function of trip frequency and rapid response to emerging problems, based on a study among a number of shippers in Indonesia that use rail freight services, and show the importance of service frequency and rapid response to problems as representatives of service flexibility. INRETS (2000) and Gruppo CLAS (2000) interviewed decision-makers in the freight transportation industry and recognized flexibility as an important factor to improve quality of intermodal transportation. Bolis and Maggi (2003) showed that flexibility is important to companies in Switzerland and Italy operating in a Just-in-Time (JIT) context and within the consumer goods industry, highlighting that, in modern logistics, goods can be stored while moving, but the importance of price and time are higher than flexibility. Grue and Ludvigsen (2006) conducted an extensive interview with 246 shipper companies using road and rail transport services. They found transportation flexibility as an important factor in mode choice tasks of the intra-European freight transportation flows. The study by Danielis and Marcucci (2007) considered flexibility as the LSP's ability to change transportation service components before finalizing the booking of the service. Their study highlighted the significance of transportation cost and flexibility in all transportation modes, while this was not the case for transportation time and reliability. Rotaris et al. (2012) incorporate flexibility in their choice experiment for unimodal and intermodal transportation and conducted the study among UK. Their results confirm the significance of flexibility only at a 10% confidence level. Although the concept was not included in their choice tasks, Arencibia et al. (2015) defined flexibility as the ability of LSPs to perform last-minute changes in shipments.

According to Khakdaman et al. (2020), flexibility could include changes in the destination, increasing or decreasing the transit time, aggregation or disaggregation of shipment quantity and so on" (see the systematic review by Jafari (2015) for further details). The definition of flexibility by Khakdaman et al. (2020) goes beyond Swafford et al. (2006) and Ben-Akiva et al. (2008) and has not yet been applied in any transportation service choice study, although its importance from a wider logistics perspective has already been emphasised by Danielis and Marcucci (2007). In addition, the scale of the existing studies is limited to a geographical location and does not reflect a global perspective on the value of flexibility for shipper firms. Furthermore, the existing studies fail to include the choice of shippers in different business and market circumstances, to demonstrate when and in what circumstances shippers are willing to utilize competencies of LSP-driven flexible services.

Our first research question (RQ) focuses on how shipper firms value the flexibility of transportation services:

RQ1: *"How strong is the willingness of shipper firms to use LSP-driven flexible logistics services?"*

While we expect that willingness to be significant, we do not think that its importance will be the same for all shippers. Considering a large body of literature about preference heterogeneity of shippers to use transportation services, shippers make trade-offs among different attributes of the logistics service based on their supply chain context. The contextual factors could mainly include business and market environment, as well as supply chain capabilities.

With regards to the first contextual category, scholars usually consider two common business settings, namely volatile business setting (i.e., customized setting) and (relatively) stable business setting (i.e., commoditized setting) (Coltman and Devinney, 2013). Two major types of uncertainties exist for a supply chain operating in the volatile business setting: demand volatility and supply uncertainty (Angkiriwang et al., 2014). Demand volatility in particular is considered to be the most important type of supply chain uncertainty (Chung et al., 2004; Pujawan, 2004) and the key challenge to improve their supply chain competitiveness and sustain a robust and reliable supply chain (MHL news, 2011). Demand volatility indicates the probabilistic nature of demand realization time, quantity, types and locations. Pujawan (2004) emphasized that demand volatility could be: in the form of forecast errors (Schmitt, 1984), changes in current orders of customers (Van Kampen et al., 2010; Wong et al., 2011), uncertainties and changes in the future customer demand for a product/service mix (Van Donk and van der Vaart, 2005; Khakdaman et al., 2015), and demand fluctuations due to the competitors' marketing promotions (Wong et al., 2011). Demand volatility is seen as the underlying factor that sometimes creates supply and process uncertainties via its bullwhip effect.

With regards to the first research question, we examine the willingness among shippers to apply LSP-driven flexible services in different market settings:

RQ2. *"How different is the choice of shippers with regard to LSP-driven flexible logistics services when they operate within volatile and stable demand business settings?"*

Apart from external business and market setting, internal supply chain capabilities can also affect a shipper's choice of flexible services. Malhotra and Mackelprang (2012), who investigated the complementarity of internal and external flexibilities in the supply chain, emphasize that shipper's investment on internal modification, mix or new product flexibility capabilities to improve overall delivery and service level will only pay off when it is accompanied by external supplier and logistic flexibility capabilities and, importantly in our case, vice versa. As such, our study also looks at the role of the internal supply chain capabilities of shippers in their choice of LSP-driven flexible services.

Martínez Sánchez and Pérez Pérez (2005) identified different types of supply chain capabilities in terms of various flexibility types within a supply chain. Taking their research into account, we included five operational flexibility types of shipper supply chains i.e., product, volume, postponement, sourcing and new product development (launch) as the internal flexibilities of the focal company's supply chain. *Volume* flexibility is a firm's ability to effectively increase or reduce aggregate production in response to customer demand. *Product* (or mix or product-mix) flexibility is a firm's ability to handle changes in the product mix and product design in response to customer demand. *Launch* (or new product development) flexibility is the ability to rapidly introduce many new products and product varieties. *Sourcing* flexibility is the ability to find another supplier for each specific component or raw material. *Postponement* flexibility is the capability of keeping products in their generic form as long as possible, in order to incorporate the customer's product requirements in later stages (Martínez Sánchez and Pérez Pérez, 2005).

We examine the role of the various types of internal flexibilities in a shipper's decision to select LSP-driven flexible services in different business environments. As such, our third research question is,

RQ3. *"Which shippers' internal supply chain flexibilities mediate the effect of demand-volatile market setting on their choice of LSP-driven flexible logistics services?"*

3. Research design and method

To answer our research questions, we carried out a comprehensive choice experiment among major global firms. We built on the Thomson Reuters business classification (2012) to cover different industry types and sampled from global fortune 500 companies (Fortune magazine, 2017) and major customers (firms) of the 40 largest LSPs worldwide (Logistics Quarterly magazine, 2011).

In the following section, we discuss the design of our choice experiment within the context of synchromodal logistics services and its implementation among global supply chain leader firms.

3.1. Experiment design and implementation

We conducted discrete choice experiments (Ben-Akiva and Lerman, 1985) to elicit shippers' preferences and test the impact of firm-difference factors. We designed a comprehensive experiment to test the main effects, i.e., willingness to choose flexible services (RQ1),

Table 1
Logistics service attributes, their definition and levels for alternative choices.

Attributes	New service		Current service
	1 (premium)	2(budget)	
Door-To-door *Cost* ($): Total amount of money that the shipper pays to the LSP for shipping one TEU (20-foot container) from origin to destination (adapted from Arencibia et al., 2015).	+1% +2% +4%	Current level −1% −3%	Current level
Door-To-door *Time* (days): Duration from the shipment's first origin to the final destination (adapted from Arencibia et al., 2015).	−10% −20% −30%	+20% Current level −20%	Current level
Control (service level): The authority level of the shipper to decide about its preferred transportation mode and route	No control Low	No control Low	Current level
Flexibility (service level): The capability to fulfil a shipper's required changes in service components before finalizing the booking of logistics service and even while goods are on their move toward the destination. Examples of these changes include change in delivery time/location, shorten or extend lead times, consolidate or deconsolidate volume/variety via warehouses or cross-docking terminals (mode-volume switch locations).	Medium High	No flexibility Low Medium	Current level
Reliability (% delivery times): The on-time delivery of freight/goods at the destination (adapted from Arencibia et al., 2015).	+10% +15% +20%	−10% Current level +10%	Current level
Value-added services (VAS) (service level): Ancillary services, including tracking and tracing, customs, handling and packaging offered by the LSP beyond the main logistics service (Roso et al., 2009).	Medium High	No VAS Low Medium	Current level

the shipper firm's market setting effect, i.e., willingness to choose flexible services in different market setting (RQ2) and the mediator role of shipper firm's internal flexibilities i.e., volume flexibility, on their willingness to use flexible servicesin different market settings (RQ3). In the choice experiment, we considered the common attributes of a logistics service, such as cost, time, reliability and flexibility. Necessary for the flexible logistics context, we added the *control* attribute, since shippers will have to relinquish their authority as far as the selection of the transportation mode and route is concerned. We also considered Value-added services (VAS) as ancillary services beyond the main logistics service. The definitions of attributes and their levels are shown in Table 1.

In the next step, we needed to consider alternatives with different flexibility grades to examine trade-offs. Consistent with our definition of flexibility discussed above, we adopted a mode-abstract approach to our choice problem. In real-world terms this implies flexible operations by LSPs as developed recently under the idea of synchromodal systems (for further details, see Van Riessen et al., 2015; Behdani et al., 2016; Tavasszy et al., 2018, and others). Transportation options are presented as service packages and not as modes of transport. We considered two service alternatives, budget and premium, representing low and high levels of flexibility, respectively. We also added the *current option* alternative to refer to the service the firm is currently using, to allow for the option of shippers being unwilling to use the other two alternatives.

As depicted in Table 1, each synchromodal alternative has 6 attributes, with two or three levels. Cost, Time and Reliability are reflected with positive (increase) or negative (decrease) percentage compared to the current logistics service the shipper is using. The attribute levels for Control, Flexibility and VAS are constructed based on the service-level concept for attributes such as flexibility and frequency applied in Danielis and Marcucci (2007) and Arencibia et al. (2015). Consistent with Tongzon (2009), we considered *high level* of control for the current option alternative, since 78% of shippers in our sample regarded themselves, rather than their LSPs, as the main mode selector. On the other hand, control for synchromodal options has the two service-levels of *Low* and *No control*, the latter indicating that decisions regarding transportation mode and route will be made by the LSP alone. *Low level* of control means that the LSP will still have the exclusive authority to make decisions regarding transportation mode and route, but would consult with the shipper if needed. Flexibility has the four service levels of *High, Medium, Low* and *None*. A *High* flexibility grade means that the logistics service is highly flexible to adapt to the shipper's required changes in terms of delivery time window, lead time, freight volume (de) consolidation, destination, etc. When the service level goes from high to low, the number of LSP-approved changes to the service components is reduced proportionately, i.e., three, two and one approved changes to the service components for a high, medium and low level of flexibility. VAS also has four service levels, *High, Medium, Low* and *None,* which are different in terms of the quantity of value-added services offered to the shipper firm.

The characteristics of the reference alternative i.e., the current service, are defined in a way similar to the studies that elicit responses based on differences with a base case, in line with the DC-RUM approach (see e.g., Arencibia et al., 2015, for a similar case). With regard to cost, time and reliability, the attribute levels of the reference alternative are set to zero (no change) to be comparable to the percentage changes in the synchromodal alternatives (same approach as the one used by Arencibia et al., 2015). For example, when a synchromodal alternative time is −20%, that means that the door-to-door transportation time is 20% shorter than that of the current alternative. To apply the same logic for the new variables, the base service level for flexibility and VAS attributes of the reference alternative was set to zero. Shippers were asked to compare current flexibility (and VAS) of the reference alternative with *low, medium and high* level of flexibility (or VAS) of a synchromodal alternative. As stated above, with regard to the control attribute, we set it to *high* for the reference alternative, since 78% of shippers indicated at the start of the survey that they are the mode chooser, meaning that

Table 2
Example of a choice task.

Attributes	New service		Current service
	1	2	
Door-To-door transportation Cost ($)	+2%	−1%	
Door-To-door transportation Time (days)	−30%	+20%	
Control over transportation mode and route (service level)	Low	No control	
Flexibility to adapt shippers' required changes (service level)	High	Low	
Reliability in on-time delivery (% delivery times)	+10%	Current level	
Value-added services: tracking, customs etc. (service level)	Medium	Medium	

Table 3
Demographics of the respondents and their firms.

Respondent Position	%	Company size (#employees)	%	Annual Revenue	%	Economic sector	%
C-level/Top Management	21%	<99	4%	<$100 Mn	10%	Basic Materials	12%
Senior/Middle Management	79%	100–249	7%	$100–250 Mn	8%	Consumer Cyclicals	18%
		250–999	7%	$250 Mn-1 Bn	10%	Consumer Non-Cyclicals	19%
		1000–9999	18%	$1–10 Bn	23%	Energy	6%
		10000–49999	28%	$10–50 Bn	27%	Healthcare	11%
		> 50,000	36%	> $50 Bn	22%	Industrials	7%
						Technology	16%
						Telecom Services	8%
						Utilities	2%
						Others	0%

they have high control over the modal selection. Thus, when they compare the control attribute of their current service with the synchromodal alternatives, they compare their high level of control with a zero or low level of control in synchromodal services.

In the next step, we design the choice set, using the *efficient* experiment design method (Kuhfeld et al., 1994; Rose and Bliemer, 2009) which requires a smaller and therefore more feasible choice set, instead of a full fractional factorial design set that includes all the possible choices (Rose and Bliemer, 2009). To construct a D-efficient design experiment, priors for parameters of the model were obtained via a pilot study (Appendix A). Using these priors, we applied the Ngene software (ChoiceMetrics, 2009) to construct an optimal design with six choice tasks, conditioned on the two business environments of volatile demand markets and stable demand markets. In the survey, we described the volatile demand market as a business setting where products have relatively unstable and/or unpredictable demand with a shorter life cycle, for instance mobile phones. The stable demand market is explained as a business setting where products have predictable and stable demand with long life cycle, for example toothbrushes. Table 2 shows an example of a choice task. To avoid a complex choice experiment, we made some assumptions regarding other important attributes of a logistics service, including rules and regulations, frequency, security and safety. We assumed that (i) international rules and regulations allow for flexible logistics arrangements, (ii) the service frequency is the same as the current transportation service of shippers, and (iii) goods will be delivered without any change in damage or loss compared to the existing transportation option. We communicated the above assumptions to the respondents in the choice experiment survey.

The logistics service choice sets were included in a web-based survey questionnaire using the Surveygizmo platform (Surveygizmo, 2017), in which we first introduced transportation options with two clarifying examples about the flexibility offering. Next, we asked about the respondents' sociodemographic information (e.g., position, job function) and their company's operations (e.g., industry type, size (number of employees), annual revenue and product types; and supply chain's internal flexibilities such as product flexibility, volume flexibility, etc.). Using a Likert scale from 1 to 5 (1: Very low, 2: Low, 3: Medium, 4: High and 5: Very high), we asked respondents to indicate the level of internal flexibilities of their supply chains. Then, we asked them to choose one of their goods/materials being shipped by containerized transportation and to choose their preferred logistics service in the six choice tasks based on the demand volatility/stability characteristics of the chosen product.

To build up our sample, we focused on firms whose operations affect the global production and trade of goods, including firms with high overall revenues and firms that manage large freight flows. The former type of companies were identified via the Global Fortune 500 list (Fortune magazine, 2017), while the latter category was identified via the list of major customer firms of the 40 largest LSPs worldwide (Logistics Quarterly magazine, 2011). This magazine presents between 5 and 10 leading customer shippers for each LSP. Combining these lists and correcting for overlaps, 556 unique companies were identified.

In the next step, we identified who we should contact for the stated preference (SP) experiment. Since moving towards exploiting benefits of LSP-driven flexible services could be a strategic decision that affects long-term contracts of shippers with LSPs, we targeted both top (c-level) and senior/middle level managers responsible for leading various supply-chain-related functions (from procurement to manufacturing to distribution). In total, 2752 managers (e.g., vice-president, director of logistics, supply chain manager) were approached. The final survey was e-mailed to 2490 respondents between December 2017 and February 2018 (the remaining 262 executives participated in the pilot study). After three follow-up rounds, 296 usable responses were collected, providing 1776 usable SP observations from 194 unique firms, representing a response rate of 12% and 39% among individuals and companies, respectively.

Table 3 shows the profiles of the respondent companies.

3.2. Econometric models

To analyze the stated preferences, we assumed that the managers selected LSP-driven flexible services based on their perceived utility for each choice. This assumption is based on the random utility maximization paradigm (McFadden, 1974) and similar to the main portion of applications of discrete choice modeling. We first apply the classic multinomial logit (MNL) model (Ben-Akiva and Lerman, 1985), in which the utility of logistics service choice *i* perceived by the decision-maker *k* can be expressed as:

$$U_{ki} = V_{ki} + \varepsilon_{ki} \tag{1}$$

where

$$V_{ki} = \beta_1 CONTROL_{ki} + \beta_2 COST_{ki} + \beta_3 FLEXIBILITY_{ki} + \beta_4 RELIABILITY_{ki} + \beta_5 TIME_{ki} + \beta_6 VAS_{ki} \tag{2}$$

In (1), V_{ki} is the systematic part of the U_{ki} and represents a function of different observed attribute levels of the logistics service shown in (2), and ε_{ki} is the error term representing unobserved factors by the analyst and randomness in the choices of individual *k*. The MNL model assumes independent ε_{ki}'s across different choices and follows a Gumbel distribution with location parameter 0 and scale parameter 1 (McFadden, 1974). In (2), β_i's are coefficients for the alternative specific variables, and they are the same across all individuals. The boldface variables are vectors of independent variables for alternative *i* of the decision-maker *k*. Given a choice set S, the probability of selecting logistics service choice *i* is

$$P_i = \frac{exp(V_i)}{\sum_{s \in S} exp(V_s)} \tag{3}$$

While MNL assumes fixed parameters across individuals, Mixed logit (ML) model assumes individual-specific parameters to capture within-subject correlation, recognizing taste heterogeneity *among* individuals. The individual-specific parameters have the same choice probabilities, like Equation (3) (with individual-specific β_i's), and are assumed to draw from a probability distribution with a joint density function $f(\beta, \theta)$, where θ specifies the distribution of $\beta = (\beta_1, \cdots, \beta_6)$ as parameters to be estimated. In the case of a normal distribution, the β_i s are the means, and the significance of their variance accounts for existence of heterogeneous preferences. In our modeling, we do not need to include an intercept term, e.g., γ_i in (2); because of the abstract mode approach, no alternative-specific effect or "brand effect" is expected (Train, 2009). However, this is not the case for the *current option* alternative, which requires an intercept variable to model its utility function.

3.2.1. Interaction model

In addition to direct effects, interaction effects can be applied to identify the impact of shippers' specific characteristics on their choice. For instance, the volatility of the market demand will impact shippers' decisions on the choice of flexible services. Taking products with volatile demand characteristic as an example, the expected utility including demand-volatile market interaction terms can be represented as:

$$\begin{aligned} V_{ki} = {} & \beta_1 CONTROL_{ki} + \beta_2 COST_{ki} + \beta_3 FLEXIBILITY_{ki} + \beta_4 RELIABILITY_{ki} + \beta_5 TIME_{ki} + \beta_6 VAS_{ki} + \alpha_1 CONTROL_{ki} DV_k + \alpha_2 COST_{ki} DV_k \\ & + \alpha_3 FLEXIBILITY_{ki} DV_k + \alpha_4 RELIABILITY_{ki} DV_k + \alpha_5 TIME_{ki} DV_k + \alpha_6 VAS_{ki} DV_k \end{aligned} \tag{4}$$

where DV_k represents the demand volatility of shipper *k*, and the interaction coefficients, α_i, capture the potential effect of shipper's demand volatility on their perceived utility of a flexible service alternative. It may be clear that the impact of other supply-chain-specific variables could be examined in the same way.

3.2.2. Mediation model

To determine how an independent variable (e.g., demand volatility) affects a dependent variable (e.g., choice of flexible services), a commonly employed test for mediation process is one proposed by Preacher et al. (2007). We examine whether the effect of shipper's demand volatility (our independent variable) on their perception of flexible logistics service (our dependent variable) is mediated by the shipper's internal supply chain flexibility (our proposed mediator) e.g., volume flexibility. To test for mediation, we need to perform three steps: (i) assess the impact of independent variable on the mediator variable, (ii) regress the dependent variable on both independent variable and the mediator variable, and (iii) test the indirect effect of the independent variable on the dependent variable via the mediator variable by applying the previous two steps (Preacher et al., 2007). The first and second steps are shown in models (5) and (6), respectively.

$$Volume\_flexibility_k = \gamma_0 + \gamma_1 DV_k + \varepsilon_k \tag{5}$$

$$V_{ki} = \beta . Main_{effects_k} + \alpha_1 FLEXIBILITY_{ki} DV_k + \alpha_2 FLEXIBILITY_{ki} Volume\_flexibility_k \tag{6}$$

In (5), γ_1 measures the impact of shipper's demand volatility on their decision to build volume flexibility in their supply chain. This effect could be easily measured via a simple linear regression. Model (6) is an MNL interaction model similar to (4), in which β is the

Table 4
MNL Estimation results for the main study.

Variable	Main effects model	
	Coefficient	Std. error
Current option	0.435***	4.21
Cost	−10.28***	−5.26
Control	0.863***	2.87
Flexibility	0.382***	3.23
Reliability	0.692	1.50
Time	−1.047***	−4.58
VAS	0.153	1.10
Number of responses	1776	
Number of respondents	296	
Log-likelihood	−1914.267	
McFadden's R^2	0.127	

Note. ***p < 0.01, **p < 0.05 and *p < 0.1 for statistical significance.

Table 5
Coefficients for the Mixed Logit model.

Variable	Main effects model		
	Coefficient	Std. error	Relative importance
Current option	0.423	0.129***	16%
Control	0.901	0.203***	7%
Cost	−10.4	2.05***	28%
Flexibility	0.363	0.136***	14%
Reliability	0.664	0.482	
Time	−1.09	0.277***	21%
VAS	0.141	0.152	
Standard Deviation for random effects			
Flexibility	0.677	0.332*	
Number of responses	1776		
Number of respondents	296		
Log-likelihood	−1673.26		
McFadden's R^2	0.237		

***p < 0.01, **p < 0.05 and *p < 0.1 for statistical significance.

coefficients' vector capturing the main effects, and α's are interaction coefficients. Together, γ_1 and α_2 examine the existence, strength and significance of indirect effect of DV_k (shipper's demand volatility) on V_{ki} (perceived utility of having a LSP-driven flexible services) via *Volume_flexibility*$_k$ (volume flexibility of shipper's supply chain). According to Preacher et al. (2007), $\widehat{\gamma}_1\widehat{\alpha}_2$ indicates the point estimate of this indirect effect, which can be tested for statistical significance in two ways. The first way involves the application of a z-test in which the standard error of the indirect effect can be approximated by

$$SE_{\widehat{\gamma}_1\widehat{\alpha}_2} = \sqrt{\widehat{\gamma}_1^{\,2} s_{\alpha 2}^2 + \widehat{\alpha}_2^{\,2} s_{\gamma 1}^2} \tag{7}$$

In (7), s_γ^2 and s_α^2 represents the standard error of the model coefficients γ and α, respectively. Secondly, bootstrapping can be applied to derive a confidence interval of the indirect effect. This confidence interval, if it does not include zero, indicates the significance of the mediation model. We applied both methods in our data analysis.

3.2.3. Latent class analysis

While the ML models already address the three research questions, it is worthwhile also to consider a Latent Class (LC) modeling approach (Kamakura and Russell, 1989) to capture unobserved heterogeneity and the potential impact of mediators. The basic assumption in LC is that the underlying heterogeneity in the parameters is discrete rather that continuous. Furthermore, LC modeling makes it possible to allocate individuals to classes, which allows for a better behavioral interpretation of results (Greene and Hensher, 2003; Hess et al., 2008) from both a policy and marketing perspective. We estimate the latent class model using the approach of Kamakura and Russell (1989). In order to determine the optimal number of classes, we applied two common fitness measures: the Akaike Information Criterion (AIC) and the Bayesian Information Criterion (BIC) (Bhat, 1997; Boxall and Adamowicz, 2002) as

Table 6
Interaction model for demand volatility and the choice of flexible services.

Variable	Main effects model		Model with interactions	
	Coefficient	Std. error	Coefficient	Std. error
Current option	0.423	0.129***	0.399	0.125***
Control	0.901	0.203***	0.592	0.203***
Cost	−10.4	2.05***	−10	2.14***
Flexibility	0.363	0.136***	0.495	0.133***
Reliability	0.664	0.482	0.458	0.519
Time	−1.09	0.277***	−1.12	0.257***
VAS	0.141	0.152	0.315	0.163**
Demand volatility * Current option			−0.0299	0.125
Demand volatility * Control			0.234	0.335
Demand volatility * Cost			1.15	2.14
Demand volatility * Flexibility			0.246	0.119**
Demand volatility * Reliability			−0.363	0.519
Demand volatility * Time			−0.18	0.257
Demand volatility * VAS			0.335	0.163**
Standard Deviation for random effects				
Flexibility	0.677	0.332**	0.561	0.219**
Number of responses	1776		1776	
Number of respondents	296		296	
Log-likelihood	−1673.26		−1655.715	
McFadden's R^2	0.237		0.245	

***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$ for statistical significance.

follows.

$$AIC = -2LL + 2M \tag{8}$$

$$BIC = -2LL + MlnN \tag{9}$$

where *LL* is the convergence value of log-likelihood function, expressing the fit with modelled and observed choice probabilities; *M* is the number of parameters in the model and *N* is the sample size. According to Walker and Li (2007), *BIC* is superior to *AIC*, since *BIC* is stricter in imposing a penalty for a larger number of parameters in the LC models.

4. Empirical results

4.1. Results of the MNL and ML models

The results of estimating the MNL and ML models (using Biogeme[2] software release 2.0 (Bierlaire, 2003)) are shown in Tables 4 and 5, respectively. In the MNL model, all parameters have the expected sign (i.e., positive utilities for increases in control, flexibility, reliability and VAS, and negative utilities for increases in cost and time). The estimated values of cost, time, control and flexibility are significant. The estimated value of the alternative-specific constant (ASC) for the current transportation service is positive and significant, indicating that some shippers may be biased towards their current choice. The estimated value of reliability is not significant at 10% confidence level (although it is significant at 13% level). This could be due to the small range of attribute levels defined for reliability that failed to attract (a sufficiently large proportion of) decision-makers. However, the LC analysis shows that the estimated value of reliability is significant for a large-size class of shippers (see Section 4.2 for more details).

Table 5 shows the results of the estimation of the main effects ML model. All parameters have the expected sign (e.g., increases in time and cost reduced utilities, and increases in control, flexibility, reliability and VAS raised utilities). While cost, time and control are significant attributes of the logistics service choice, our attention and interest is drawn towards the significant role *flexibility* plays in the choice of a logistics service. This addresses RQ1. The relative importance of attributes shows that, apart from cost and time as main classic contributors to the utility of shipper firms, the flexibility of the logistics service emerges as the third largest contributor to the shippers' utility. The estimated value of the ASC for the current transportation service is significant and positive, quantifying the inertia of shippers towards changing their current logistics services or transportation modes.

Although the main effects model reveals a preference for flexible services, it does not explain when they are willing to use them.

[2] We applied Biogeme standard settings that are quite common and well-documented. For instance, Biogeme assumes a normal distribution to estimate the random parameters in ML models. We used 1000 Hess-Train draws as one of the most common approaches.

Table 7
Interaction model for stable demand and the choice of flexible services.

Variable	Main effects model		Model with interactions	
	Coefficient	Std. error	Coefficient	Std. error
Current option	0.423	0.129***	0.399	0.125***
Control	0.901	0.203***	0.592	0.203***
Cost	−10.4	2.05***	−10	2.14***
Flexibility	0.363	0.136***	0.495	0.133***
Reliability	0.664	0.482	0.458	0.519
Time	−1.09	0.277***	−1.12	0.257***
VAS	0.141	0.152	0.315	0.163**
Stable demand * Current option			0.0299	0.125
Stable demand * Control			−0.234	0.335
Stable demand * Cost			−1.15	2.14
Stable demand * Flexibility			−0.246	0.119
Stable demand * Reliability			0.363	0.519
Stable demand * Time			0.18	0.257
Stable demand * VAS			−0.335	0.163**
Standard Deviation for random effects				
Flexibility	0.677	0.332**	0.402	0.281
Number of responses	1776		1776	
Number of respondents	296		296	
Log-likelihood	−1673.26		−1655.715	
McFadden's R2	0.237		0.245	

***p < 0.01, **p < 0.05 and *p < 0.1 for statistical significance.

Conditioning the choice tasks on volatile and stable markets helps us determine whether supply chain managers perceive different utilities under these circumstances. In the interaction model, we find that shippers operating in volatile markets are predominantly willing to use flexible services (see Table 6, where the interaction term is significant). On the other hand, shippers operating in stable markets favor an undifferentiated logistics service that is efficient enough to address their logistical needs (see Table 7). The difference between these two models highlights the critical role *context* plays in the choice of flexible services.

The data we collected about the characteristics of the shippers' supply chain in the first part of the survey allowed us to determine whether the impact of demand volatility on their choice of flexible services is driven by their internal supply chain flexibilities, such as volume flexibility. As stated in Section 3.1, we measured the level of internal flexibilities of shippers using a Likert scale from 1 to 5 (1: Very low, 2: Low, 3: Medium, 4: High and 5: Very high). For ease and robustness of interpretation, we considered higher scores in the volume flexibility measures (i.e., Likert scales of 4 and 5) as an indicator of there being enough volume flexibility in the shippers' supply chain, dividing the respondents into two groups, enough (or high) volume flexibility and not enough (or low) volume flexibility, and coded them with +1 and −1, respectively, in the dataset for model estimation. Table 8 (Model with interactions (1)) shows the interaction model where only demand volatility and volume flexibility have a significant impact on the managers' choice of flexible services. In particular, when controlling for volume flexibility, shippers operating in volatile (versus stable) markets have a greater preference for flexibility in their logistics service. In addition, when controlling for a volatile market setting, managers with volume flexibility in their supply chain nodes experience higher utility when exploiting LSP-driven flexible services.

Other internal supply chain flexibilities, however, such as product, launch, sourcing and postponement flexibilities, do not play a significant role in the decision to use LSP-driven flexible services (see Appendix B). As an illustration, the interaction model (2) in Table 8 shows an example of including interaction terms with product flexibility resulting in insignificance of the interaction terms (see further discussions in Section 4.2 and Appendix B).

As explained in Section 3.2.2, we need to test for the mediation effect to address RQ3. Firstly, we applied a simple linear regression (i.e., Ordinary Least Squares regression) to test the direct impact of shippers' demand volatility on their volume flexibility. Table 9 (direct effects) shows the results where shippers operating in demand-volatile markets are more in need of building enough volume flexibility in their supply chain. This is supported by Jack and Raturi (2002), who argue that the main reason and driver of building volume flexibility in a supply chain is the existence of volatile demand. When demand is stable, however, supply chain managers do not need to invest in building volume flexibility capabilities. In the second step, we tested the impact of shippers' volume flexibility on their perceived utility of choosing flexible services. As Table 9 demonstrates, the impact of shippers' volume flexibility is significant. The last step involved testing for mediation via z-test and bootstrapping. As shown in the second part of Table 9 (indirect effects), the z-test is applied to test the significance of the indirect effect of shippers' demand volatility on their choice of flexible services. The bootstrapping procedure is used to assess the confidence interval for the indirect effect. Using 1000 bootstrapping iterations, the 90% confidence interval of [0.001, 0.046] is obtained for the indirect effect. Since it does not include zero, it shows the significance of the mediation model consistent with the z-test in Table 9. As such, we can conclude that the impact of shippers' demand volatility on their perceived utility of flexible service choice is mediated by their volume flexibility in their supply chain. This mediation is partial, since

Table 8
Interaction model for demand volatility and volume flexibility.

Variable	Main effects model		Model with interactions (1)		Model with interactions (2)	
	Coefficient	Std. error	Coefficient	Std. error	Coefficient	Std. error
Current option	0.423	0.129***	0.4	0.125***	0.292	0.129**
Control	0.901	0.203***	0.591	0.203***	0.544	0.211***
Cost	−10.4	2.05***	−10	2.15***	−8.99	2.23***
Flexibility	0.363	0.136***	0.497	0.134***	0.462	0.14***
Reliability	0.664	0.482	0.454	0.52	0.532	0.547
Time	−1.09	0.277***	−1.12	0.257***	−0.972	0.266***
VAS	0.141	0.152	0.316	0.164**	0.291	0.169*
Demand volatility * Current option			−0.0243	0.125	−0.048	0.126
Demand volatility * Control			0.213	0.338	0.19	0.339
Demand volatility * Cost			1.06	2.16	1.35	2.17
Demand volatility * Flexibility			0.223	0.134*	0.212	0.125*
Demand volatility * Reliability			−0.349	0.523	−0.333	0.524
Demand volatility * Time			−0.197	0.259	−0.157	0.26
Demand volatility * VAS			0.358	0.235	0.356	0.165**
Volume flexibility * Current option			−0.0433	0.105	0.0756	0.113
Volume flexibility * Control			0.176	0.308	0.281	0.331
Volume flexibility * Cost			0.703	1.98	−0.613	2.14
Volume flexibility * Flexibility			0.186	0.102*	0.235	0.129*
Volume flexibility * Reliability			−0.121	0.468	−0.212	0.5
Volume flexibility * Time			0.117	0.233	−0.0791	0.251
Volume flexibility * VAS			−0.192	0.142	−0.168	0.153
Product flexibility * Current option					−0.362	0.116***
Product flexibility * Control					−0.295	0.34
Product flexibility * Cost					3.74	2.2*
Product flexibility * Flexibility					−0.134	0.134
Product flexibility * Reliability					0.265	0.523
Product flexibility * Time					0.56	0.257**
Product flexibility * VAS					−0.082	0.156
Standard Deviation for random effects						
Flexibility	0.677	0.332**	0.276	0.108**	0.283	0.208
Number of responses	1776		1776		1776	
Number of respondents	296		296		296	
Log-likelihood	−1673.26		−1646.94		−1644.75	
McFadden's R2	0.237		0.249		0.250	

***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$ for statistical significance.

Table 9
The mediation model.

	Coefficient	Std. error
Direct effects		
Demand volatility on Volume flexibility	0.125	0.026***
Volume flexibility on Choice of flexible logistics service	0.186	0.102**
Mediation (indirect effects)		
Demand volatility → Volume flexibility → Choice of flexible logistics service	0.023	0.0136*

Note: the adjusted R^2 for the direct effect of Demand volatility on Volume flexibility is 0.82.
***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$ for statistical significance.

the significant indirect effect of shippers' demand volatility on their choice of flexible services (i.e., coefficient of 0.023 in Table 9) could not change the significance of their direct effect (i.e., coefficient of 0.223 in Table 8) to insignificant.

4.2. Results of the latent class model

We estimated the latent class model using the Latent Gold software v.5.1 (Vermunt and Magidson, 2005). We started estimating models with one to five classes. The model fit of the various models is shown in Table 10. As mentioned in Section 3.2.3, we need to consider models with the lowest possible AIC and BIC measures to determine the appropriate number of latent classes. When the number of classes increases in Table 10, the AIC decreases, while BIC increases after the third class, which is why we use the latent class model with three classes, which has the lowest BIC and a decent model fit, i.e., McFadden's R^2 of 0.374.

Table 10
Model fit for the latent class choice models.

Criteria	Number of classes				
	1 (MNL)	2	3	4	5
Log-likelihood at convergence	−1914.2	−1636.5	−1580.3	−1544.5	−1518.2
McFadden's R^2	0.127	0.2617	0.3744	0.4122	0.4279
Number of parameters	7	21	35	49	63
Number of observations	1776	1776	1776	1776	1776
Akaike information criteria (AIC)	3842.54	3315.13	3230.67	3186.99	3162.41
Bayesian information criteria (BIC)	3868.37	3392.63	3359.83	3367.82	3394.90

Table 11
Estimation results for the MNL and latent class models.

	MNL		LCM					
			Class1		Class2		Class3	
	Estimate	z-value	Estimate	z-value	Estimate	z-value	Estimate	z-value
Class size (%), n = 1776			39.6		39.1		21.3	
Taste parameter estimates								
Current option	0.435***	4.21	−0.03	−0.05	−2.44**	−2.51	2.11***	3.14
Cost	−10.28***	−5.26	−28.1***	−5.32	−7.74**	−2.10	−4.75	−1.14
Control	0.863***	2.87	2.37***	2.92	2.81**	2.02	−0.57	−0.83
Flexibility	0.382***	3.23	0.07	0.28	1.56***	2.73	0.14	0.47
Reliability	0.692	1.50	0.24	0.25	3.72***	3.67	−4.48***	−2.94
Time	−1.047***	−4.58	−0.25	−0.45	−4.32***	−2.72	1.01*	1.83
VAS	0.153	1.10	0.29	0.94	−0.82	−1.06	0.41	1.28
R^2 (%)	12.7		30.6		39.5		31	
Class membership functions								
Demand volatility			−0.556	−1.39	1.21***	2.70	Base segment	
Internal flexibility types								
Volume flexibility			0.145	0.38	−0.299**	−1.97		
Product flexibility			0.595	1.45	0.2977	0.66		
Postponement flexibility			−0.145	−0.35	0.1537	0.34		
Launch flexibility			−0.103	−0.25	0.2549	0.56		
Sourcing flexibility			0.162	0.38	0.4133	0.87		
Intercept			−0.814	−1.4	0.259	0.43		

Note. *$p < 0.1$, **$p < 0.05$ and ***$p < 0.01$ for statistical significance.

We examined the impact of demand volatility and five internal flexibility types by considering them as covariates in the LC models (see estimation results in Table 11). Taking covariates into account helps clarify the variability in class memberships by evaluating how the probability of belonging to each class depends on different covariates. The dummy variables of demand volatility and five internal flexibility types are used as segment membership variables. All covariates are nominal, with the data divided into two categories, e.g., demand volatility (demand volatility or demand stability, coded with +1 and −1, respectively), and volume flexibility (high volume flexibility and low volume flexibility, coded with +1 and −1, respectively). Other internal flexibilities were coded in the same way as volume flexibility. The reference category for demand volatility is demand stability and, for each of the five internal flexibilities, the reference category is low internal flexibility (for instance, low volume flexibility).

Table 11 shows three distinct classes of shippers and their class membership functions relevant to demand volatility of their products and five internal flexibility types in their supply chain. A large shipper segment (approximately 40% of the population) is the second class of shippers, i.e., Class2, in which firms are distinguishably willing to use flexible transportation services, i.e., the coefficient of flexibility is significant and has the expected sign. Apart from flexibility, the coefficients of cost, time, control and reliability are also significant and have the expected sign, indicating that this class of shippers is looking for a quality transportation service for a competitive price. The insignificant coefficient of VAS reveals that shippers in the second class are not looking for value-added services, as their desire for basic service performance are more important or have not yet been met. The coefficient of the ASC of the current transportation option is negative and significant, indicating that these shippers are potentially dissatisfied with the existing transportation services. Looking into the class membership functions, we can see that the probability of belonging to the second class of

Table 12
Willingness to pay and its confidence interval for the MNL and LC models.

Attribute	MNL		LCM			
			Class1		Class2	
Control (€/service level)	8.39**	[1.63; 15.15]	8.45***	[2.12; 14.78]	36.38	[–23.95; 96.71]
Flexibility (€/service level)	3.71***	[1.15; 6.28]	–	–	20.19**	[1.16; 39.22]
Reliability (€/delivery times)	–	–	–	–	48.13**	[4.66; 91.61]
Time (€/day)	10.17***	[5.06; 15.29]	–	–	55.8	[–22.28; 133.89]

Note. Confidence intervals of WTP in [;], *$p < 0.1$, **$p < 0.05$ and ***$p < 0.01$ for statistical significance.

shippers is higher for firms operating in demand-volatile markets, i.e., the significant coefficient of demand volatility, and firms with high volume flexibility in their supply chains, i.e., the significant coefficient of volume flexibility. However, the insignificance of the coefficients of the other internal flexibilities shows that they are not distinguishable as far as firms of the second class are concerned. The results are in line with our findings (see Section 4.1).

Unlike the second class of shippers, the first and the third classes are not willing to use flexible transportation services. While the first class of shippers (class size of 38.1%) are very sensitive to the cost and control attributes of the transportation service, i.e., significant coefficients with expected signs, shippers in the third class are willing to continue using their current transportation services, i.e., significant coefficient of the ASC of the current transportation option. It would appear that the first and the third shipper classes do not differentiate their usage of transportation services based on their demand volatility and internal flexibility capabilities, i.e., insignificant coefficients in the class membership functions.

One of the important bias signs in a discrete choice experiment is the presence of significant ASC coefficients, usually originating in non-trading behavior of respondents, i.e., selecting a particular alternative in all choice situations. Such behavior could indicate a reluctance to consider (a) particular alternative(s), misunderstanding or fatigue during the stated choice exercise, or political/strategic behavior towards particular alternative(s) (Hess et al., 2010). To determine how this bias affects our results, we examined our dataset and found that only 3% of respondents selected the first alternative in all choice tasks, against 1.3% and 12.5% for the second and third alternatives, respectively. These figures still fall well within DCE's acceptable standards (Johnson et al., 2006), so it is unlikely that respondents were confused by the choice modelling exercise. Although these data could be removed from the analysis, some scholars suggest including them (e.g., Lancsar and Louviere, 2006) if they fall within acceptable DCE standards and within utility maximization assumption. We prefer to keep this data in our analysis, since, based on our investigation, they mainly demonstrate utility maximizing behavior of our respondents (Hess et al., 2010).

Another important bias is *self-selection* bias, which occurs because of incomplete observational data due to sampling from a population. Restricting data analysis to a sample of respondents (not the entire population) leaves us with a *self-selected* sample (Dubin and Rivers, 1989). Using a self-selected sample to identify relationships between variables may not be sufficient to establish causality (Mokhtarian and Cao, 2008) and could result in misleading and biased interpretations (Dubin and Rivers, 1989). To robustly infer causality, at least four kinds of evidence are needed: *association* (a statistically significant relationship), *causal mechanism* (a logical explanation showing why the supposed cause should produce the observed effect), *time precedence* (cause precedes effect), and *nonspuriousness* (a relationship that cannot be attributed to another variable) (Schutt, 2004; Singleton and Straits, 2005; Mokhtarian and Cao, 2008).

We think that self-selection bias is not a major concern in our study, because the evidence needed for a robust inference of causality is present. Considering our dataset, the evidence for *association* is presented throughout Section 4 by showing statistically significant relationships among variables. The *causal mechanism* exists because one of the main reasons for developing and utilizing flexibility in supply chains is the existence of uncertainties like demand volatility (see Tachizawa and Thomsen, 2007; Angkiriwang et al, 2014; Sreedevi and Saranga, 2017, among others). Regarding *time precedence*, it is clear from the operations management literature that, as long as the causes, e.g., demand volatility, have not happened, the effects, e.g., building flexibility capabilities, will not happen since building flexibility capabilities in transportation and supply chain are relatively time-consuming and capital-intensive (see, for example, Jack and Raturi, 2002, among others). It is also obvious that flexibility capability cannot cause demand volatility. With regard to *nonspuriousness*, since addressing uncertainties like demand volatility usually requires a change in the supply chain, e.g., change delivery location/time/volume, by definition the only attribute that can support changes in transportation service components is flexibility.

We also examined our dataset with respect to the self-selection bias. According to the Thomson Reuters business classification (2012), there are nine business sectors relevant to our study, in which we have respondents from all nine sectors (see Table 3). In light of the fact that shippers in this study are all Global fortune 500 companies, which are often industry leaders, we expect the preferences of these global shippers to be a good representative of the preferences across their industry. Therefore, we think that the occurrence of high self-selection bias in this study is unlikely.

4.3. Willingness to pay measures

After addressing our research questions using ML and LC models in Sections 4.2 and 4.3, respectively, it would be useful for LSPs to know more about the willingness to pay (WTP) of shippers for different attributes of the transportation service. Similar to the approach adopted by Arencibia et al. (2015) and Khakdaman et al. (2020), we measure WTP to offer guidelines to LSPs wanting to improve their transportation services and to policymakers who evaluate different improvement policies. WTP is the ratio of marginal utility of the attribute and the marginal utility of the transportation cost (McFadden, 1981). We applied the Latent Gold software to obtain the WTP for each attribute in the MNL and LC models, as shown in Table 12.

While point estimates for WTP are informative, it is important to measure confidence intervals for each point estimate, in particular for random variables of the ML model, i.e., Flexibility. To calculate the confidence intervals for WTP, we applied the *Delta* method (Hole, 2007) as a suitable approach for studies with large sample sizes, i.e., N > 100 (Hole, 2007; Gatta et al., 2015). In the Delta method the confidence intervals of a WTP point estimate is obtained using

$$\widehat{WTP}_k \pm z_{\alpha/2}\sqrt{var(\widehat{WTP}_k)} \tag{10}$$

where, $\widehat{WTP}_k$ is the WTP point estimate for attribute k, and $z_{\alpha/2} = \Phi^{-1}_{[1-\alpha/2]}$, Φ^{-1} is the inverse of the cumulative standard normal distribution and the confidence level is $100(1-\alpha)\%$ (Hole, 2007). The main assumption of the Delta method is that WTP is normally distributed and thus symmetrical around its mean. Hole (2007) emphasized that, when a model is estimated using a large sample and the estimate of the coefficient for the cost attribute is sufficiently precise, it is likely that WTP is approximately normally distributed. Although Gatta et al. (2015) argued that the normality assumption of the Delta method limits its accuracy for small sample sizes, they showed that, when sample size is large and the coefficient of variation for the cost coefficient is low, which is the case in our study, the Delta method produces similar results to other methods like the Fieller method or Bootstrap.

We calculated the WTP figures and the associated confidence intervals only for parameters that are significant and have the expected sign. When the confidence interval does not include zero for an attribute, a positive WTP is likely to exist among shippers. In addition, we assumed that the average shipment cost of one TEU container is €100. Taking the MNL model into account, the average WTP for a day's reduction in the end-to-end transportation time is estimated at €10.17, ranging between €5.06 and €15.29. Shippers' WTP for control and flexibility is approximately €8.39 [1.63;15.15] and €3.71 [1.15;6.28], respectively, for one level enhancement of control and flexibility. Regarding the latent class model, Shippers in Class1 are willing to pay €8.45 [2.12;14.78] for control attribute for one level of service improvement. Shippers in Class2 are willing to pay €20.19 [1.16;39.22] and €48.13 [4.66;91.61] for flexibility and reliability, respectively, for every unitary improvement in these service dimensions. Compared to the other latent classes, shippers in Class2 indicate the highest intention for WTP for flexible transportation services.

Considering WTP confidence intervals in both MNL and LC models, shippers' willingness to pay for flexibility is between approximately 1 to 6 Euros for one level of service improvement, and it can go up to approximately 39 Euros for the second class of shippers based on the contextual factors of their business. This implies the importance of flexibility of logistics services among shippers compared to the other service attributes. While the WTP confidence intervals in the MNL model for control and time show higher average values compared to flexibility, e.g., the maximum value of approximately 15 Euros for time and cost compared to 6 Euros for flexibility, only the confidence intervals for flexibility and reliability are strictly positive in the second class of shippers. These results highlight the importance of detecting the existence of latent segments in the population that present differentiated behavior, e.g., the second class of shippers look for high-quality logistics services. A correct design and evaluation of transportation policies are directly influenced by accurately identifying the shippers' preferences in different market segments.

5. Practical implications and conclusions

5.1. Practical implications

The willingness of the customers of LSPs to use flexible services, especially in volatile markets, highlights new opportunities for LSPs to develop and offer service packages with different levels of flexibility. Identifying seasonal products of their customers, for instance, LSPs can provide service packages with higher flexibility levels to address highly fluctuating demand for those seasonal products. The results of the LC analysis show that there is a certain degree of willingness among specific leading shippers to derive value from flexible transportation services. Since the main characteristics of these shippers are that they operate in demand-volatile markets and experience high volume flexibility in their supply chains, LSPs managers could design tailor-made flexible services based on the level of the internal volume flexibility in their customers' supply chain. In the long run, the tendency among the customers of LSPs to use traditional methods to address demand volatility, for instance through high inventory levels, could shift towards using LSP-driven flexible services when LSPs are able to provide accurate flexible logistics services.

In order to be able to offer the required flexibility in the logistics services, LSPs may need to change their business operations to adapt to customers' changing preferences, which means they may need to have access to lots of locations to be able to expand their logistics network whenever needed. Instead of owning and managing many locations, LSPs can create an extensible network with operators providing on-demand warehousing and fulfilment services with available capacity in every market location (FLEXE, 2020), allowing LSPs to (1) add locations to improve the last mile of delivery for their shipper customers, (2) secure additional capacity to accommodate peak-season demand or new product rollouts and (3) resolve shippers' unexpected inventory overflow situations. In addition to locations, LSPs may also need to have access to different modes of transportation to improve utilization of transportation capacity and to address extreme weather events and political decisions regarding international free trade agreements (e.g., lowering the capacity of international shipping) by switching between different modes of transportation in real-time. Multiple transportation modes can be accessed by using the services of different transport operators in addition to their own transport modes and services.

Offering flexible transportation services will have consequences for the business models of LSPs. Flexibility in logistics services will become more relevant in the value proposition of LSPs (FLEXE, 2020). Operationalizing flexible services will involve changing three major functions in the business model: service package design, revenue management, and supply and capacity planning. The service design function should introduce different levels of flexibility to address the requirements of various customer segments. In their revenue management systems, LSPs will need to differentiate prices for different flexibility service levels. Supply and capacity planning will need to be equipped with sophisticated resource allocation algorithms, to enable fulfilling changes in orders while maintaining control over the utilization of resources. In addition, shipper firms could also establish collaborative practices with their LSPs. Many initiatives have been taken recently to improve supply chain responsiveness in volatile markets, resulting in strategic volume flexibility and mix flexibility. Shipper firms could initiate different levels of partnership with LSPs as suppliers of the logistics function, to strengthen their delivery/logistics flexibility (Purvis et al., 2014).

The insights provided by this study could be used by public policymakers to make long-term decisions to improve the flexibility of national and international transportation networks. Since logistical flexibility is an important service requirement among many shippers, existing infrastructure and service investments should be enhanced to enable LSPs to provide flexible services. This could be done by establishing scalable warehousing locations and transportation modes, as well as by providing advanced logistics information systems. Finally, provision and utilization of flexible logistics services on an international scale also means that the international rules and regulations need to be modified.

5.2. Conclusions and future research directions

In this study, we discussed flexible logistics services as one of the service requirements in the modern era of logistics services. We conducted a large-scale experiment among global shipper companies to understand how they appreciate flexibility of freight logistics services. We demonstrated how their choice of LSP-driven flexible services differs depending on whether they operate in markets with highly volatile demand or in stable markets. Having a better understanding of customer requirements under different business conditions will help LSPs design customized logistics service packages, with the potential of improving their own and their client's competitive advantage. We also demonstrated the effect of internal supply chain flexibility on the choice of flexible logistics services among shippers. While shippers with volume flexibility are willing to use LSP-driven flexible services as a supplementary external flexibility, those with other internal flexibilities i.e., product, launch, sourcing and postponement, seem more reluctant to use flexible services.

The results of this study suggest several avenues for future research into flexible services in transportation and logistics. One such avenue would be to examine the willingness among shippers to use flexible logistics services in specific industries, for instance retail and apparel. Choice studies could be conducted to examine the impact of other business circumstances, e.g., supply and process uncertainty, on the choice of flexible services, and the dynamics involved could be compared for different industries to determine where higher levels of flexibility may be required. Additional research could help identify the requirements and obstacles global LSPs face in their quest to provide more flexible services to shippers.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. The MNL estimation results for the pilot study

We conducted a pilot study to obtain priors to design our D-efficient design experiment. We developed an orthogonal fractional factorial design (Kocur et al., 1982) for the pilot study, in which 18 choice tasks are blocked in two choice sets, each one containing nine choice tasks, which were included in a web-based survey using an online survey platform (Surveygizmo, 2017). The surveys were sent via e-mail to 131 respondents from 56 randomly selected firms out of the list of 556 firms (in all, 262 executives were contacted). We received 19 and 22 complete responses from pilot surveys 1 and 2, respectively (average response rate of 15.6%). Aggregating the results, 19 choice sets each one containing 18 complete choice tasks (342 observations) are applied to estimate model parameters. The results of estimating the MNL model (using Biogeme software release 2.0 (Bierlaire, 2003)) on the pilot study data, is shown in Table A1.

Table A1
Estimation results for the pilot study (orthogonal design).

Variable	Main effects model	
	Coefficient	Std. error
Current option	0.591***	3.11
Control	0.789**	1.98
Cost	−10.1***	−5.39
Flexibility	0.102*	1.69
Reliability	0.328***	3.01
Time	−1.06*	−1.74
VAS	0.153	1.36
Number of responses	342	
Number of respondents	38	
Log-likelihood	−338.448	
McFadden's R^2	0.138	

Note. ***p < 0.01, **p < 0.05 and *p < 0.1 for statistical significance.

Appendix B. Insignificance of four internal flexibility types with demand volatility

See Tables B1–B4.

Table B1
The interaction model for demand volatility and product flexibility.

Variable	Main effects model		Model with interactions	
	Coefficient	Std. error	Coefficient	Std. error
Current option	0.423	0.129***	0.297	0.129***
Control	0.901	0.203***	0.562	0.21***
Cost	−10.4	2.05***	−9.03	2.23***
Flexibility	0.363	0.136***	0.485	0.139***
Reliability	0.664	0.482	0.507	0.545
Time	−1.09	0.277***	−0.972	0.265***
VAS	0.141	0.152	0.275	0.168
Demand volatility * Current option			−0.0381	0.125
Demand volatility * Control			0.229	0.336
Demand volatility * Cost			1.25	2.15
Demand volatility * Flexibility			0.244	0.134*
Demand volatility * Reliability			−0.36	0.52
Demand volatility * Time			−0.168	0.258
Demand volatility * VAS			0.332	0.164**
Product flexibility * Current option			−0.333	0.109
Product flexibility * Control			−0.191	0.317
Product flexibility * Cost			3.49	2.05
Product flexibility * Flexibility			−0.0474	0.125
Product flexibility * Reliability			0.184	0.49
Product flexibility * Time			0.526	0.239
Product flexibility * VAS			−0.144	0.146
Standard Deviation for random effects				
Flexibility	0.677	0.332**	0.378	0.336
Number of responses	1776		1776	
Number of respondents	296		296	
Log-likelihood	−1673.26		−1642.56	
McFadden's R2	0.237		0.251	

***p < 0.01, **p < 0.05 and *p < 0.1 for statistical significance.

Table B2
The interaction model for demand volatility and launch flexibility.

Variable	Main effects model		Model with interactions	
	Coefficient	Std. error	Coefficient	Std. error
Current option	0.423	0.129***	0.403	0.132***
Control	0.901	0.203***	0.489	0.22**
Cost	−10.4	2.05***	−9.95	2.34***
Flexibility	0.363	0.136***	0.548	0.144***
Reliability	0.664	0.482	0.273	0.563
Time	−1.09	0.277***	−1.02	0.276***
VAS	0.141	0.152	0.315	0.174*
Demand volatility * Current option			−0.0295	0.125
Demand volatility * Control			0.222	0.336
Demand volatility * Cost			1.17	2.15
Demand volatility * Flexibility			0.251	0.134*
Demand volatility * Reliability			−0.379	0.52
Demand volatility * Time			−0.173	0.257
Demand volatility * VAS			0.334	0.164**
Launch flexibility * Current option			0.00748	0.113
Launch flexibility * Control			−0.412	0.333
Launch flexibility * Cost			0.112	2.16
Launch flexibility * Flexibility			0.124	0.13
Launch flexibility * Reliability			−0.452	0.509
Launch flexibility * Time			0.229	0.25
Launch flexibility * VAS			0.00432	0.152
Standard Deviation for random effects				
Flexibility	0.677	0.332**	0.439	0.675
Number of responses	1776		1776	
Number of respondents	296		296	
Log-likelihood	−1673.26		−1647.60	
McFadden's R2	0.237		0.2487	

***p < 0.01, **p < 0.05 and *p < 0.1 for statistical significance.

Table B3
The interaction model for demand volatility and sourcing flexibility.

Variable	Main effects model		Model with interactions	
	Coefficient	Std. error	Coefficient	Std. error
Current option	0.423	0.129***	0.2	0.18
Control	0.901	0.203***	0.729	0.228***
Cost	−10.4	2.05***	−7.64	2.44***
Flexibility	0.363	0.136***	0.581	0.147***
Reliability	0.664	0.482	−0.254	0.587
Time	−1.09	0.277***	−0.92	0.292***
VAS	0.141	0.152	0.26	0.178
Demand volatility * Current option			−0.0295	0.125
Demand volatility * Control			0.231	0.336
Demand volatility * Cost			1.18	2.15
Demand volatility * Flexibility			0.249	0.134*
Demand volatility * Reliability			−0.371	0.521
Demand volatility * Time			−0.178	0.257
Demand volatility * VAS			0.334	0.164**
Sourcing flexibility * Current option			−0.2	0.18
Sourcing flexibility * Control			0.442	0.333
Sourcing flexibility * Cost			4.5	2.15
Sourcing flexibility * Flexibility			0.166	0.122
Sourcing flexibility * Reliability			−1.37	0.533
Sourcing flexibility * Time			0.376	0.268
Sourcing flexibility * VAS			−0.106	0.142
Standard Deviation for random effects				
Flexibility	0.677	0.332**	0.262	0.281
Number of responses	1776		1776	
Number of respondents	296		296	
Log-likelihood	−1673.26		−1644.75	
McFadden's R2	0.237		0.25	

***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$ for statistical significance.

Table B4
The interaction model for demand volatility and postponement flexibility.

Variable	Main effects model		Model with interactions	
	Coefficient	Std. error	Coefficient	Std. error
Current option	0.423	0.129***	0.341	0.136***
Control	0.901	0.203***	0.483	0.229**
Cost	−10.4	2.05***	−9.06	2.45***
Flexibility	0.363	0.136***	0.532	0.151***
Reliability	0.664	0.482	0.371	0.593
Time	−1.09	0.277***	−0.882	0.287***
VAS	0.141	0.152	0.224	0.179
Demand volatility * Current option			−0.033	0.125
Demand volatility * Control			0.224	0.336
Demand volatility * Cost			1.23	2.15
Demand volatility * Flexibility			0.25	0.134*
Demand volatility * Reliability			−0.374	0.52
Demand volatility * Time			−0.164	0.258
Demand volatility * VAS			0.329	0.164**
Postponement flexibility * Current option			−0.127	0.117
Postponement flexibility * Control			−0.358	0.35
Postponement flexibility * Cost			1.94	2.28
Postponement flexibility * Flexibility			0.0697	0.138
Postponement flexibility * Reliability			−0.157	0.54
Postponement flexibility * Time			0.474	0.262*
Postponement flexibility * VAS			−0.189	0.158
Standard Deviation for random effects				
Flexibility	0.677	0.332**	0.093	0.088
Number of responses	1776		1776	
Number of respondents	296		296	
Log-likelihood	−1673.26		−1644.09	
McFadden's R2	0.237		0.2503	

***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$ for statistical significance.

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