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Shippers' willingness to delegate modal control in freight transportation

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ABSTRACT

This paper investigates the willingness of shippers to delegate control over the transportation mode in freight transportation, using discrete choice analysis. Data originate from a large survey among global shippers. The results show that, under certain conditions, most shippers are willing to hand over mode selection authority to the service provider. Using latent class analysis, we classify shippers into four market segments, each with a different degree of willingness against different types of performance improvements. Firms can use this characterization of freight transportation demand to design service packages that will meet the demands of global supply chains.

1. Introduction

Understanding the preferences and requirements of customers is one of the main keys to the success of any transportation service, especially if their demands vary widely and change over time. Mass customization of goods and services in the global business environment has required logistics service providers (LSPs)[1] to adapt their business strategies toward a more demand-driven rather than supply-based logistics system (Black and Halatsis, 2001). To this end, Veenstra et al. (2012), and Van Riessen et al. (2016), among others, emphasized the need for an integrated logistics network. However, the reluctance among shippers to delegate control over the transportation mode and route to the LSPs has left limited room for the global logistics system to maximize the efficiency and flexibility of the transportation network operations. Eventually, this has also made effective demand-supply integration a more difficult task for LSPs.

Delegating authority over transportation modes to LSPs is considered to be part of the outsourcing of a shippers' logistics and transportation function. The outsourcing of non-core competencies in manufacturing, logistics, IT and business processes is common practice in many industries (Rao and Young, 1994). For many shipper firms, however, logistics is still mainly remained at the out-tasking level, with transportation-related operations being outsourced to the LSPs, but not the decision-making *authorities* (Hsiao et al. 2010). In particular, many firms do not outsource *decisions* regarding the selection of *transportation modes* to LSPs, since, according to Tongzon (2009), shippers determine every aspect of the freight movement to maintain ultimate control over how goods are transported. As pointed out by Tsai et al. (2012), an important reason for this is the perceived risk of loss of control and visibility once shippers fully outsource the transportation function. However, Zhang and Pel (2016) emphasize that letting LSPs decide

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[1] Whenever we use the term Logistics service provider (LSP) in this paper, we refer 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 real-word practice, this could include 3rd/4th Party Logistics (3PL/4PL), Integrate Logistics Providers (ILP) and so on.

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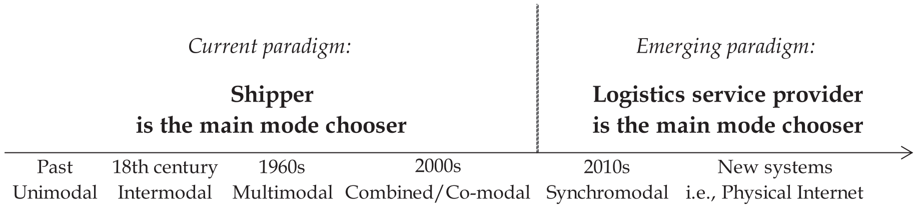

Fig. 1. Paradigms in transportation modal choice.

provides a mode-free booking flexibility for them, e.g., in the context of synchromodal transportation (see further details in section 2 and studies such as Tavasszy et al. 2010; Verweij, 2011), which could enable LSPs to reduce transportation costs as well as improve service levels. It could also help reduce delivery times and enhance capacity utilization of different transportation modes, resulting in a more robust, reliable and flexible transportation system (Zhang and Pel, 2016). The critical question "under which circumstances and to what extent are global shippers willing to give mode and route selection authority to the LSPs?" has yet to be addressed in the literature.

We consider the global shippers' agreement/permission to fully delegate modal control authority to LSPs as an emerging paradigm in transportation and logistics. We validate this paradigm in the context of synchromodal transportation, since decisions regarding transportation mode/route are made by LSPs in real-time. Unlike synchromodal transportation, mode choice decisions in other freight transportation systems are made predominantly by the shippers and transportation modes are booked in advance by the LSPs i.e., from their own resources or other carriers/LSPs (Coulter et al. 1989; Coyle et al. 2011; Tryfleet, 2017). As such, in a transportation system like synchromodality, with real-time modal decision-making based on the availability of different modes in the transportation network, almost no prior awareness could be provided by LSPs to shippers before transportation execution. This unique characteristic of synchromodality can provide LSPs with a network-wide freedom to fully utilize their authority on mode and route control, in order to maximize the overall efficiency, flexibility and performance of the global transportation system. Obviously, shippers could become aware of applied mode(s)/route(s) for their goods after transportation execution e.g. via the tracking and tracing capabilities offered by LSPs. Fig. 1 summarizes current and emerging paradigms in transportation modal choice. In the current paradigm, the shipper is the main party selecting the transportation mode in booking transportation services.

To address the question of modal control delegation, this study aims to empirically assess willingness among shippers to delegate their mode choice authority to the LSPs within the framework of evaluating their demand preferences for synchromodal service attributes, using discrete choice modelling (Ben-Akiva and Lerman, 1985). Taking existing research on the transportation demand into account, mode choice studies are largely based on the current paradigm in which shippers predominantly select the transportation mode. However, their preferences and heterogeneity in relation to the new emerging paradigm in synchromodal transportation, and their attitude with regard to a service choice approach have not yet been examined.

Delegation of modal control brings fundamental trade-offs for shippers across their end-to-end supply chains (Eng-Larsson and Kohn, 2012). Dong et al. (2018) emphasized that a broader impact of applying synchromodal transportation on the entire supply chain should be considered. To that end, the supply chain managers of the shipper companies synchronize transportation-related decisions with other decisions within their supply chain, such as inventory management, production and distribution schedules, and service level fulfilments (Dong et al. 2018). This highlights the fact that the supply chain managers of shipper companies will delegate modal control in exchange for being able to make more effective decisions within their supply chain. To consider these trade-offs, we incorporated the following two attributes in the choice experiment: *flexibility* and *value-added services (VAS)*.

The freedom to choose the transportation mode and route could allow LSPs to provide flexible service components to shippers (Zhang and Pel, 2016). We define flexibility as the capability of the logistics system to provide possible changes in the service components in response to a shipper's business needs at any point in time, before and after the departure of the freight/goods towards the destination. Our definition, which extends the definitions by Swafford et al. (2006) and Ben-Akiva et al. (2008), has not yet been applied in any mode choice study. The third new attribute involves value-added services (VAS), which are ancillary services beyond the main transportation service, such as container tracking, customs-oriented services, stripping/stuffing and cleaning (Roso et al. 2009). Although value-added services have been applied in logistics and transportation since the 1980s (Pettit and Beresford, 2009), so far no transportation service choice study has incorporated them as a service attribute into a choice experiment. (see further details in section 2). The final limitation in existing mode choice literature is the fact that most studies collect a limited number of observations and/or focus a particular geographical area, such as a city, country or continent. We found no studies that reflect on the demand-related characteristics of global shippers in connection to recent innovations in transportation and logistics, including synchromodal transportation.

In this research, a systematic study is conducted among Global Fortune 500 companies (Fortune magazine, 2017) and major customer firms of the 40 largest global LSPs (Logistics Quarterly magazine, 2011), including all different industries and commodity types that account for the majority of global transportation volume and value. Stated preference (SP) data from our survey among these global shippers are used to analyze their attitudes toward moving from a transportation mode choice approach to a transportation service choice approach. Firstly, multinomial logit modeling method is applied to estimate the preferences of shippers regarding the main attributes of the synchromodal transportation services, such as cost, transit time, reliability (punctuality), modal control, flexibility (changeability, adaptability) and value-added services. Next, latent class modelling is used to capture the non-observable heterogeneity of the shippers' preferences within each class. Willingness to pay for different transportation attributes is also measured.

The main contributions of this research are as follows. First and foremost, it addresses the paradigm shift in logistics and transportation service choice, concerning shippers' willingness to delegate the authority to decide the mode of transportation to the LSPs. A new choice modelling attribute, called *modal control*, is introduced. The approach empirically validates one of the fundamental assumptions of implementing synchromodality in practice. Secondly, flexibility is operationalized in this broader context and incorporated into the discrete choice study. In the same context, we also include value-added services, above and beyond the primary transportation service. And finally, this study adopts an international perspective to depict preferences, taste heterogeneity and segmentation of leading shippers. While earlier studies were geographically constrained, we focus on global shippers. In the following section, we present the background of the study. We discuss the research methodology, including the econometric approach, the data and the choice experiments in Section 3. Section 4 is dedicated to the results and discussion. Section 5 provides managerial insights along with conclusions and future research directions.

2. Background of the research

Synchromodal transportation, as a technological and organizational innovation in freight transportation and logistics, is designed to enable LSPs to implement demand-driven transportation services (Tavasszy et al. 2018). A successful implementation in a large-scale network requires shippers to move away from a transportation mode choice approach towards a transportation service choice approach. Synchromodal transportation is the latest generation of a family of transportation systems designed to improve overall efficiency of the transportation system by combining several modes of transportation. As pointed out by Reis (2015), the most established concepts in this regard are multimodality, intermodality and combined transportation, which were developed in the 1980s and 1990s. Multimodal transportation, which was defined by UNCTAD (1980) as the transportation of goods using two or more modes of transportation, has been practiced since the 1960s. Intermodal transportation, which has been practiced since the 18th century, was defined and operationalized in research by Hayuth (1987), who added three main features to multimodality (one and the same unit load, door-to-door transportation and greater integration). The combined and co-modal transportation systems (UNECE, 2001; European Commission, 2006) are also types of intermodal transportation, with the latter focused more on efficiency and the former more on sustainability.

Synchromodal transportation (see e.g. Tavasszy et al. 2018) has added two distinguishing features of flexible (adaptive) mode choice and decision-making based on real-time information. The word synchromodality can be explained as 'synchronized intermodality', where LSPs have the flexibility to make real-time decisions about switching between transportation modes and routes, in response to the demand variations and resource/network availabilities (e.g., congestions, transit times, delays, pricing - see for further elaboration and detail e.g. Van Riessen et al. (2015) and Behdani et al. (2016)). Without putting the authority of choosing modes and routes of transportation in the hands of the LSPs, the implementation of synchromodality is unfeasible within a large-scale transportation network.

Taking the research on the transportation demand into account, the existing mode choice literature is based mainly on the paradigm in which shippers predominantly select the transportation mode. Fries and Patterson (2008) reviewed different research projects involving the question whether shippers actually tend to choose between different transport modes or between different transport service offers of LSPs (i.e., letting the LSP select the appropriate transport mode). While they emphasized that there is no simple 'yes' or 'no' answer to this question, they concluded that the transportation mode is important to shippers, and highlighted that the quality and price of transport service are crucial as far as shippers are concerned, but that the transportation mode plays a non-negligible role that is an implicit part of their choice. However, it is not clear under which circumstances and to what extent shippers tend to permit LSPs to determine the appropriate transport mode. A recent literature review by Reis (2014) identified transportation safety and security, service frequency, transportation cost, transit time, service reliability and service flexibility as the common components of a logistics service that influence modal choice decisions of the shippers. Almost every research considered transportation cost, time and reliability to be the three core attributes of a logistics service (Reis, 2014), while transportation service flexibility and value-added services are largely ignored in the relevant studies.

As stated in the introduction, we define flexibility as the capability of the logistics system to provide possible changes in the service components in response to the shippers' business needs at any point before and after the departure of the freight/goods towards their destination. That could include changes in the destination, increasing or reducing transit time, aggregation or disaggregation of shipment quantity, and so on. Synchromodal transportation enhances flexibility by switching between different transportation modes and routes at mode-volume switch locations (Europe Container Terminals, 2011) in the transportation network i.e., warehouses and cross-docking terminals that also allow for the consolidation and deconsolidation of freight based on the business requirements of shippers. In the existing literature on mode choice, few studies include flexibility as an attribute of the transportation service. For example, Norojono and Young (2003) referred to flexibility as the responsiveness level of the LSP to the problems, while Danielis and Marcucci (2007) saw it as the LSP's capability to change some of the service components before finalizing the service booking. Arencibia et al. (2015) defined flexibility as the LSP's capability to perform unexpected changes in the booking of transportation service, such as last-minute changes in the shipment. Our definition extends ones provided by Swafford et al. (2006) and Ben-Akiva et al. (2008) in a way that has not yet been applied so far in the transportation mode choice studies. We define flexibility as the LSP's ability to help shippers respond to their demand fluctuations, supply chain disruptions or other operational or market requirements. In our view, flexibility can drive many business values for shippers.

Value-added services (VAS) refer to ancillary services that go beyond the main transportation service, such as customs-oriented services, container tracking, storage and handling, stripping and packaging, and so on (Roso et al. 2009). LSPs now have access to a larger variety of services and can potentially align a service better to match the needs of individual or groups of shippers. As synchromodal transportation services provide the LSP new options to meet the requirements of shippers, new business opportunities also emerge to combine the basic transportation service with value-added services. Another research gap concerns the preferences of shippers with regard to such value-added services, which have existed since the 1980s (Pettit and Beresford, 2009), even though they are not included as a service attribute in any of the existing relevant studies.

3. Methodology

Random utility theory (McFadden, 1974) introduced discrete choice models as one of the well-established methods in econometrics to shed light on the preferences and taste heterogeneity of customers in Business-to-Consumer and Business-to-Business markets (Ben-Akiva et al. 2008). Multinomial Logit (MNL) (Ben-Akiva and Lerman, 1985) is one of the simplest approaches that assumes fixed deterministic parameters for all individuals. Mixed logit (ML) models (Hensher et al. 2005; Train, 2009), by contrast, allow parameters to vary randomly across individuals to reflect taste heterogeneity. In ML models, a particular type of distribution e.g., normal distribution for parameters of the utility function is assumed by the analyst, parameters' mean and variance are estimated, and the significance of the variance accounts for existence of heterogeneous preferences. There is a rich body of literature involving the application of MNL and ML models in freight transportation.

To accommodate the effects of unobserved heterogeneity, we use the Latent Class (LC) modeling approach (Kamakura and Russell, 1989), which performs similar to the continuous approaches, i.e., ML, for representing heterogeneity (Andrews et al. 2002). Kamakura and Russell (1989) developed LC modeling and removed some of the drawbacks of ML models, i.e., the analyst should assume and fit distribution functions for parameters. Here, an important problem lies in specifying a well-fitted distribution function for each parameter and the need for conducting tests to validate different types of density functions. LC model (also called endogenous market segmentation or the finite (discrete) mixture model) is a special type of broader class of mixture models based on a logit kernel (Train, 2009) that uses observable variables to identify the membership function of each category of the mixture distribution. LC models assume a fixed number of latent classes among individuals and directly use data to detect behaviorally homogenous segments. To this end LC modelling does not need simulation-based estimation, which is an advantage over the ML model (Greene and Hensher, 2003). While LC modelling fits the data and captures unobserved heterogeneity as well as ML models do, it allows for a better and easier behavioral and intuitive interpretation of results to obtain managerial insights for practitioners and policymakers (Greene and Hensher, 2003; Louviere, 2006; Shen, 2009; Hess et al. 2011). Louviere (2006) highlighted that results can also be difficult to interpret when applying continuous distributions in ML models.

Although Boxall and Adamowicz (2002) reported a significant growth in the application of LC models, especially in the areas of marketing and psychology, Arunotayanun and Polak (2011) emphasized that relatively few studies involving transportation demand analysis have so far applied LC modelling. This could be due to data unavailability or the difficult, time-consuming and cost-intensive nature of data collection in general, especially from global firms, and the relatively high data-intensity of latent class approach compared to mixed logit, in particular (Marcucci, 2013). Our examination of existing literature also shows that their claim is still valid. The limited research into latent class analysis of unimodal, multimodal and intermodal transportation was conducted by Wen and Lai (2010), Arunotayanun and Polak (2011), Bergantino et al. (2013), Di Ciommo et al. (2013), Feng et al. (2013), Chu (2014), Kim et al. (2017), Piendl et al. (2017), Duan et al. (2017), Román et al. (2017) and Piendl et al. (2018). We used the LC modeling approach along with MNL modeling as our main research method.

3.1. Econometric approach

The vast majority of applications of discrete choice modeling in the area of transportation are based on the random utility maximization (RUM) paradigm. RUM considers the utility of alternative k for decision-maker i by $U_{ki} = V_{ki} + \varepsilon_{ki}$, where V_{ki} is the systematic, observable utility of alternative k for decision-maker i, and ε_{ki} is the error term representing unobserved factors by the analyst in the choices of individual i. Based on the assumptions about the distribution of the error term, different choice probability formulations can be obtained, representing different families of models, including multinomial logit, nested logit, mixed logit and probit. The multinomial logit (MNL) is the most basic form of the model, based on an extreme value type I (Gumbel) probability density function and the additional assumption of independent and identically distributed ε_{ki}. As discussed earlier, to reveal taste heterogeneity among shippers, we apply the LC modelling approach, in which, for shipper (decision-maker) i in class s, the utility of alternative k is

$$U_{ik|s} = \alpha_{k|s} + \beta_s^{'} X_{ik} + \varepsilon_{ik|s} \tag{1}$$

where $\alpha_{k|s}$ is the segment-specific constant; $\beta_s^{'}$ is the vector of the utility parameters for segment s; X_{ik} is the vector of independent variables for alternative k of the decision-maker i; $\varepsilon_{ik|s}$, as above, is the independently and identically distributed (IID) error term of the utility function. The probability of selecting alternative k within each class by the shipper i is

$$P_{(ik|s)} = \frac{\exp(\alpha_{(k|s)} + \beta_s^{'} X_{ik})}{\sum_{k\in K} \exp(\alpha_{(k|s)} + \beta_s^{'} X_{ik})} \tag{2}$$

Assuming W_{is} as the class membership probability of individual i belonging to class s, the unconditional probability of selecting alternative k is

$$P_{ik} = \sum_{s=1}^{S} P_{ik|s}.\ W_{is} \tag{3}$$

in which $P_{ik|s}$ is the choice probability within each class, and where S is the total number of classes. As can be seen, the probability P_{ik} depends on two kinds of probabilities: the class membership probability (W_{is}) and the choice probability within each class ($P_{ik|s}$). A standard logit formulation can be applied to display W_{is} as

$$W_{is} = \frac{\exp(\gamma_s^{'} Z_i)}{\sum_{s=1}^{S} \exp(\gamma_s^{'} Z_i)} \tag{4}$$

where γ_s is the vector of estimated parameters for segment s and Z_{i} is the vector of segment variables for characteristics of respondents which is also called concomitant variables of the latent class model. The γ_s parameters will demonstrate only constants if no concomitant variables are specified in the model.

The Bayesian Information Criterion (BIC) and the Akaike Information Criterion (AIC) are considered among the most usual ways to determine the optimal number of segments (Bhat, 1997; Boxall and Adamowicz, 2002). Their formulas can be expressed as

$$AIC = -2LL + 2M \tag{5}$$

$$BIC = -2LL + M\ln N \tag{6}$$

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

3.2. Experiment design and implementation

It is our aim to obtain a comprehensive understanding of the willingness among shippers to delegate modal control and their preferences with regard to the synchromodal transportation services. Our focus is on the transportation flows of the world's biggest firms, which mainly purchase and/or produce all different types of products/materials/equipment and deliver or distribute them to their customers or consumers. We were able to identify two main sources that could provide us with a list of these major firms: the list of Global Fortune 500 companies, as published every year by Fortune Magazine, containing the names of the world's 500 largest firms by revenue, and the list of major customers (firms) of the 40 largest LSPs worldwide based on Logistics Quarterly Magazine, which lists between 5 and 10 major customers (leading shippers) for each LSP. As expected, there is significant overlap between these lists. In total, 556 unique company names were identified.

In the next step, we identified the people we should contact for the stated preference survey. The decisions involving a shift towards a fundamentally new transportation service such as synchromodal transportation are strategic/tactical level decisions that affect long-term contracts of shippers with LSPs, which is why we targeted top (c-level) and senior/middle level managers of shipper firms. Because we would expect synchromodal transportation to affect various functions in the supply chain (from procurement to manufacturing to distribution), we focused on top/senior managers involved in supply chain and transportation operations. In total, 2752c-level and senior managers in the supply chain, transportation, logistics and distribution functions (e.g., vice-president of supply chain, director of logistics) of our list of 556 global largest firms were approached.

Two web-based surveys were constructed, as a pilot and as the main study. For the pilot study, we developed an orthogonal experimental design (Street et al. 2005) to estimate the parameter priors for our main experiment, which was based on efficient design method (Huber and Zwerina, 1996; Rose and Bliemer, 2009). The response rate was 15.6% (of the 262 respondents) for the pilot study and 11.9% (of the 2490 respondents) for the main study. The details of the data collection in both cases are explained in the below section.

3.3. Discrete choice experiments

Constructing a D-efficient design experiment requires priors for parameters of the model that can be obtained via three different ways: existing literature, expert judgement and pilot studies (Bliemer and Collins, 2016). We chose the third option, because, in addition to this being the first study examining synchromodal transportation demand, no existing study includes control as an attribute to account for the transfer of the mode choice decision from shippers to LSPs. With regard to the second option, although we know what the right sign is for every attribute e.g., transportation cost has a negative sign in the utility function, having one or a few expert(s) assume the magnitude of the priors for synchromodal transportation increases the likelihood of obtaining biased priors, which is why we decided to conduct a pilot study, as the most reliable option to obtain priors from our population of interest.

3.3.1. The pilot study

An orthogonal SP experiment was created to obtain preliminary insights about shippers' preferences for two hypothetical synchromodal transportation services, against their current transportation alternative. Three sets of attributes were included in the experiment: the common attributes of modal choice, such as transportation cost, time and reliability, the special attributes of synchromodal transportation, which are control and flexibility, and value-added services (VAS). The attributes are defined as follows:

Table 1
Attributes and their levels in the pilot study.

Attributes	*Synchromodal service*		*Current service*
	1 (premium)	*2 (budget)*	
Door-to-door transportation Cost ($)	+1% +2% +4%	Current level −1% −3%	Current level
Door-to-door transportation Time (days)	−10% −20% −30%	+20% Current level −20%	Current level
Control over transportation mode and route (service level)	No control Low	No control Low	Current level
Flexibility to adapt shippers' required changes (service level)	Low Medium High	No flexibility Low Medium	Current level
Reliability in on-time delivery (% delivery times)	+10% +15% +20%	−10% Current level +10%	Current level
Value-added services (VAS): tracking, customs, … (service level)	Low Medium High	No VAS Low Medium	Current level

- End-to-end cost is the total amount of money paid for shipping one TEU (20-foot container) from origin to destination (adapted from Arencibia et al. 2015).
- End-to-end transportation time is the duration from the shipment's first origin to its final destination (adapted from Arencibia et al. 2015).
- Reliability is the on-time delivery of freight/goods at the destination (adapted from Arencibia et al. 2015).
- Control is the authority level of the shipper to decide its preferred transportation mode/route.
- Flexibility is defined as the ability of a transportation service to effectively fulfil a shipper's required changes in service components before finalizing the booking of the transportation service, and while goods are on their way towards their destination. Examples include changing in delivery time/location, shortening or extending lead times, and consolidating or deconsolidating volume/variety via warehouses or cross-docking terminals (mode-volume switch locations). The shipper has full authority over the volume-related decisions (we extended the definitions of flexibility proposed by Swafford et al. (2006) and Ben-Akiva et al. (2008)).
- Value-added services (VAS) are ancillary services including tracking and tracing, storage and handling, customs and packaging offered by the LSP beyond the main transportation service (Roso et al. 2009).

The next step in designing the orthogonal SP experiment involved determining attribute levels. We considered three alternative transportation services, including two synchromodal transportation services called *budget* synchromodal service (BSS) and *premium* synchromodal service (PSS), and the *current* service that the shipper is using at the moment. As depicted in Table 1, each synchromodal alternative has six attributes with three levels. Cost, Time and Reliability are reflected with positive (increase) or negative (decrease) percentage compared to the current transportation service the shipper is using. The attribute levels for Control, Flexibility and VAS are based on the service-level concept for attributes like flexibility and frequency, as applied in Danielis and Marcucci (2007) and Arencibia et al. (2015). Control has two service levels (*Low* and *Not provided*) compared to the current transportation market, where shippers usually have a high level of control over selection of their desired transportation mode and route (Tongzon, 2009). *Not provided* means that decisions regarding transportation mode and route will exclusively be made by the LSP, while a *Low level* of control means that the LSP still has the authority to make decisions regarding transportation mode and route, but would consult with shipper if needed. Flexibility has four service levels (*High, Medium, Low* and *Not provided*). As an example, a *High* flexibility level means that the synchromodal transportation service is highly flexible to adapt shipper's required changes in terms of destination, delivery time window, lead time, freight volume (de)consolidation, and so on. VAS also has four service levels (*High, Medium, Low* and *Not provided*). The quantity of value-added services provided by the LSP will be reduced from a High service level to a Low one.

The characteristics of the reference alternative i.e., the current service, is 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 (or no change) to be comparable to percentage changes in the synchromodal alternatives (same approach as Arencibia et al., 2015). For example, when a synchromodal alternative time is +20%, that means that the door-to-door transportation time is 20% longer than that of the current alternative. Unlike cost, time and reliability, our definitions for flexibility and VAS have not been empirically tested in existing literature. This increased our concerns about whether or not the respondents would be able to make a true comparison between the flexibility attribute of the synchromodal alternatives and that of their current option. As such, the base service level for flexibility and VAS attributes of the reference alternative was set to zero, to maintain the same picture for the respondents. Based on this assumption, the shippers are asked to compare zero flexibility (and VAS) of the reference alternative with none (zero), low, medium and high level of flexibility (or VAS) of a synchromodal alternative. 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 they have high control over 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 non-existing or low level of control in synchromodal services. Since our study is not a mode choice study, but a mode abstract study examining the extent to which shippers are willing to relinquish control within the context of mode choice, we do not examine the modal split of the current alternative.

Using a full factorial design would need $3^{(2*5)} * 2^{(1*2)} = 236{,}196$ choice tasks. To reduce that number, an orthogonal fractional factorial design[2] (Kocur et al. 1982) was developed in which 18 choice tasks are grouped in two choice sets (two blocks), where each one contained nine choice tasks and was included in a web-based survey using an online survey platform (Surveygizmo, 2017). 262 executives from 56 firms (out of the list of 556 firms) were randomly selected for the pilot study. Each survey was sent via email to 131 respondents from the population of companies selected as responding to the pilot study. We received 19 and 22 complete responses from pilot surveys 1 and 2, respectively (representing an 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 are shown in Table 2.

All attributes have the expected signs, i.e., negative utilities for increase in cost and time and positive utilities for increase in control, flexibility, reliability and VAS. Apart from value-added services, the remaining attributes are statistically significant. The significance of the current transportation option reveals the fact that some shippers may face inertia or be unwilling to move toward synchromodal transportation.

3.3.2. The main study

Efficient designs are among the most popular choice experiment design methodologies due to their advantages when dealing with stated choice data. Obtaining more reliable estimates with a smaller sample size is regarded as one of the main advantages of efficient designs (Rose and Bliemer, 2013). Table 3 shows the attributes and their levels for the main study. To avoid an overly complex choice experiment, we made a number of necessary assumptions regarding other important attributes, such as safety, security, frequency and rules and regulations. We assumed that (i) international rules and regulations allow for synchromodal transportation requirements, (ii) freight will be delivered without any change in damage or loss compared to the shippers' current transportation option, and (iii) service frequency is the same as their current transportation service.

Using the parameter priors from our pilot study and revised attribute levels, the Ngene software (Choice Metrics, 2010) was applied to maximize statistical efficiency for creating a D-efficient optimal design for the main study. In order to create the choice sets for the main study we applied the Ngene software. In general, we selected a fractional factorial design as our main design type. Two major design types in fractional factorial designs are orthogonal design and efficient designs (Rose and Bliemer, 2009). Because of the advantages of efficient designs mentioned earlier, we chose efficient designs. When it comes to efficient design, several design types exists including A-efficient, S-efficient, D-efficient, C-efficient designs which are different in the way they measure the design's efficiency (Rose and Bliemer, 2009). We considered the D-error statistic[3], as the most predominantly used measure (Rose and Bliemer, 2009), to generate a D-efficient design. In particular, we applied a Dp-efficient design where none-zero priors (obtained from pilot study) are incorporated into the design procedure[4] (Rose and Bliemer, 2009).

Keeping that in mind, we obtained the choice sets from Ngene software via the following steps. In the first step, because our synchromodal alternatives were unlabeled, we considered all parameters (six attributes and one alternative-specific constant for the current option) as generic. We considered the attribute levels of the pilot study (see Table 1) and entered them into the utility function as effects codes between 0 and 1, i.e., a percentage between 0% and 100% for cost, time and reliability, and an attribute level of *None, Low, Medium and High,* coded as 0, 0.33, 0.67 and 1, for flexibility, VAS and control. We considered the main effects for the MNL model. In the next step, we added the constraint of having attribute level balance[5] in Ngene and created the initial random D-efficient design consisting of 12 choice tasks. Once the initial design was obtained from Ngene, we calculated the choice probabilities for each alternative, to ensure the utility balance between the alternatives. Next, the statistical efficiency of the design was evaluated using the D-error reported by Ngene. In the subsequent steps, we changed the initial design to identify more efficient designs i.e., lower D-error. After several trials and after investigating dominancy of the choice tasks we obtained, we realized that the high degree of overlap regarding the flexibility and VAS attribute levels between premium and budget synchromodal services may make some of the budget services dominant, in particular, from practical viewpoint. As such, we reduced the attribute levels of flexibility and VAS from three to two (removing the lowest attribute level) for the premium service to make this service more distinct from the budget service, which also helped reduce the D-error of the design. The final D-efficient design (D-error = 0.08508) has 6 choice tasks.

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[2] This design was a sequential orthogonal design, in which orthogonality holds within each alternative only.

[3] The D-error statistic is calculated by taking the determinant of the asymptotic variance–covariance (AVC) matrix assuming a single respondent, $\Omega 1$, and scaling that value by the number of parameters, K.(Rose and Bliemer, 2009)

[4] Based on the assumptions about the values for prior parameters, three type of D-efficient designs exist. If the priors are assumed to be zero, the resulting design is called Dz-efficient design. When priors are known with certainty, the design is called Dp-efficient design. If the true population parameters are not known with certainty, prior parameter estimates are drawn from Bayesian parameter distributions (with parameters θ). These designs are known as Bayesian or D_b-efficient designs (see further explanations in Rose and Bliemer, 2009)

[5] Attribute level balance means that "each attribute level appears an equal number of times for each attribute. Having attribute level balance ensures that the parameters can be estimated well on the whole range of levels, instead of just having data points at only one or a few of the attribute levels" (Rose and Bliemer, 2009).

Table 2
Estimation results for the pilot study (orthogonal design).

Attributes	*MNL model*	
	Coefficient	*t-value*
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. *$p < 0.1$, **$p < 0.05$ and ***$p < 0.01$ for statistical significance.

Table 3
Attributes and their levels in the main study.

Attributes	*Synchromodal service*		*Current service*
	1(premium)	*2(budget)*	
Door-to-door transportation Cost ($)	+1% +2% +4%	Current level −1% −3%	Current level
Door-to-door transportation Time (days)	−10% −20% −30%	+20% Current level −20%	Current level
Control over transportation mode and route (service level)	No control Low	No control Low	Current level
Flexibility to adapt shippers' required changes (service level)	Medium High	No flexibility Low Medium	Current level
Reliability in on-time delivery (% delivery times)	+10% +15% +20%	−10% Current level +10%	Current level
Value-added services (VAS): tracking, customs… (service level)	Medium High	No VAS Low Medium	Current level

Table 4
Example of a choice task in the main study.

Attributes	*Synchromodal 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 4 shows an example of a choice task.

One of the key advantages of the family of D-optimal designs (i.e., Efficient designs) is their robustness when it comes to minimizing the variance of the resulting parameter estimates. This helps avoid bias parameter estimates which can come from the presence of dominant alternatives in orthogonal designs (Hess et al. 2010; Bliemer et al. 2015). A dominant alternative is a choice that all of its attributes are better (or worse) than the other alternative(s). It posits no trade-off for the respondent, thus providing no information to the analyst (Hensher et al. 1988). While none of our six choice tasks are dominant, we also captioned synchromodal budget and premium services to generic services, called service1 and service2 in our web-based survey, to prevent non-trading (e.g., always choosing a dominated alternative) and lexicographic (always choosing a particular attribute) behavior of respondents. Hess et al. (2010) emphasized that non-trading behavior is far less common in the unlabeled choice experiments and the chance of

Table 5
Demographics of the respondents.

Respondent Position	*%*	*Company size (#employees)*	*%*	*Annual Revenue*	*%*	*Economic sector*	*%*
C-level/Top Mgmt	21%	< 99	4%	< $100 Mn	10%	Basic Materials	12%
Senior/Middle Mgmt	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%
		10,000–49,999	28%	$10–50 Bn	27%	Healthcare	11%
		> 50,000	36%	> $50 Bn	22%	Industrials	7%
						Technology	16%
						Telecom Services	8%
						Utilities	2%
						Others	0%
Total	100%	(296)					

lexicographic behavior is much smaller in complex choice experiments i.e., the ones with more than two attributes.

Using the Surveygizmo platform, a web-based survey was constructed consisting of three main sections. Synchromodal transportation was introduced in the first section, explaining its characteristics, the idea of the mindset shift from physical toward service connectivity, along with two examples of its operation and the resulting business value. We included containerized synchromodal transportation as a global standard norm, to avoid misunderstanding among respondents with regard to bulk, pipeline and other transportation types. The second section was designed to collect sociodemographic information of the respondents, their company and their logistics function. The third part of the survey involves the SP choice task. We conditioned the choice tasks based on different shipment sizes, since mode choice decisions are usually associated with the amount of products to be shipped.

The survey was sent via email to 2490 respondents between December 2017 and February 2018. After three follow-up rounds, 296 usable responses were collected, providing 1776 usable SP observations. Based on the number of questionnaires we distributed, the response-rate is 11.9%. We looked at if there was more than one respondent per company. In total, 194 unique companies responded to our survey, representing 38.8% of the 500 companies in our list of Global Fortune 500 companies and the main customers of largest LSPs. Table 5 shows the profiles of the respondents and companies involved.

The estimation of the latent class model is done by applying the Latent Gold software (Vermunt and Magidson, 2005). In the first step, we determine the proper number of latent classes by estimating the models based purely on the available information on shippers' choices, without explicitly considering covariates like commodity type. Using latent Gold, we started estimating models with one to six classes. Table 6 shows the model fit of the various models. As highlighted in section 2.1, models with the lowest possible BIC and AIC measures reveal the proper number of latent classes. As shown in Table 6, when the number of classes increases, the AIC decreases, whereas BIC increases after the fourth class. As a result, the latent class model with four classes, which has the least BIC and a good model fit (McFadden's R2 of 0.409), is chosen.

After establishing the main LC model with four classes (see estimation results in Table 7), we need to see the impact of contextual variables (or covariates) of the shipment. Considering covariates helps explain the variability in class memberships by assessing how the probability of belonging to each class depends on different covariates. We included several contextual factors as model covariates. Covariates like product type (i.e., finished, semi-finished and raw), respondent position (i.e., C-level, senior/middle manager) and respondent's job function (i.e., supply chain, transportation/logistics, distribution) proved to be insignificant, while covariates like shipment size, commodity type and company size turned out to be significant (See Table 8). In the web-based survey, the commodity types are categorized based on the Thomson Reuters business classification (2012). The dummy variables of commodity types and shipment sizes are used as segment membership variables. The reference category for commodity type is telecommunication and, for shipment size, it lies above 100 TEUs. The annual revenue is included as a continuous variable in our modeling with Latent Gold.

Table 6
Model fit for the latent class choice models.

Criteria	*Number of classes*					
	1 (MNL)	*2*	*3*	*4*	*5*	*6*
Log-likelihood at convergence	−1914.26	−1639.12	−1562.38	−1487.51	−1447.87	−1410.87
McFadden's R^2	0.1270	0.2657	0.3754	0.409	0.395	0.4379
Number of parameters	7	33	59	85	111	137
Number of observations	1776	1776	1776	1776	1776	1776
Akaike information criteria (AIC)	3842.53	3344.25	3242.77	3145.03	3117.74	3095.75
Bayesian information criteria (BIC)	3868.36	3466.03	3460.50	3458.71	3527.37	3601.33

Table 7

Estimation results for the MNL and latent class models.

	MNL		*LCM*							
			Class1		*Class2*		*Class3*		*Class4*	
	Estimate	*z-value*	*Estimate*	*z-value*	*Estimate*	*z-value*	*Estimate*	*z-value*	*Estimate*	*z-value*
Class size (%), n = 1776			35.9		32.3		18.4		13.4	
Choice share within each class (%)										
PSS	39.8		71.6		19.1		31.9		0.4	
BSS	28.8		22.7		32.6		65.9		1.1	
Current option	31.3		5.7		48.3		2.2		98.5	
Taste parameter estimates										
ASC$_{\text{Current option}}$	0.435***	4.21	−0.671*	−1.82	1.148***	4.74	−3.187***	−5.86	9.303*	1.66
Cost	−10.28***	−5.26	−9.089***	−2.62	−25.22***	−5.31	−3.452	−0.72	52.98	1.03
Time	−1.047***	−4.58	−3.341***	−4.67	−0.480	−0.93	0.760	1.31	0.280	0.02
Control	0.863***	2.87	1.603**	2.15	2.373***	3.35	−0.399	−0.52	−24.67*	−1.79
Flexibility	0.382***	3.23	1.222***	3.90	0.078	0.30	0.242	0.72	8.303	0.90
Reliability	0.692	1.50	4.583***	4.15	0.508	0.56	−6.009	−3.98	−49.47	−1.21
VAS	0.153	1.10	−0.546	−1.36	0.282	0.99	0.517*	1.73	1.988	0.24
R^2 (%)	12.7		43.6		10.6		31.5		96.5	

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

Table 8

Class membership functions of the Latent class model.

	Class1		*Class2*		*Class3*		*Class4*	
	Estimate	*z-value*	*Estimate*	*z-value*	*Estimate*	*z-value*	*Estimate*	*z-value*
Commodity types								
Energy	0.969	0.80	1.690*	1.73	0.332	0.31	Base segment	
Chemicals	2.294*	1.87	2.337**	2.09	0.614	0.49		
Basic materials	2.571*	1.82	1.899	1.41	3.144***	2.47		
Industrials	2.353**	2.13	0.494	0.42	0.069	0.05		
Automobiles & auto parts	7.144	0.86	6.498	0.79	5.025	0.61		
Diversified cyclical retail	7.402	1.01	6.491	0.89	5.832	0.80		
Textiles & apparel	1.156	0.97	0.849	0.80	0.282	0.26		
Other non-cyclical retail	2.177*	1.82	0.352	0.26	−4.731	−0.48		
Food & drug	2.836*	1.89	3.169***	2.35	1.884	1.39		
Food & tobacco	1.796*	1.70	1.666*	1.79	0.175	0.16		
Health equipment	3.562*	1.85	2.185	1.05	0.915	0.41		
Pharmaceuticals	1.082	1.04	−0.010	−0.01	−0.620	−0.58		
Computer & semiconductor	3.303***	2.35	2.373*	1.73	2.137	1.55		
Electronic equipment & parts	0.912	0.86	1.233	1.38	0.734	0.78		
Others	3.930***	2.66	2.627*	1.78	0.694	0.40		
Shipment size (TEU)								
Up to 25	0.388	0.62	−0.037	−0.06	−0.646	−0.92		
25–100	−0.998	−1.36	−1.316*	−1.85	0.051	0.07		
Annual revenue	1.370**	2.17	1.164**	1.81	0.145	0.20		
Intercept	−1.708	−1.58	−0.825	−0.87	−0.240	−0.26		

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

4. Estimation results and discussion

4.1. Results of the multinomial logit and latent class models

The results of estimating the MNL and LC models are shown in Table 7. 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 value of cost, time, control and flexibility is 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. As shown in Table A1 (see appendix 1), cost, time and flexibility make up a larger proportion of relative importance among all attributes.

The latent class model is developed here to clarify the apparent ambiguity of shippers' preferences for different attributes and unfold a substantial degree of taste heterogeneity. It should be pointed out that, during the estimation of the MNL and LC models, we considered high level of modal control for the current alternative, since 78% of the respondents indicated that they themselves (and not the LSP) decide the transportation mode, when asked about it in the first part of the survey. This assumption is consistent with existing literature (see e.g. Tongzon 2009). In addition, we do not consider any ASC for both synchromodal alternatives, since we included them as unlabeled generic alternatives in our modeling. This is due to the fact that we named premium and budget synchromodal alternatives as synchromodal service 1 and synchromodal service 2 in the web-based choice experiment, respectively. As such, there is no difference between them in terms of brand effect. According to Train (2009), there is no need to consider ASC for unlabeled alternatives, since there is no brand effect in generic alternatives.

One of the remarkable advantages of latent class modelling is that it allows to identify behaviorally homogeneous segments within a potentially heterogeneous population (Greene and Hensher 2003; Hess et al. 2011). In Table 7, two distinct segments of shippers are recognizable, based on their willingness to delegate control of mode and route to LSPs. The first category includes the first and second latent classes, which together make up 68.2% of the sample and are potentially willing to delegate authority involving the selection of transportation mode and route to the LSPs. The second group involves third and fourth classes (31.8%), which may not be willing to risk losing their control over the transportation mode and route.

More than one third of the population (35.9%) belongs to the first class of shippers, which could be called *high service-level seekers*. Most of them selected premium synchromodal service (PSS) i.e., in 71.6% of choice situations. This class of shippers is seriously seeking improvements in service levels of the transportation, since the coefficients of time, flexibility and reliability are significant and have the expected signs. In addition, they selected a synchromodal service (i.e., PSS or BSS) in more than 94% of choice situations, emphasizing their willingness to delegate their authority over transportation mode and route selection to the LSPs in return for a reliable, fast and flexible transportation service at a competitive price. The significance of control in the first latent class shows the shippers' natural instinct to maintain modal control. However, the maximum level of control is *low* for the synchromodal services selected by most respondents in this class. This highlights the fact that, although shippers like control, they prefer to maintain control at the lowest possible level (e.g., little to no control), in return for a quality service with desirable levels with regard to time, reliability and flexibility. Table A1 (see appendix 1) indicates that time, reliability and flexibility are the core attributes (highest relative importance) for these shippers. It seems that they are not looking for value-added services, as their requirements for basic service performance are more important or have not yet been met (viz. the insignificant coefficient of VAS). The negatively significant alternative-specific constant of the current transportation option ($\text{ASC}_{\text{Current option}}$) indicates that these shippers are not very satisfied with the existing transportation services in the market.

The second class of shippers (class size of 32.3%) could be called *cost-sensitive risk-taking shippers.* These firms selected a synchromodal service more than half of the time (51.7%) and their control attribute is positively significant, which tells us that they are willing to take risk and transfer their modal selection authority to the LSPs, provided they get a very cheap transportation service in return (i.e., a significantly large cost coefficient). Otherwise, they will probably return to their current transportation services, with which they are satisfied as it is (i.e., positive and significant value for ASC of the current transportation option). In 48.3% of choice situations, they selected their current transportation service and in 32.6% of they chose a BSS, which has the same or a lower price compared to their current service. The relative importance of cost and $\text{ASC}_{\text{Current option}}$ together represents more than 70% (see Table 8). These results demonstrate that the shippers in the second class are more interested in procuring the most cost efficient transportation services, irrespective of whether that is their current service or a new service for which they would have to delegate modal control.

The third group of shippers represents 18.4% of the population and could be called *Ancillary service seekers*. They are not satisfied with their current transportation services (i.e., negatively significant $\text{ASC}_{\text{Current option}}$ coefficient). Most shippers in this group (97.8%) opt in favor of the two synchromodal services (i.e. PSS and BSS), which they believe are likely to provide a reasonable level of value-added services. These shippers are mainly looking for value-added services beyond the main transportation service.

13.4% of shippers fall into the last segment and could be called *risk-averse shippers.* They are satisfied with their current transportation service and selected that service in 98.5% of choice situations, to avoid changes in their current transportation operations. In particular, it appears that they do not even evaluate any new service package if it violates their modal control authority (see the negatively significant coefficient for the control attribute).

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 examine how this bias affects our results, we investigated our dataset, which shows 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 keeping 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).

We now turn to the membership question: to what extent does the probability of belonging to a certain class depend on the type of firm, shipment size and commodity type? The class membership functions of the latent class model are shown in Table 8, while Table 9 categorizes the companies based on the number of employees and annual revenue.

The probability of belonging to the *high service-level seekers* group is higher for companies with annual revenues in excess of more than US$ 10 billion (i.e., positively significant coefficient in Table 8). According to Table 9, these companies are often extra-large and

Table 9
Annual revenue based on company size.

Annual Revenue	*Company size (# employees)*				*Total*
	SME (Up to 999)	*LE (1000–9999)*	*XLE (10,000–49,999)*	*XXLE (50,000 +)*	
Below 1 Bn	17.3% (51)	8.7% (26)	2.4% (7)	0	28.4% (84)
$1–10 Bn	0.3% (1)	6.1% (18)	13.9% (41)	3% (9)	23.3% (69)
$10–50 Bn	0	1.7% (5)	9.1% (27)	15.9% (47)	26.7% (79)
> $50 Bn	0.3% (1)	1.7% (5)	2.4% (7)	17.2% (51)	21.6% (64)
Total	17.9% (53)	18.2% (54)	27.8% (82)	36.1% (107)	100% (296)

Note. SME: small and medium-sized enterprises, LE: large enterprises, XLE: extra-large enterprises, XXLE: extra extra-large enterprises.

extra extra-large global shippers with more than 10,000 employees. The shipment quantity of this class of shippers is most likely up to 25 TEUs (i.e., positive coefficient reveals higher probability (see Table 8)). Companies operating in Industrial goods and equipment (i.e., aerospace and defense, construction and engineering, diversified industrial goods, industrial conglomerates; and machinery, tools, heavy vehicles, trains and ships), pharmaceutical industry, and other non-cyclical retail products (i.e., beverages, and personal and household products and services) most probably fall into the first class of shippers.

Extra-large and large firms (10,000–50,000 employees) with annual revenues of US$ 1 to 10 billion are more likely to belong to the second class of *cost-sensitive risk-taking shippers*, where they are also willing to send shipment sizes up to 25 TEUs. The energy industry (i.e., coal, electric utilities and IPPs, natural gas utilities, oil and gas, and oil and gas related equipment and services) falls mainly in this second class, and it is most probably the major segment for industries in the electronic equipment and parts business as well.

The third class of shippers most probably includes small to medium-sized fortune companies with fewer than 1000 employees and up to US$ 1 billion USD in annual revenues. The *Ancillary service seekers* appear to be willing to have shipment sizes in excess of 25 TEUs. Shippers of basic materials (i.e., construction materials, containers and packaging, metals and mining, and paper and forest products) are fall into this third class, while some of them are also interested in the transportation services included in the first latent class.

With regard to other industries, it seems that shippers operating in the healthcare equipment industry are mainly *high service-level seekers*, although some of them also belong to the *cost-sensitive risk-taking shippers* category. Companies operating in the chemical industry, in textile and apparel, or food and tobacco (i.e., fishing and farming, food processing and tobacco) most probably belong to the first or second class, and are less likely to fall into the third class. Four industries, including automobiles and auto parts, food and drug retailing, computer and semiconductors (i.e., communications and networking, semiconductors and its equipment, office equipment; and computers, phones and household electronics), and diversified cyclical retail goods (i.e., diversified retail, home-building and construction supplies, household goods, and leisure products) do not have a distinguishable association to one of the four transportation service demand classes identified here.

4.2. *Willingness to pay measures*

To understand the impact of different attributes of the transportation service on the choice of shippers, we estimate their willingness to pay (WTP) for improving attributes of the services provided by LSPs (our approach is similar to the one adopted by Arencibia et al., 2015). WTP measures provide very useful guidelines to LSPs in terms of improving their transportation services, and to policymakers when it comes to evaluating different improvement policies. Using the Latent Gold software, the WTP for each attribute in the MNL and LC models is obtained as the ratio of marginal utility of the attribute and the marginal utility of the transportation cost (McFadden, 1981) (see Table 10).

WTP figures are only calculated for parameters that have the expected sign. The average shipment cost of one TEU container is considered to be € 100. In the MNL model, the average WTP for a day's reduction in the end-to-end transportation time is estimated at € 10.17. Regarding control, flexibility and value-added services, shippers are willing to pay € 8.39, € 3.71 and € 1.49, respectively, for one level enhancement of control, flexibility and VAS. The *high service-level seekers* category of the latent class model are willing to

Table 10
Willingness to pay for the MNL and Latent class models.

Attribute	*MNL*	*LCM*		
		Class1	*Class2*	*Class3*
Time (€/day)	10.17***	36.76**	1.90	–
Control (€/service level)	8.39**	17.63	9.40***	–
Flexibility (€/service level)	3.71***	13.43**	0.31	7
Reliability (€/delivery times)	6.72	50.43***	2.01	–
VAS (€/service level)	1.49	–	1.12	14.96

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

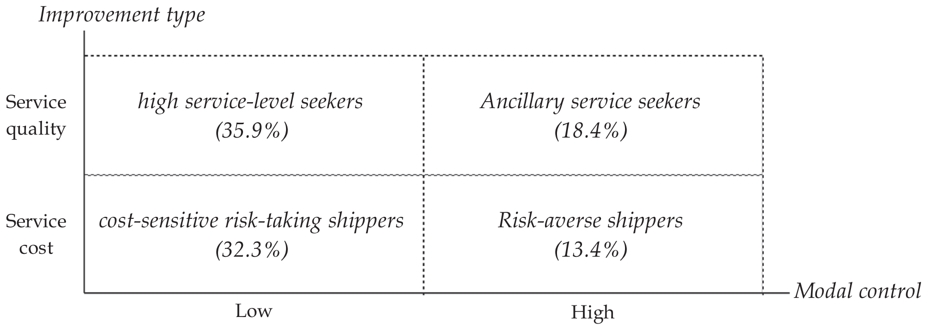

Fig. 2. Service improvements sought by shippers based on their modal control.

pay € 36.76, € 50.43 and € 13.43, respectively, for every unitary improvement in time, reliability and flexibility of the transportation service demonstrating the highest intention for WTP compared to the other latent classes. As expected, the *cost-sensitive risk-taking shippers* (second latent class) are reluctant to pay much to improve service attributes, because they are looking above all for low-cost transportation services. Although not statistically significant, willingness to pay for new ancillary value-added services is highest in the *Ancillary service seekers* category (the third latent class of shippers) i.e., almost € 15 for one level of service improvement.

4.3. Shippers segmentation

The approach used in this study clarified the shippers' attitude toward modal control delegation and synchromodal transportation demand, and identified four different market segments for service quality and cost improvements toward the global community of LSPs, freight forwarders and carriers. Incorporating the demographic and shipment characteristics of shippers into the latent class model not only increased the model fit, but also uncovered crucial information about the type and magnitude of the shippers' companies and their commodities. The demand for synchromodal transportation is different for different shipper segments. As shown in Fig. 2, there are two categories of shippers based on the type of improvement sought: cost reduction or service quality improvement (i.e., improving the quality of the transportation service in one of the attributes of time, flexibility, reliability and VAS or a combination of them).

More than 54% of shippers (i.e., class 1 and class 3) are interested in service improvements, with almost 36% of shippers (i.e., *high service-level seekers*) looking for improvements in the main service attributes, such as time, flexibility and reliability, while approximately 18% are looking for ancillary services that go beyond the transportation service, such as value-added services. The remaining shippers, representing approximately 46% of the overall population (i.e., class 2 and class 4) are mainly interested in cost reductions. With regard to the delegation of modal control, the first and second classes (approximately 68% of the overall population) are willing to hand over control to the LSPs, whereby the first class of shippers need to be rewarded with service improvements, while the shippers in the second class are looking for cost reductions in return. Shippers of the fourth segment are not willing to hand over control, while shippers in the third segment appear to be less strict about deciding which mode of transportation is selected, although some of them are willing to maintain modal control.

5. Conclusions and practical implications

5.1. Implications for practice

This research indicates that there is a certain degree of eagerness among leading shippers to derive more value from transportation services, with the aim of supporting supply chain competitiveness. With regard to the first three classes of shippers which are more inclined to favor changes in transportation services, there appears to be sufficiently fertile ground to innovate logistics and transportation services, which is reinforced by the fact that the shippers in these three classes are all Global fortune 500 companies and often industry leaders. The strategic decisions that they make have significant impacts on their competitors and customers, as well as on the global market as a whole (Bloom and Kotler, 1975; Yeung, 2007; Defee et al. 2009). As a result, it is to be expected that the preferences of these global leader shippers will at some point become widespread within the industry.

Several managerial recommendations can be derived from this study as far as LSPs and public policy-makers are concerned:

- LSPs can use the results in Table 8 to identify industries that may be interested in working together to develop pilot projects involving the use of synchromodal transportation services. Right value proposition for different shipper segments is key factor in attracting them. For shippers looking for cost reductions (i.e., the *cost-sensitive risk-taking shippers*), LSPs can efficiently utilize the obsolete capacity of transportation modes to obtain cost-saving benefits. Regarding customer segments that seek high service quality (i.e., the *high service-level seekers*), LSPs can provide service benefits by exploring the impact of flexibility. In addition, LSPs can adopt a gain sharing approach (Hartmann and de Grahl, 2011) and work together with other LSPs to share their mode-volume switch locations (e.g., warehouses, crossdocking terminals) in order to provide flexible services to shippers. This could enable shippers to ask for changes in the transportation lead time, delivery window, destination and shipment volume (i.e., via consolidation and deconsolidation of volumes) in response to their market circumstances. Providing long-term quality services to shippers that delegate modal control to the LSPs is crucial to gain the trust required for the long-term growth of synchromodal transportation services.

- LSPs can explore the different characteristics of the four customer segments to design tailor-made service packages with different service levels, varying in transportation frequency (e.g. daily availability), speed, reliability, value-added services and flexibility, at different prices. A sophisticated revenue management system and capacity planning and allocation process is needed to determine the long-term and short-term transportation (e.g., different modes) and ancillary (e.g., value-added services) resources required to meet shipper's demand for various service packages.
- Public policy-makers could use the insights provided by this study as input for long-term decisions about transportation network improvements, with the aim of providing greater flexibility, reliability, efficiency and sustainability. As modal control delegation becomes more common, predictive freight flow models that help guide infrastructure and service investments have to be aligned to these new practices. Policy measures could be introduced to support the development of the transshipment hubs and information systems needed for synchromodality (Veenstra et al., 2012). This could help the policy-makers of international organizations like the European Commission to achieve their objective of re-balancing the modal share between road and rail/maritime towards a more sustainable transportation system (European Commission, 2006). Special attention should also be paid to the adoption of international rules and regulations to enable the true utilization of synchromodal services.
- The emerging paradigm in modal control delegation could pave the way for transitioning towards major transportation and logistics innovation visions, such as the Physical Internet (Montreuil, 2011). Improving the efficiency and utilization of international transportation networks could ultimately help global production and transportation community move more quickly towards global sustainable supply chains. Having full freedom to select different modes and routes could enable LSPs to work together with manufacturing/production environment toward an integrated manufacturing and logistics network. Ultimately, collaboration and coordination of suppliers, manufacturers and distributors with transportation service providers could make the vision of an open global supply network a reality.

5.2. Conclusions and future research directions

In this study, we focused on the attitudes of leading shippers regarding the delegation of control over the selection of transportation mode and route to LSPs. We identified the heterogeneity in shippers' behavior and demand for synchromodal transportation. Compared to most mode choice studies, this study introduced three interesting attributes to reveal hidden decision-making attitudes among shippers that are important for developing innovative service propositions: modal control, flexibility and value-added services.

The first attribute is called *modal control*. Almost all studies involving the planning, application and implementation of synchromodality, for instance Dong et al. (2018), assume that shippers can and will hand over modal control to the LSPs. However, in practice, shippers find it difficult to relinquish control. What we assumed and empirically validated about the possibility of delegating control is very important, because it has a direct impact on the feasibility of implementing synchromodal transportation and future transportation innovations like the Physical Internet. In this study, we validate our assumption by introducing modal control as a new service attribute into a service choice experiment among major leading firms. The results emphasize the important impact of modal control on service choice of shippers. Also, it shows that there is a considerable likelihood that shippers will delegate modal control to LSPs, if they are rewarded by improved service quality or cost. Another newly defined attribute applied in this research is *flexibility*. Our definition of flexibility covers various changes required by shippers before finalizing the booking, as well as after departure of freight toward its destination. Compared to existing literature, the *en-route* part of our definition of flexibility is new. It could be provided by mode-volume switch options in the synchromodal transportation network, to allow shippers to (de)consolidate commodities based on demand fluctuations at their destination market locations. The third novel attribute is *value-added services*, or ancillary services beyond the basic transportation service, which has also received very little attention in relevant literature, in which VAS does not included in choice modeling studies. Our results show that there is at least one segment in the market willing to consider and pay for each of the three new attributes.

We find that over two-thirds of the shippers may be willing to relinquish control over transportation modes and routes, if they are rewarded by better services or lower costs. This result is particularly interesting since 78% of the shippers in our sample highlighted that they (rather than their LSPs) are currently in charge of selecting the transportation mode when we asked them about their current role regarding modal control at the start of the survey. Four distinct market segments were identified in this study, with a different nature of demand for services. The first and largest segment is called *high service-level seekers,* who have high willingness to use synchromodal services and delegate modal control, provided LSPs are able to secure high-quality transportation in terms of service time, flexibility and reliability. The *cost-sensitive risk-taking shippers* make up the second largest segment. They are mainly willing to relinquish modal control in exchange for cheaper transportation services. The third shipper segment is called *ancillary service seekers* who are to a large extent willing to delegate modal control by shifting towards synchromodal services that provide the value-added services they are looking for in a transportation service. The fourth segment contains the *risk-averse shippers* who are not willing to relinquish modal control and prefer using the transportation services they are currently using. The segments indicate that there are opportunities for a variety of transportation service improvements. While low-cost synchromodal services could be in demand in three of the four segments, the first and largest segment (making up more than one-third of the market) favors a premium synchromodal transportation service. The remarkably high WTP of this group indicates a great potential for LSPs when it comes to designing and implementing synchromodal services for the large leading shippers in this segment.

Several new studies could be conducted to shed more light on the way the modal control delegation paradigm is emerging. Scholars can focus on specific industries, geographical areas or commodity types. Important attributes that could be added include safety and security, trust and collaboration between LSPs and supply chain actors, as well as cost and profit sharing among LSPs and shippers. Some shipment characteristics, like distance or commodity value, can be used to model the shippers' choice. Requirements and conditions of shippers when it comes to applying synchromodality could be identified. The identification of customer segments presents opportunities for differentiated planning, scheduling, network design, revenue management and real-time decision-making. Business cases could drive forward more detailed studies involving supply chain resilience and flexibility, demonstrating the value of delegated modal control in the face of network disruptions or sudden demand changes.

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Appendix

Table A1.

Table A1
Relative importance (RI) and marginal effects (ME).

Attributes	*MNL*		*LCM*							
			Class1		*Class2*		*Class3*		*Class4*	
	RI (%)	*ME*	*RI (%)*	*ME*	*RI (%)*	*ME*	*RI (%)*	*ME*	*RI (%)*	*ME*
$ASC_{\text{Current option}}$	16.8	0.097 (0.02)	10.4	−0.149 (0.08)	27.7	0.255 (0.05)	49.4	−0.708 (0.12)	18.5	2.067 (1.26)
Cost	27.7	−2.286 (0.43)	9.9	−2.02 (0.77)	42.6	−5.604 (1.06)	3.8	−0.767 (1.07)	21.3	33.996 (32.9)
Time	20.2	−0.233 (0.05)	25.9	−0.743 (0.16)	5.8	−0.107 (0.11)	5.9	0.169 (0.13)	0.3	0.062 (3.94)
Control	6.7	0.192 (0.07)	5	0.356 (0.17)	11.5	0.527 (0.16)	1.2	−0.089 (0.17)	9.8	−5.484 (4.59)
Flexibility	14.7	0.085 (0.03)	19	0.271 (0.07)	1.9	0.017 (0.06)	3.7	0.054 (0.08)	16.5	1.845 (2.06)
Reliability	8.0	0.154 (0.10)	21.3	1.019 (0.25)	3.7	0.113 (0.2)	28	−1.335 (0.34)	29.6	−10.995 (9.08)
VAS	5.9	0.034 (0.03)	8.5	−0.121 (0.09)	6.8	0.063 (0.06)	8	0.115 (0.08)	4	0.442 (1.87)

Note. Standard deviation in parenthesis.

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