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2010

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Acknowledgments

This research has been supported by a grant from the Australian Research Council (ARC), the Centre for Business Service Science and the Institute for Innovation in Business and Social Research at the University of Wollongong. The views expressed here are solely those of the authors who are listed in alphabetical order. The authors wish to thank Dr John Gattorna and Stuart Whiting for their contributions to discussions and the direction of the research project.

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ABSTRACT

It is generally believed that companies choose supply chain partners on the basis of their distinctive value propositions; a fact one would also expect holds true when companies choose a logistics service provider. However, faced with the complexities of varied customer demands, it can be difficult for logistics service companies to obtain an effective understanding of how customers differentially value the service components they offer. In this paper, we address this by identifying the factors that are important in a customer's choice of a logistics service provider. Using stated choice methods we explore the relative importance of seven service attributes using a sample of 309 managers with a central role in purchasing logistics services across a range of industries and countries. The results reveal that three distinct decision models populate our data where the preferences for different logistics service attributes – such as price and delivery performance –vary greatly between customer groups represented by these models. Strategically, our findings provide the management of a third party logistics provider with a logical starting point from which to determine the goals that are set for their operations, particularly in choosing the customer segments to service.

Keywords: third party logistics; survey methods; discrete choice modeling

INTRODUCTION

The desire by firms to pursue gains from the trade of specialized production has contributed to the rise of specialized intermediate markets in the supply chain (Holcomb and Hitt 2007). These intermediate markets intensify the partitioning of production and shift the focus from the final market for goods and services to the processes by which value is created in intermediate markets (Jacobides 2005). Third party logistics (3PL) provides a good example of a rapidly emerging intermediate market that is characterized by the increasing use of outsourcing, particularly as organizations have moved into foreign markets and globalised their supply chains and sources of materials. This trend has led to rapid growth in the provision of contract third-party logistics (3PL) services (Razzaque and Sheng 1998; Sanders et al. 2007). Armstrong and Associates (2009) estimate that the global 3PL market for Fortune 500 companies amounts to $187 billion in revenues in 2007, with three quarters of US Fortune 500 companies using 3PL providers.

Although an important component of global economic activity and an area of interest to supply chain management scholars (Carter and Ellram 2003; Marasco 2008; Lai et al. 2008), it remains difficult for 3PL providers to understand the expectations of their customers and determine what drives their choice of one provider over another (Power, Sharafali and Bhakoo 2007). We address this issue by developing a more consistent understanding of the factors that are important in the choice of a logistics service provider. In addition, the approach we have used is applicable to other buyer-supplier relationships where a key challenge is the better understanding of how customers, with different needs, differentially value each component of the service when choosing a provider.

An overarching premise of this research is that customers differ in terms of their preferences for particular 3PL offerings and the customization of logistic service packages to different customer segments can improve the perceived value of the service offering. This logic implies two research questions that are the empirical focus for this study:

1. From the set of service components that influence the choice of a 3PL provider which components matter most?
2. Are the preferences of different customers sufficiently distinct to enable segmentation?

We will focus on a customer's choice between competing 3PL service offerings, and by doing so we take an approach that is different from, but complementary to, prior work that has sought to identify the way logistics service capabilities can be leveraged to create value within a supply chain. Other authors have looked at the level of customer satisfaction within existing 3PL relationships (Knemeyer and Murphy 2005; Stank, Keller and Closs 2001; Bowersox, Closs and Stank 1999), differentiated capabilities (Lai et al. 2008) and logistics service quality (Mentzer, Flint and Hult 2001). Our approach provides for a more direct examination of the factors that matter at the point of deciding on a particular 3PL supplier.

The third party logistics industry provides a particular challenge to understanding the way customers value different service components. Not only are the key service components (transport, warehousing, etc.) inherently complex, involving physical movement of goods, IT system support and contact with service personnel, but a 3PL provider must be able to bundle a broad range of services for different customers with different needs. To address this complexity more rigorously we use discrete choice stated preference modeling, which allows us to identify those components of the 3PL service offering that managers consider important in their choice amongst logistics service providers. This approach has been shown in the service literature to be a very effective way to understand what customers value in both business-to-business and consumer-to business contexts (Goodale, Verma and Pullman 2003; Iqbal, Verma and Baran 2003).

The next section positions this study within the buyer-supplier literature and describes the relevance of the methodology. We then move onto the heart of the paper and describe the aggregate results that reveal what customers value most when selecting a 3PL provider. The majority of customers considered reliable performance, price, customer service recovery and being easy to deal with as most critical to their choice of 3PL provider. Next, three customer segments

are identified that reveal variation in customer value for different 3PL service components. This behavior based segmentation model provides 3PL managers with a useful starting point from which they can build a more customer aligned service offering.

CONCEPTUAL BACKGROUND

Buyer-supplier exchange relationships involve both (1) a choice of the activities to outsource and (2) the selection of an appropriate supplier to perform these activities. The conditions that determine the boundary between the activities carried out within or outside the firm has been widely discussed in the literature using a range of theoretical lenses (Sarkis and Talluri 2002; Holcomb and Hitt 2006; Terpend et al. 2008; Wallenburg 2009).

Transaction cost economics (TCE) is at the core of nearly all discussions of the "make or buy" decision and has generally received strong empirical support across a range of different economic situations (Walker and Weber 1987; Williamson 2008; Wallenburg 2009). In the case of logistics outsourcing TCE argues that the buyer/customer will, once they have made the choice to outsource logistics generally, choose that provider offering the greatest efficiency in terms of "planning, adapting, and monitoring" costs (Williamson 1985, p. 2). Additionally, TCE notes that in transaction environments where performance is unpredictable – such as that commonly found within the 3PL industry – buyers will seek safeguards to minimize uncertainty in outcomes (Williamson 1985) Therefore, according to TCE theory, differences in the costs and risk prevention competencies amongst the group of competing 3PL providers are likely to provide robust determinants for why a buyer selects a particular 3PL provider.

However, an exclusive focus on TCE as an explanation of the 3PL selection process offers us an incomplete picture of the complexity of the decision being made. Supplier selection is also based on the perceived value created by the outsourcing and the inherent desire amongst buyers to maximize the benefits that they derive from establishing outside supplier relationships (Terpend et al. 2008). An alternative set of theories drawn from the resource-based view of the firm (RBV), examines how firms seek to build embedded capabilities and knowledge for addressing complex,

practical and repeated problems (Madhok 2002, McIvor, 2005). In line with this thinking, there is strong empirical support for the proposition that the decision to outsource is heavily influenced by organizational capability considerations (Jacobides and Winter 2005; Hoetker 2005) and the creation of new value (Terpend et al. 2008). From a logistics service provider's perspective, this suggests that contracts will be won by presenting to potential customers unique capabilities and embedded knowledge that are not on offer by their competitors.

Recent work on the resource-advantage (R-A) theory of competition suggests that the TCE and RBV focus on long term equilibrium is too broad to be an effective basis for strategic SCM research (Hunt and Davis 2008). They argue that SCM scholars need to pay greater attention to heterogeneity and the effective matching of specific supplier capabilities with the needs of particular market segments in environments in which information is imperfect and costly.

We return to these considerations of heterogeneity and segmentation below. First we consider the attributes of logistics providers that will be important for a buyer.

3PL Literature – Importance of Different Attributes

Traditionally, 3PL providers have offered customers three primary competitive benefits: reduced cost, faster delivery and improved reliability (Silveira 2005; Voss et al. 2006). However, recent work in supply chain management has suggested that a new paradigm is emerging based on a more sophisticated supply chain (Melnyk et al. 2010). If new competitive pressures are emerging then an important unanswered research question is: "to what extent has the structure of demand in the 3PL customer base changed?" One difficulty in seeking answers to this question is the very large number of different attributes that have been suggested by different authors. This reflects the richness of the bundle of services that a 3PL provider offers as well as the usual difficulties of precisely defining the nature of transactions and quality dimensions in a service environment. To illustrate the point, Sarkis and Talluri (2002) list 31 potential factors and Stank et al. (2001) utilize 38 items in their analysis.

In broad terms, we can distinguish between economic exchange factors (that will potentially be wider than simply an initial price); logistics performance (encompassing delivery speed, reliability etc); technology (primarily IT related capabilities); relational attributes (e.g. understanding the customer, and fit between cultures); flexibility (being able to respond to changes in requirements); as well as a range of other social exchange factors that do not fit easily into these categories (such as reputation, ability to innovate, and managerial involvement).

Different studies have provided mixed results on the relative importance of economic and social exchange factors. For example, studies have shown that customers prefer a cost focus and are reluctant to remunerate 3PLs for outstanding service performance (van Laarhoven, Berglund and Peters 2000). Voss et al. (2006) report that delivery reliability is critical to carrier selection – ranking second in terms of importance and first when it comes to intention to purchase. Delivery speed and price are also considered to be order winners according to Silveira (2005).

Yet, in a survey of 66 US 3PL firms, Stank et al. (2003) indicate that performance quality is primarily an order qualifier and not a differentiator in the eyes of the customer. Likewise, Griffiths, James and Kempson (2000) state that attributes such as operational performance quality, technology and price are frequently taken for granted. Lai et al. (2008) propose that the level of information technology capability significantly affects the competitive advantage of a 3PL provider by reducing costs, supporting innovation and service quality. If correct, this work has direct customer service implications because it appears that customers of 3PL services are increasingly recognizing that cost advantages and delivery performance, whilst necessary, are not always sufficient in the modern business world (Cahill 2006). Furthermore, Voss et al (2006) demonstrate empirically that the importance of operational and strategic attributes has changed in recent years due to competitive pressures and constrained transportation capacity.

According to these varied theoretical perspectives and empirical findings the selection of a 3PL provider requires economizing on both transaction costs and the costs of developing capabilities and utilizing idiosyncratic knowledge found amongst alternative suppliers. Wallenburg

(2009) has called for further research in supply chain management that is able to clearly distinguish where customer value is derived. This call is at the heart of the empirical logic behind this paper and motivates our desire to not only identify the relative importance of attributes (McGinnis and Kohn 1990; Sarkis and Talluri 2002), but to unpack the specific levels for each attribute and thereby, separate the order winners from the order qualifiers (Hill 2002).[1] Moreover, it makes little sense to weigh up the relative importance of delivery reliability in comparison with, say, contract price, unless scholars can put levels on the different attributes and specify precisely what is meant by less reliable performance and how it makes a difference to 3PL supplier selection. We therefore derive the following proposition:

> ***Proposition 1****: Buyers will trade off between a range of attributes that <u>both</u> minimize transaction costs and create value, but the final choice of 3PL provider will be determined by the specific <u>levels</u> of each attribute rather than a simple weighting of attributes.*

Heterogeneity and Segmentation

It is reasonable to expect that the value derived from any combination of service attributes will differ considerably between individual customers purchasing 3PL services. Yet the dominant perspectives in the supply chain literature – TCE and RBV – provide no mechanisms to look at the nature of customer demand. Resource-advantage theory (Hunt and Davis 2008) has the benefit of highlighting the complex choices that are required given heterogeneity in customer tastes and preferences, and the distinct self-interest seeking behavior amongst decision makers. Hence, it is inappropriate to aggregate demand data amongst all buyers of a 3PL service offering, but rather demand is best viewed as collections of market segments (Hunt and Davis 2008).

Studies have shown that variation in supply chain demand is frequently unrelated to standard *a priori* factors, such as customer size or customer industry (Dibb and Wensley 2002;

[1] The terms "order qualifiers" and "order winners" refer to the operational capabilities (or attributes as used in this paper) that lead to competitive advantage. Order qualifiers are attributes where a performance on a par with the competition, or at some minimum level, is necessary in order to be in the consideration set of a buyer. Order winners are attributes where being better than the competition significantly increases the chance of being selected.

Godsell et al. 2006). Coltman, Devinney and Keating (2010) have extended this literature and proposed that the logic of segmentation – based upon simple observable characteristics – may be too simplistic as a representation of what customers are actually doing and demanding. Hence, it is our argument that the mixed findings reported in the segmentation literature suggest that the historic emphasis on products (e.g. Fisher 1997) or transactions (Mentzer, Flint and Hult 2001) as isolated segmentation criteria is insufficient. Erevelles and Stevenson (2006) foresaw this when they stated that when B2B segmentation research has proven to be suboptimal, it has focused on relatively isolated buying situations rather than an *a priori* understanding of customers needs along several dimensions simultaneously.

Our thinking is in line with Gattorna (2006), who suggests that it is possible to develop an appropriate supply chain strategy by developing a more sophisticated understanding of the series of "behavioral logics" that interact and are traded off in the final selection decision by customers. The behavioral logic – that can be measured empirically using utility theory – explains why a group of end customers buy a product and from this point it is possible to develop an appropriate supply chain strategy to meet the needs of the segment concerned. Utility theory provides an appropriate lens to examine buyer preferences directly and identify those tangible and intangible attributes that are most important to market segments. Utility maximization proposes that people will select the 3PL service provider that offers maximum benefits, utility or value. It follows logically that the customer's overall assessment of the product and service offering is a key determinant of any decision to invest in a new business exchange relationship (Dwyer, Schurr and Oh 1987) or continue with an existing relationship (Jackson 1985).

This brief review of the literature indicates that scholars have made little progress with the issue of exactly how service attribute levels should be configured and segmented. Our approach is to use an experiment to examine buyer decisions (albeit looking at stated choices rather than actual choices). This allows us to directly address the capabilities, attributes and levels that are most likely to improve positional advantage in the market. We derive the following proposition:

Proposition 2*: Different buyers have different preferences for 3PL services, and these preferences are sufficiently distinct to enable identification of segments that have implications for positional advantage in the marketplace.*

RESEARCH METHODS AND SAMPLING

An effective method for evaluating the level of demand for various service characteristics offered by different 3PL providers is to model preferences as a choice response to experimentally designed service profiles. Discrete choice analysis (DCA) has been used to model the choices of key decision makers in a variety of organizational areas spanning marketing, operations management, transportation and economics. In the B2B service context, Goodale, Verma and Pullman (2003) used DCA to develop an improved understanding of service capacity scheduling while Iqbal et al. (2003) showed that service development and exposure to information, influences the features of transaction-based e-services. Buckley, Devinney and Louviere (2007), in studying foreign direct investment location choice, demonstrated the efficacy of DCA in understanding very complex managerial decision making.

Discrete Choice Analysis

The theoretical model underpinning DCA draws on Thurstone's (1927) original propositions in Random Utility Theory to provide a well-tested and generalizable theory of behavioral science (McFadden 1974). It allows scholars to conceptualize choice as a process of decision rules that can be statistically tested using the multinomial logit model (Louviere, Hensher and Swait 2000). When selecting any product, service, or combination of both, a decision maker will consciously or unconsciously compare alternatives and make a choice that involves trade-offs between the components of those alternatives. The result of this process is a choice outcome that can be decomposed conditional upon the options available within the experimental design (Hensher and Puckett 2005).

Discrete choice experiments typically involve the following steps: (1) identification of the key attributes; (2) specification of the levels of the attribute; (3) creation of the experimental design; (4) presentation of alternatives to respondents; and (5) estimation of the choice model. Verma, Thompson and Louviere (1999) review the DCA literature and provide guidelines for designing and conducting DCA studies in the services context. Research has demonstrated that choice predictions resulting from DCA based experiments are, in general, very accurate representations of reality (Louviere, Hensher and Swait 2000).

Experimental Design

Discrete choice analysis applies experimental design techniques that allow us to discern the marginal utility associated with an attribute and its levels without having to consider every possible combination of alternatives available. As the starting point we used a 4^7 fractional factorial design to construct our base design and then combined it with an endpoint design to enable the estimation of some two-way interactions as well as all main effects (Louviere et al. 2000). This approach utilizes the principles of orthogonality and asymmetry to maximize the efficiency of the parameter estimates whilst controlling for the desired number of choice sets (see Street and Burgess 2007, for a more detailed explanation). The final design was divided into 12 blocks of 16 choice sets, with respondents completing one block of 16 choice sets each. Every choice set required respondents to choose between two generic logistics service profiles, an example of which is given in Appendix B, in which the levels of seven different attributes were varied according to the underlying experimental design. To avoid biases from order effects, the sequence of the 16 choice sets and the allocation of respondents to a particular block were randomized. A technical appendix that describes the creation of the choice sets is presented at the end of this paper (see Appendix C).

Insert Figure 1 approximately here

3PL Service Attributes, Levels and Covariates

A substantial amount of empirical and conceptual work has examined the relative importance of service and cost as determinants of both shipper freight transportation choice (La Londe and Cooper 1989; McGinnis 1990) and 3PL provider choice (Flint, Larsson and Gammelgaard 2005). As we have discussed above there are many attributes that may be important in selecting a logistics provider. We began with a list that has been produced Coltman, Devinney and Keating (2010) who identified the relative importance of 21 factors that characterize core and peripheral attributes underlying 3PL demand. Based on a reduced form of utility-theoretic discrete choice analysis, known as maximum difference scaling or best-worst analysis, they pared these 21 factors down to those ten attributes most relevant to the 3PL choice decision in the minds of the customer. These ten attributes accounted for more than 75 percent of explained variation and include: (1) reliable performance, (2) delivery speed, (3) customer interaction, (4) track and trace, (5) service recovery, (6) supply chain flexibility, (7) professionalism, (8) proactive innovation, (9) supply chain capacity, and (10) relationship orientation. Table 1 presents the definitions for each attribute.

Insert Table 1 approximately here

The Coltman, Devinney and Keating (2010) study measures an extensive array of attributes on a relative importance scale, but does not address the issue of specifically how the levels of these attributes matter in a more realistic decision making context and how they interact with price. Our aim is to achieve a more complete utility based examination that better explains individual behavior.

In our experiment each attribute comprises four levels and this gives an opportunity to combine related attributes. For example, attributes such as reactive customer service and proactive service recovery are combined under the more general "customer service recovery" attribute label. By presenting related attributes as levels under a higher order attribute label, we were able to

narrow the final set of attributes in this study to seven. The nature of the experiments makes it preferable to have limited numbers of different attributes. Subjects are presented with a series of choices and increasing the number of attributes considered would tend to increase the number of choice sets that need to be assessed, with each choice involving the assessment of scenarios with more attribute specifications. The end result would be a longer and more arduous task to be completed by the experimental subjects.

In order to refine the definitions of the attributes and to identify representative levels for each attribute we also conducted an extensive pre-testing procedure that included several rounds of qualitative work to ensure realism. This work included reviewing the academic literature, industry reports and websites, along with insight gained from semi structured interviews across the seven countries with a total of 37 3PL customer firms. The interviews were used to ensure that the definitions accurately reflect the conceptual domain of each attribute and thereby, establish content and face validity. Appendix A gives a complete description of the attribute definitions as well as the associated levels.

The final selection of levels for each attribute is as follows. *Reliable performance*, as a measure of delivery in full, on time, and error free was divided into three percentage-point increments ranging from a high of 98-100% to a low of 89-91% of the time. *Price* levels were allocated as a percentage of the difference vis-à-vis price parity, starting with a low price of 0-4% less than price parity, defined as "what you currently pay" and ranging to a price of 5-8% higher than price parity. The levels for *customer interaction* pick up two different aspects of the service concept. The first relates to the ease with which business is conducted with the logistics service provider. The second relates to the effort that the provider puts into building the relationship with their customer through measures such as loyalty schemes. *Capacity* equates with being able to meet unanticipated customer needs and the levels vary in a range between excellent (industry leader) to below industry average. *Service recovery* is defined in a more expansive way than for example, just finding missing packages by distinguishing between proactive and reactive service

recovery efforts. The levels range from being very proactive (an industry leader) to being slow to respond to problems and unlikely to propose solutions. *Innovation* is defined as the provision of new services and the options vary in a range between very innovative (an industry leader) to poor innovation and unlikely to propose solutions. Innovation offers substantial potential for service providers to differentiate themselves from competitors. The emphasis on logistics innovativeness as a source of customer value has recently been reported by Flint, Larsson and Gammelgaard (2005), Wagner (2008). Moreover, logistics outsourcing has steadily gained a more relational focus that emphasizes the benefits of long-term exchange over spot market transactions (Murphy and Wood 2004). However, prior attempts by 3PL providers to improve innovativeness and enhance customer relationships have faced many challenges (Wallenburg 2009). *Professionalism* is concerned with the knowledge of the service provider. It effectively combines two slightly different areas of knowledge: that related to the logistics industry and that related to the customer's business.

Besides the DCA task, the survey instrument also included various background questions that were used to examine the impact of covariates on the model. Firm size was measured based on the number of employees in the company. A measure of 3PL importance was based on the following question: "How important is transportation and logistics service providers to your business? We are particularly interested in your product and/or service cycle time and whether logistics is critical or not. Provide a rating from 1 to 5, where 1 means not critical, and 5 means absolutely critical (make or break)". Finally, preferred style of exchange relationship was based on the customer's preference for a collaborative relationship between supplier and customer vis-à-vis an exchange relationship that is focused on efficiency and lowest cost to serve. The question required respondents to "Please allocate a percentage between 0 and 100 to the particular style of exchange relations your company prefers with transportation and logistic service providers. There are four relationship styles for you to choose from, interactions that are (1) primarily collaborative relationships between supplier and customer, based on trust, (2) focused on efficiency and lowest

"cost-to-serve", (3) capable of quick response to irregular demands and flows, and (4) based on finding "solutions" to unpredictable situations."

Segmentation Analysis

The indiscriminate pooling of data offers limited insight because it can mask the importance of relationships between explanatory attributes (Hatten, Schendel and Cooper 1978). In response, a variety of latent class techniques have been developed and applied to generate more accurate cluster or segment solutions (McLachlan and Basford 1988; Bensmail, Celeux and Raftery 1993; Wedel and Kamakura 2000). These models are particularly useful in estimating the likelihood that a specific firm fits into a class of firms for which a particular model applies. More specifically, by using latent class modeling we are able to derive a maximum likelihood-based statistical model that accounts simultaneously for both the similarity and differences between decision makers based on their actual preference for different service characteristics. The advantage of using this approach is well documented and provides a more elegant interpretation of the cluster or segment criterion that is less arbitrary and statistically more appropriate (see Vermunt and Magidson 2002 for a general explanation).

Sampling and Data Collection

Invitations to participate in the study were sent via email to the account representative with primary responsibility for 3PL contracts. A sample of 998 Asia Pacific company contacts was obtained all of whom were customers of large multinational 3PL providers. During the data collection phase, each respondent received an e-mail from the research team with an invitation to join the research project. Although no explicit remuneration was provided for participation, each respondent's details were entered into a draw to win a plasma television. After agreeing to participate, respondents were directed to a web page that provided information on the survey and definitions of the attributes under investigation. Native language versions of the survey were available in English, Chinese, Japanese and Korean. Extensive rounds of forward and backward validation

were carried out using a commercial translation service (http://www.translationsabc.com/) and native language experts in each country to ensure that the translations were identical.

The respondents were then asked to complete a survey that included 16 experimentally generated choice sets. Three hundred and nine firms completed the survey giving a final response rate of 31% once undelivered emails were taken into account. Approximately one third of responding firms are from Australia and New Zealand, and another third are from China, with the remaining firms located in Hong Kong, India, Japan, South Korea and Singapore. The distribution by industry type is skewed towards the largest users of 3PL services such as manufacturing, wholesale/retail and transport/storage. The median firm size was approximately 3,200 employees, with the smallest firm having 16 employees and the largest 400,000. The summary characteristics for all the responding firms are shown in Table 2. One salient characteristic of the data is that although the respondents are all customers of Company X, they typically deal with more than one global 3PL provider (79% of firms use multiple 3PL providers). Thus, even though the firms are common in that they all use Company X, their use of other 3PLs reduces the extent that selection bias is a problem in the sample.

Insert Table 2 approximately here

ANALYSIS AND RESULTS

The multinomial logit (MNL) model has well defined statistical properties that can be applied to pooled data or segment based models. The approach used in this study matches established conventions, closely mirroring that of previous studies in operations management and marketing (Iqbal et al. 2003; Verma et al. 2002). Our examination of the choice-modeling responses is divided into two stages: (1) aggregate level MNL results, and (2) a latent class segmentation model.

Aggregate Results

The first objective of our study deals with the trade-offs customers make between attributes as proposed in H1. Table 3 shows the relative main effects for each attribute with respect to all other attributes within the model – in fact the table lists attributes in order of importance. The main effect values were obtained using a two step approach: (1) main effects were calculated for each attribute by subtracting the utility associated with the lowest level of the attribute from the utility associated with the highest level; and (2) normalizing these values such that the main effects from all of the attributes sum to one. An advantage of this analysis is that it allows for the comparison between the relative importance of each attribute on a common scale (Verma, Louviere and Burke 2006). In this case operational performance is nearly 10 times more important than professionalism when it comes to choosing a 3PL provider.

Insert Table 3 approximately here

The results also allow us to delve deeper into the customer value proposition by understanding how customers strategically trade-off between the various service features available when choosing a 3PL provider. We provide more detailed commentary for each of the service attributes in turn.

Reliable performance is the core competence for logistics service providers and it is the single attribute that has the greatest influence on choice. As the levels of reliability increase from a low of 89–91% to a high of 98–100%, of the time, there is a steady increase in the effect.

Price levels are important as a determinant in choice and in this study, the results reveal a surprising lack of statistical significance at the "0 - 4% more than now" level ($\beta = 0.044$, p = n.s.). This indicates that there may be some customers that are not price sensitive, providing price increases are not too great. It is interesting that the value of β for the case of prices being 0 - 4% less than now is smaller than the value of β at prices equivalent to now. This suggests that for

some customers lower prices are not an incentive, and may even be a disincentive. For example this might occur if a customer felt that a big drop in price signaled some potential problem in an area that was not captured by the specific attribute levels of the survey.

The results for *customer interaction* indicate a positive and statistically significant relationship between the choice of logistics provider and being "easy to deal with" independent of whether rewards are provided ($\beta = 0.177$, $p<0.001$ and $\beta = 0.147$, $p<0.001$). Interestingly, the strongest effect was observed when providers were "difficult to deal with" and used rewards ($\beta = -0.198$, $p<0.001$). This suggests that customers will not choose providers who try to buy the loyalty of their customers through rewards programs without investing sufficiently in the relational aspects of service delivery.

A review of the 3PL market indicates that the industry has generally adopted a reactive approach to *service recovery*; a situation where it is the customer's responsibility to contact the 3PL if they have concerns about delivery. Online track and trace capabilities are examples of sophisticated ways to automate this process. Alternatively, providers can be proactive and take responsibility for notifying the customer of likely delays – for example, through mechanisms that identify parcels that are late and proactively contact customers to advise them of the reason for the delay. The general picture here is one where being "the industry leader" ($\beta = 0.169$, $p<0.001$) or "better than the industry average" ($\beta = 0.130$, $p<0.01$) is important at the aggregate level.

Capacity equates with being able to meet unanticipated customer needs. The results show a clear preference for a provider that is the industry leader ($\beta = 0.082$, $p<0.05$) and a very strong dislike for providers that are below the industry average ($\beta = -0.135$, $p<0.001$). The large negative values of β when providers fail to meet industry average performance, and the relatively modest gains from good performance, suggest that for some customers a reasonable ability to meet unanticipated customer demands is an order qualifier, rather than an order winner. For such customers this capability is required to get a "seat at the table" but is of less value in winning work.

Innovation is defined as the provision of new services and is generally considered to be very important across all product and service categories. Being the "industry leader" is important ($\beta = 0.081$, $p<0.05$), with "poor innovation" counting against a provider ($\beta = -0.191$, $p<0.001$). The pattern of behavior here mirrors that for capacity and suggests that customers may regard a reasonable level of innovation ability as an order qualifier, rather than an order winner.

Professionalism is concerned with the knowledge of the service provider. It effectively combines two slightly different areas of knowledge – that related to the logistics industry and that related to the customer's business. The results indicate that this is not, in general, an important characteristic although there is a preference, as one would expect, for providers with deep industry and customer business knowledge ($\beta = 0.057$, $p<0.05$).

Latent Class Segmentation

To account for heterogeneity in the data, a latent class segmentation analysis was conducted using a three-step procedure to select the best solution. This involved: (1) finding the model with the best information criterion based fit; (2) using classification statistics for the preferred model to ensure that the model had an acceptably low ratio of classification errors; and (3) plotting the estimates for each segment in the preferred model against one another to ensure that the segment solution was not an artifact of scale factor differences.

First, an examination of the fit statistics revealed that the three-segment model had the best fit in terms of information criteria scores such as the Bayesian information criterion (BIC) and the consistent Akaike information criterion (CAIC). Second, an examination of the classification statistics indicates that the three-segment model is preferred to both two and four segment alternatives and has an acceptably low ratio of classification errors. Lastly, the estimates for each segment in the preferred model were plotted against one another to confirm that the three-segment solution represented actual differences rather than systematic variance. The various fit criteria and

classification statistics are shown in Table 4 for models with between 1 and 4 segments and can be interpreted as the lower the value, the better the model fit.

Insert Table 4 approximately here

The segment scores for each attribute and level are shown in Table 5. The Wald statistics reported in this table reveal whether the beta parameters vary within each attribute and across the segments. A non-significant p-value associated with this Wald statistic (e.g., *professionalism*) means that the indicator does not discriminate between the clusters in a statistically significant way. The p-values associated with the beta parameters provide a deeper understanding of how the preference structures differ between the segment models. One of the most interesting aspects of these models is that they show how the segments differ not only in terms of what matters to respondents but also in terms of what they don't consider to be important. Interpretation of this data requires deeper discussion and we provide a detailed segment-by-segment commentary below.

Insert Table 5 here

Segment 1

Segment 1 is the largest group comprising 62% of responding firms. The segment is most concerned with *reliable performance*, *customer interaction* and *customer service recovery*. An interesting characteristic of this segment is that the respondents do not reward extremely high performance (98-100% of the time) or penalize poor performance (89-91% of the time) as heavily as segments 2 or 3. Further, the firms in segment 1 are not highly price sensitive. For customers in this segment price is an order qualifier rather than an order winner. Instead there is a clear preference for firms that are easy to do business with and promote exchange relationships based on interaction and high levels of supply chain service recovery and innovation. These are firms who

also regard industry average levels of capacity and innovation as order qualifiers for a 3PL provider.

An examination of the covariate or descriptive data analyses reported in the table indicates that the number of employees (a frequently used measure for firm size) has a positive and statistically significant relationship to membership in this segment ($\beta = 0.353$, $p<0.001$). Segment 1 comprises mainly large companies with 50% of firms in this segment employing more 200 employees and 34% are of medium size (20 to 200 employees). 3PL operations are considered to be critical to the buying firms business ($\beta = 1.158$, $p<0.01$), and the style of exchange relationship with a 3PL provider is not based on efficiency or low cost to serve strategies ($\beta = -0.012$, $p<0.001$). In summary, the buyer behavior of customers in Segment 1 goes beyond a purely transactional relationship. Comparisons with the other segments and the observations of the covariates suggest that the key differentiator for customers in this segment is a strategic exchange relationship that allows them to manage the risk in the business exchange and generate innovative solutions that better meet their business critical transportation requirements.

Segment 2

Segment 2 is the second largest group with 27% of responding firms. This group comprises 49% large firms and 41% medium size firms. The respondents were primarily concerned with *reliable performance* where extremely high performance is highly regarded ($\beta = 1.877$, $p<0.001$) and low performance is penalized heavily ($\beta = -2.027$, $p<0.001$). The relationship to price is nearly linear and this segment looks favorably on customer interaction. Being the industry leader in terms of service recovery and capacity is important to these firms; however, they do not value innovation or professionalism.

The covariate analysis indicates that firms in Segment 2 do not believe 3PL services are critical to their business ($\beta = -0.099$, p = n.s.). Company size ($\beta = 0.224$, p = n.s.) and efficiency ($\beta = -0.004$, p = n.s.) were also not observed to be to be important the membership of this segment.

The combination of characteristics of firms in this segment – an emphasis on being the best in a number of areas and on reliability but not innovation – coupled with some indications that 3PL services are not critical strategically, suggests that these firms are looking for providers with proven solutions and low risk. We suggest that this might lead to a small consideration set that includes the relatively high profile 3PL providers (i.e., DHL, FedEx or UPS).

Segment 3

Segment 3 is the smallest group comprising 12% of the sample. These firms are concerned primarily with current *price,* where a price that is lower than what they currently pay is highly regarded ($\beta = 1.536$, $p<0.001$) and a higher price is penalized heavily ($\beta = -2.295$, $p<0.001$). Although delivery performance is important, with very high performance in particular being valued, this is less important than for segment 2. For firms in this segment, a 3PL provider should be the industry leader in terms of service recovery ($\beta = 0.669$, $p<0.01$) and place emphasis on customer interaction ($\beta = 0.578$, $p<0.05$).

The covariate analyses indicate that Segment 3 comprises 34% small companies (less than 20 employees), 28% medium sized firms and 37% large firms. The size of the firm has a negative and statistically significant relationship to 3PL choice ($\beta = -0.576$, $p<0.001$), the 3PL operations are not considered to be critical to the buyer's business ($\beta = -1.059$, p = n.s.) and the preferred style of exchange relationship with a 3PL provider is one based on efficiency or low cost to serve strategies ($\beta = 0.016$, $p<0.01$). In summary, the buyer behavior in this segment places heavy emphasis on price and is likely to reward the lowest priced 3PL provider with their business.

The relative main effects for each segment are also shown in Figure 3. This figure highlights in a simple visual way the variation between segments based on the order of magnitude differences for each attribute. Segment 1 is highest on the broader value based attributes such as customer interaction, customer service recovery and supply chain innovation. Segment 2 is driven

most noticeably by reliable performance with the score more than twice as high as the nearest alternative group. Segment 3 is clearly dominated by price.

Insert Figure 3 here

DISCUSSION AND MANAGERIAL IMPLICATIONS

We began this paper with two questions pertaining to the value that customers place on different service attributes and the way these valuations differ between customer segments. In addressing these questions, our study not only makes a contribution to supply chain management theory building but also provides normative implications for how 3PL businesses should compete. First, the results clearly indicate that the majority of managers base their decisions on four key factors: (a) reliable delivery performance; (b) price parity with other providers; (c) being amongst the industry leaders in customer recovery; and (d) not being difficult to deal with. These are the most critical issues for customers, with these attributes explaining 79 percent of the variance in the decisions.

Striking the Right Balance in Service Design

Although this is the picture in aggregate, managers will also be interested in a more detailed analysis that identifies the groups that are most worth pursuing (Yankelovich and Meer 2006). We have shown that support for *reliable performance* is consistent across all three segments, eclipsing the relative importance of all of the other features. The firms in Segment 1 will be attractive to those 3PL providers with sufficient resources to invest in service systems that transfer and share knowledge and resources. True to the spirit of service-dominant logic in marketing (Vargo and Lusch 2004), the most important attributes for this segment place emphasis on the primacy of operant attributes such as being easy to deal with and innovation. These attributes require the

application of human skills, innovation and collaborative relationships to coproduce value for the customer.

Furthermore, our results indicate that in order to strike the right balance, 3PL managers must appreciate that not all firms have the time, energy or motivation to form the type of co-productive relationships that service-dominant logic implies. Although the firms in Segment 2 are still concerned with the overall service process they are less concerned with hands on co-production and are attracted to 3PL providers with strong brands and proven solutions. On the other hand, the firms in Segment 3 are driven by the exchange of goods and will be attracted to 3PL providers that are willing to compete on price alone.

It is also important to note, that across all three segments, the greatest impact on choice is seen when an attribute scores negatively. This reveals that that poor performance on key service areas will result in a significant negative impact on the likelihood of being chosen as logistics provider.

Deviations from Previous Work

Our results provide important deviations from previous work. A considerable body of empirical work on 3PL performance has investigated the level of satisfaction with the current logistics provider. In part, this is because the overall satisfaction with the services offered is thought to be an antecedent to increased market share and profitability (Anderson, Fornell and Lehman 1994). For example, Stank et al. (2003) show that a good "relational performance" by a 3PL (measured by knowing customer's needs, cooperating with the customer and making recommendations for improvement) has beneficial effects on customer satisfaction measures.

These studies might lead to an expectation that relational factors would play a larger role than they appear to at the point of customer choice. One part of the explanation is that the choice environment is different to the environment in which an existing 3PL customer makes a statement of satisfaction with their provider. We may expect that satisfaction measures will be closely correlated with the choices that people make, but the connection between the two is not direct.

(A) If a factor that influences satisfaction is hidden or implicit then the buying firm may not be aware of its importance and hence discount this factor when choosing a supplier.

(B) If a factor is regarded as subject to fluctuations or inherently unpredictable then it may play a lesser role in supplier selection, even though it is critical to buyer satisfaction. For example, even if I view a high degree of communication as important in making me more satisfied with the relationship, I may feel that this is hard to predict at the point of deciding on a supplier, or I may judge that the quality of communication will depend on an account manager who is likely to change during the life of the contract. In either case this characteristic may become less important at the point where I make a choice between logistics service providers.

(C) A characteristic may be rise to prominence as a result of the procedures used to select a supplier, but be pushed into the background when satisfaction with the supplier is considered. For example price is likely to be a significant factor in the choice of a supplier, but may be much less salient in assessing satisfaction with an existing supplier.

The Threat of Commoditization

A concern amongst 3PL managers that was identified during our qualitative research and has been reported in prior studies relates to the extent to which the services that a 3PL provides are regarded as unique to the provider. Another way to express this is to ask whether customers regard 3PL services as a "commodity". A commodity is considered to be a non-differentiated offering that holds few if any intangible components and is sold primarily on the basis of price (Coase 1937). The core components of a commodity are well known, mostly stable, and widely shared amongst competing firms.

As the third party logistics segment has become well-established it is natural to ask whether there has been a shift towards commoditization, with the negative consequences that this would bring for logistics providers. One way of answering this question is to look carefully at how

customers view the service provision, especially as it applies to the importance of price and basic quality measures when choosing between potential 3PL providers.

It is clear from our analysis that the firms in Segment 3 have requirements that are relatively uncomplicated, that they feel confident that more than one provider can safely meet their requirements, and they tend to consider the 3PL market as a commodity. Hence one would expect that they would choose a supplier mainly on the basis of price, provided that the basic delivery requirements are effectively carried out and other characteristics meet a minimum level of competence. However, the other two segments do not appear to view the 3PL market as a commodity. Since segment 3 is the smallest segment in our sample representing only 12 percent of the overall sample we can conclude that commoditization in the 3PL industry is not a major threat at this point in time.

CONCLUSIONS, LIMITATIONS AND FURTHER RESEARCH

A major challenge for the 3PL service industries has been to determine the value that customers place on their different service offerings so that they can then focus on delivering the right service to the right customer segment. Our examination of the preferences of 309 3PL customers has identified the attributes and attribute levels that matter most to 3PL customers and shown that the heterogeneity of these preferences can be characterized by three segments. With the exception of reliable performance, each segment is driven by a different set of order qualifiers and order winners. One implication is that 3PL managers should monitor the segment profiles of their customers to avoid misalignment between these segments and their service offerings. The logic of segmentation suggests management strategies that involve a 3PL, or a team within a 3PL focusing on a particular customer group.

Although this study is one of the few to directly examine the choice preferences for a 3PL provider, it has limitations. First the nature of the experiments carried out made it necessary to limit the factors considered (to seven attributes each with 4 levels) given the size of the sample and the time required to carefully consider a whole set of different choice scenarios. As a result not all

possible attributes have been included, and we were not able to directly include either measures of trust (including ethical standards, integrity) or communication (keeps us informed, communicates expectations, seeks advice etc.). Second, it could be argued that the geographic location of customers in the Asia Pacific region may have some bearing on the results, so that the findings might not be applicable to the service operations requirements in European and American markets. It is significant however that no statistically significant differences in customer choice behavior exist between the seven countries examined in this study. Even though the numbers of respondents from some countries is small, there are sufficient numbers from Australia (112) and China (107) to make this noteworthy. Thirdly, whilst we have unique data that identifies the most important person within each buying firm it is often the case that these individuals are influenced by various parts of the organization, including finance, accounting, purchasing, information technology management, and senior management. Future research could investigate the role of the "buying centre" on the 3PL supplier selection process.

Despite these limitations we believe that the study has made a unique contribution in using a stated choice experiment to demonstrate a set of latent classes in a B2B buying relationship in the logistics industry. Further research may be able to use similar techniques to explore buying relationships in other contexts.

TABLE 1

Attribute Definitions

Reliable performance − consistent "on time" delivery without loss or damage of shipment

Delivery speed − amount of time from pickup to delivery

Customer service – prompt and effective handling of customer requests and questions.

Track & trace - transparency and "up to the minute" data about the location of shipments end-to-end

Customer service recovery − prompt and empathetic recovery and resolution of errors or problems concerning customers.

Supply chain flexibility - ability to meet unanticipated customer needs e.g., conduct special pickups, seasonal warehousing

Professionalism - Employees exhibit sound knowledge of products and services in the industry and display punctuality and courtesy in the way they interact and present to the customer.

Proactive innovation − This activity refers to the provision of supply chain services aimed at providing new solutions for the customer.

Supply chain capacity − the ability to cope with significant changes in volumes e.g., demand surges and deliver through multi-modal transport services including: international express and domestic, by air; ocean; and land.

Relationship orientation − characterized by sharing of information and trust in the exchange partner

TABLE 2

Sample Descriptive Characteristics

	Percent of Sample
Industry	
Agriculture, Forestry, Fishing	0.01
Communication	0.03
Construction	0.05
Education, Health and Community Services	0.07
Finance, Insurance, Property and Business	0.14
Government Administration and Defense	0.01
Manufacturing	0.24
Mining	0.01
Transport & Storage	0.17
Wholesale and Retail Trade	0.27
Company Size	
Small (less than 20)	0.16
Medium (20 to 200)	0.35
Large (more than 200)	0.48
Country of Origin	
Australia/New Zealand	0.28
China	0.33
Hong Kong	0.07
India	0.06
Japan	0.05
Korea	0.05
Singapore	0.16

TABLE 3

Aggregate MNL Model		
	Beta	Relative Main Effects
Reliable Performance		
98-100% of the time	0.452***	0.324
95-97% of the time	0.331***	
92-94% of the time	−0.319***	
89-91% of the time	−0.465***	
Price		
0-4% less than now	0.154***	0.176
Equivalent to now	0.193***	
0-4% more to now	−0.044	
5-8% more to now	−0.304***	
Customer Interaction		
Easy to deal with, frequently rewards	0.177***	0.132
Easy to deal with, rarely rewards	0.147***	
Difficult to deal with, frequently rewards	−0.198***	
Difficult to deal with, rarely rewards	−0.126***	
Customer Service Recovery		
Very proactive: an industry leader	0.169***	0.160
Better than industry average response	0.130**	
Equal to industry average response	−0.017	
Slow & unlikely to propose solutions	−0.282***	
Supply Chain Capacity		
Excellent: industry leader	0.082*	0.076
Better than industry average	0.066	
Equal to industry average	−0.013	
Below industry average	−0.135***	
Supply Chain Innovation		
Very innovative: an industry leader	0.081*	0.096
Better than industry average	0.066	
Equal to industry average	0.044	
Poor innovation, no solutions	−0.191***	
Professionalism		
Deep logistics and customer knowledge	0.057*	0.037
Deep logistics, acceptable customer knowledge	−0.003	
Acceptable logistics, deep customer knowledge	−0.047	
Acceptable logistics and customer knowledge	−0.007	

*p<0.05, **p<0.01, ***p<0.001.

TABLE 4

Model Fit and Parsimony for Models with Different Numbers of Segments

	Number of Segments			
	1	2	3	4
Log Likelihood	−2937.6	−2772.2	−2697.2	−2639.4
AIC	5917.3	5630.4	5524.4	5452.8
BIC	5995.7	5790.9	**5767.1**	5777.61
CAIC	6016.7	5833.9	**5832.1**	5864.6
Npar	21.0	43.0	65.0	87.0
Class Error	0.000	0.033	0.060	0.101
$R(0)^2$	0.187	0.291	0.348	0.397

Note: **Bold** items indicates best fit (i.e., minimum score).

TABLE 5

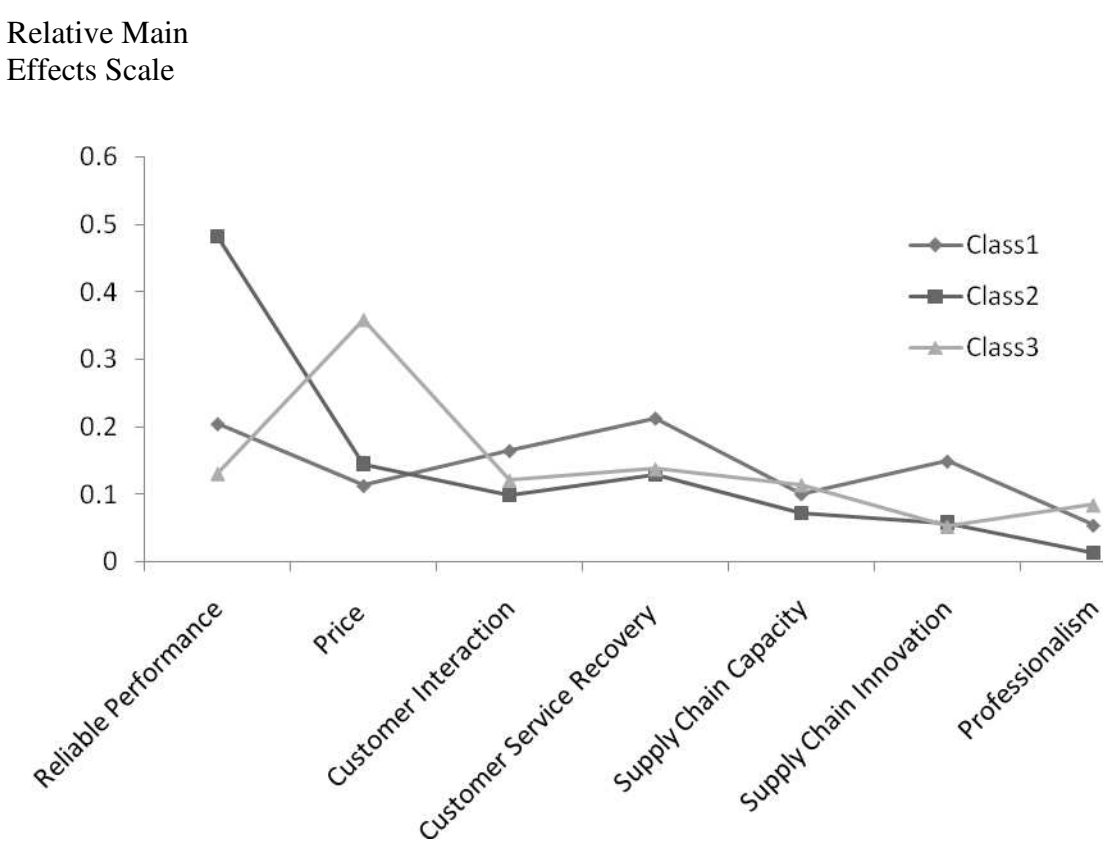
Latent Class Model with Covariates

	Segment 1	Segment 2	Segment 3	Wald
Reliable Performance				
98-100% of the time	0.199***	1.877***	0.872***	146.335***
95-97% of the time	0.226***	0.989***	0.183	
92-94% of the time	−0.181**	−0.840***	−0.531*	
89-91% of the time	−0.243***	−2.027***	−0.525*	
Price				
0-4% less than now	0.049	0.406*	1.536***	55.714***
Equivalent to now	0.103	0.310*	0.981***	
0-4% more to now	0.005	0.057	−0.221	
5-8% more to now	−0.156***	−0.772***	−2.295***	
Customer Interaction				
Easy to deal with, frequently rewards	0.164***	0.391**	0.578*	76.749***
Easy to deal with, rarely rewards	0.153**	0.271*	0.482	
Difficult to deal with, frequently rewards	−0.213***	−0.249	−0.344	
Difficult to deal with, rarely rewards	−0.104*	−0.413**	−0.715**	
Customer Service Recovery				
Excellent: industry leader	0.153***	0.510**	0.669**	137.894***
Better than industry average	0.139*	0.061	0.455	
Equal to industry average	0.042	−0.028	−0.319	
Slow to respond	−0.334***	−0.543**	−0.804**	
Supply Chain Capacity				
Excellent: industry leader	0.062	0.332*	0.622	41.113***
Better than industry average	0.052	0.129	0.291	
Equal to industry average	0.056	−0.208	−0.312	
Below industry average	−0.169***	−0.253	−0.601	
Supply Chain Innovation				
Very innovative: an industry leader	0.105*	0.235	−0.155	65.834***
Better than industry average	0.073	−0.011	0.269	
Equal to industry average	0.058	0.015	0.182	
Poor innovation, no solutions	−0.237***	−0.239	−0.296	
Professionalism				
Deep logistics and customer knowledge	0.079	−0.058	0.336	10.574
Deep logistics, acceptable customer knowledge	−0.046	0.057	0.395	
Acceptable logistics, deep customer knowledge	−0.026	0.017	−0.511*	
Acceptable logistics and customer knowledge	−0.008	−0.010	−0.221	
Covariates				
Company size	0.353***	0.224	−0.576***	13.308**
Importance of 3PL	1.158**	−0.099	−1.059	6.552*
Efficiency/low-cost-to-serve (231)	−0.012***	−0.004	0.016**	11.156**
Segment size	0.616	0.267	0.117	
$R(0)^2$	0.114	0.688	0.643	

*p<0.05, **p<0.01, ***p<0.001.

FIGURE 1

Relative Importance of Attributes across Segments (main effects)



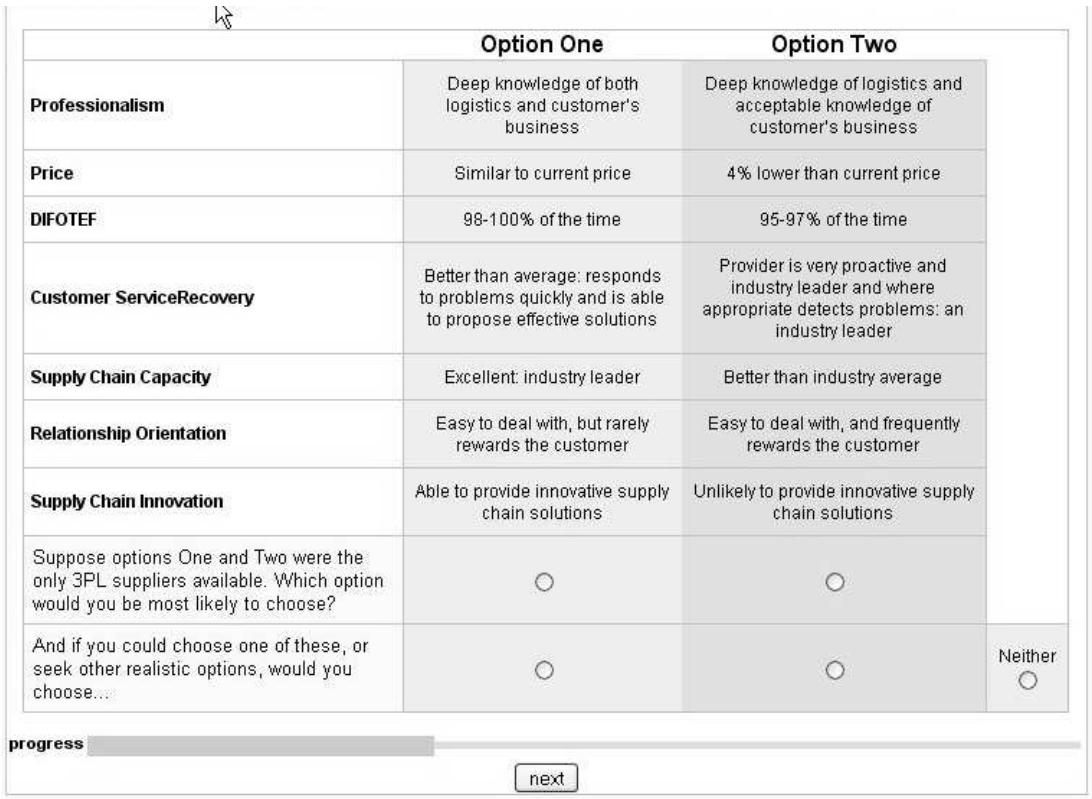
APPENDIX A

Attribute Definitions and Levels

Attribute Definitions	Levels
Reliable Performance (DIFOTEF) - Delivery in full, on time and error free. Complete delivery of product (or service) at the specified time agreed with the customer, and correspondingly accurate documentation	Lower than what you currently pay (0-4% less); Similar to what you currently pay; Higher than what you currently pay (0-4% more); Significantly higher than what you pay (5-8% more)
Price - Is what the customer pays for the service and/or product provided by the logistics service provider.	98-100% of the time; 95-97% of the time; 92-94% of the time; 89-91% of the time
Supply Chain Capacity - The capability to meet unanticipated customer needs. Includes conducting special pickups, seasonal warehousing.	Excellent: industry leader; Better than industry average; Equal to industry average; Below industry average
Customer Service Recovery - Activity aimed at identifying and resolving unexpected service delivery problems. The supplier response can vary from being very proactive towards the detection of problems and recovery; to very reactive.	Very proactive: an industry leader; Better than industry average response; Equal to industry average response; Slow to respond to problems and unlikely to propose solutions
Customer Interaction - Relates to the customer's perception of the ease with which business is conducted with the logistics provider and the extent to which they desire to reward and build mutual trust with their customers.	Easy to deal with, and frequently rewards the customer; Easy to deal with, but rarely rewards the customer; Difficult to deal with, and frequently rewards the customer; Difficult to deal with, but rarely rewards the customer
Supply Chain Innovation - This activity refers to the provision of supply chain services aimed at providing new solutions for the customer.	Very innovative: an industry leader; Better than industry average innovation ability; Equal to industry average innovation ability; Poor innovation and unlikely to propose solutions
Professionalism - Relates to the logistics service provider's knowledge of the logistics industry AND the customer's business. For example, logistics industry level professionalism would include knowledge of how to handle customs, transportation, warehousing and any other required logistics activities.	Deep knowledge of both logistics and customer’s business; Deep knowledge of logistics and acceptable knowledge of customer’s business; Acceptable knowledge logistics and deep knowledge of customer’s business; Acceptable knowledge of both logistics and customer’s business

APPENDIX B

Example of a Stated Choice Task of Buyer Preferences in the Supply Chain



	Option One	Option Two	
Professionalism	Deep knowledge of both logistics and customer's business	Deep knowledge of logistics and acceptable knowledge of customer's business	
Price	Similar to current price	4% lower than current price	
DIFOTEF	98-100% of the time	95-97% of the time	
Customer ServiceRecovery	Better than average: responds to problems quickly and is able to propose effective solutions	Provider is very proactive and industry leader and where appropriate detects problems: an industry leader	
Supply Chain Capacity	Excellent: industry leader	Better than industry average	
Relationship Orientation	Easy to deal with, but rarely rewards the customer	Easy to deal with, and frequently rewards the customer	
Supply Chain Innovation	Able to provide innovative supply chain solutions	Unlikely to provide innovative supply chain solutions	
Suppose options One and Two were the only 3PL suppliers available. Which option would you be most likely to choose?	○	○	
And if you could choose one of these, or seek other realistic options, would you choose...	○	○	Neither ○

progress

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APPENDIX C

Details on the Experimental Design

Drawing on random utility theory, we recall that the latent preference for a given attribute is specified to have an observed and unobserved component. To estimate the multinomial logit (MNL) model, we assume that the unobserved component is uncorrelated across choices and individuals. Accordingly, the latent preference or utility of respondent *n* for option *j* is given by $U = \beta' X_{nj} + \varepsilon_{nj}$, where X_{nj} is the vector of attributes of option *j* and β is the vector of parameters of preference weights associated with each attribute. By assuming ε_{nj} to be independently and identically distributed (IID) extreme value type I, Mc-Fadden (1974) showed that the choice probability could be given by:

$$P_{ni} = \frac{\exp(\beta' X_{ni})}{\sum_{j=1}^{J} \exp(\beta' X_{nj})}$$

Consistent with the assumptions of MNL, Street and Burgess (2007) provide guidance for the construction of optimal experimental designs. These designs, termed "*D*-optimal designs", enable researchers to estimate β more precisely by seeking to minimise generalized variance. Given that the asymptotic variance-covariance matrix of β is the inverse of the Fisher information matrix (FIM), Street and Burgess proposed that an optimally efficient design would have the maximum determinant of the FIM.

The design of efficient choice sets to estimate main effects and at least some two-way effects in a MNL model is achieved by combining an endpoint design and its foldover with an orthogonal main effects plan (Louviere et al. 2000). For instance, in our study we started with a 4^7 fractional factorial design to create the profiles for the first option in each choice task of the base design. We then constructed the second option in each choice task by systematically varying the levels of the attributes so that as many pairs of profiles as possible would have different levels for each attribute. As our design needed to evaluate preference for seven attributes with four levels, we used modular arithmetic to identify a generator to create the profiles in the second option where the levels in (k+1)/2 attributes must change (i.e., 4 attributes). This base design was 100% efficient and resulted in 96 choice tasks that we then divided into 12 blocks of eight. Each respondent was presented with 16 choice tasks, eight from the endpoint design (see Table C1) and eight from the base OMEP design (see Table C2). The endpoint design is a subset of the full factorial design where only the highest and lowest levels of each attribute are included. This produced in a near optimal design where the C matrix is orthogonal, and all main effects and some two-factor interactions can be estimated independently.

TABLE C1

Endpoint Design for DCA

	Option 1							Option 2						
Row	Att1	Att2	Att3	Att4	Att5	Att6	Att7	Att1	Att2	Att3	Att4	Att5	Att6	Att7
E1	0	3	0	3	0	3	0	3	0	3	0	3	0	3
E2	0	3	3	3	3	0	3	3	0	0	0	0	3	0
E3	0	0	0	0	0	0	3	3	3	3	3	3	3	0
E4	0	0	3	0	3	3	0	3	3	0	3	0	0	3
E5	3	3	0	0	3	3	3	0	0	3	3	0	0	0
E6	3	3	3	0	0	0	0	0	0	0	3	3	3	3
E7	3	0	0	3	3	0	0	0	3	3	0	0	3	3
E8	3	0	3	3	0	3	3	0	3	0	0	3	0	0

TABLE C2

Base Design for DCA

	Option 1							Option 2						
Row	Att1	Att2	Att3	Att4	Att5	Att6	Att7	Att1	Att2	Att3	Att4	Att5	Att6	Att7
1	3	1	0	0	1	3	2	2	2	2	2	0	0	1
2	3	0	1	2	3	0	1	0	2	0	3	1	3	2
3	1	1	1	1	1	1	1	2	3	0	2	3	0	2
4	0	0	0	0	0	0	0	1	2	3	1	2	3	1
5	2	2	0	1	3	3	1	0	1	1	0	0	1	3
6	2	3	1	3	1	0	2	3	1	0	0	3	3	3
7	0	2	3	3	2	0	1	2	1	0	2	3	2	3
8	2	0	1	1	0	2	3	0	3	2	0	1	0	1
9	2	0	3	2	1	3	0	0	3	0	1	2	1	2
10	0	0	2	3	1	1	3	2	3	3	2	2	3	1
11	1	0	0	3	3	2	2	3	3	1	2	0	0	0
12	3	3	3	3	3	3	3	2	0	1	1	2	0	2
13	1	0	2	0	2	3	1	0	1	0	2	1	0	0
14	1	3	2	2	3	1	0	2	1	1	3	1	0	1
15	0	1	3	1	3	2	0	1	3	2	2	1	1	1
16	2	2	0	1	3	3	1	3	0	3	2	1	2	2
17	3	2	0	2	0	1	3	1	1	1	1	1	3	1
18	3	2	2	1	1	0	0	1	1	3	0	2	2	2
19	2	2	0	1	3	3	1	1	3	2	3	2	0	0
20	1	3	2	2	3	1	0	0	0	0	0	2	2	3
21	1	1	1	1	1	1	1	3	0	2	0	2	3	3
22	3	1	2	3	0	2	1	0	3	1	0	2	1	2
23	0	3	2	1	0	3	2	1	1	1	2	2	2	3
24	3	0	1	2	3	0	1	1	3	2	1	0	2	3
25	3	3	3	3	3	3	3	0	1	2	0	1	2	0
26	3	2	0	2	0	1	3	0	0	3	3	2	0	0
27	0	2	1	0	3	1	2	3	3	3	2	2	2	1
28	1	3	0	1	2	0	3	2	1	3	2	0	3	0
29	0	3	0	2	1	2	1	3	0	2	0	0	3	0
30	0	1	1	2	2	3	3	2	0	2	1	3	1	1
31	2	3	3	0	0	1	1	1	0	1	2	3	2	0
32	1	2	1	3	0	3	0	0	3	3	1	3	0	3
33	1	2	1	3	0	3	0	3	1	2	2	1	1	2
34	2	3	1	3	1	0	2	0	2	2	2	2	2	0
35	3	1	2	3	0	2	1	1	0	3	2	1	0	3
36	1	0	0	3	3	2	2	2	2	3	0	1	1	3
37	0	2	1	0	3	1	2	1	0	0	1	1	0	3
38	1	2	3	0	1	2	3	3	1	0	3	2	0	1
39	3	0	3	1	2	1	2	1	3	0	0	3	3	0
40	2	3	1	3	1	0	2	1	0	3	1	0	1	1
41	2	1	0	3	2	1	0	3	3	3	0	0	0	1
42	2	0	1	1	0	2	3	3	2	0	2	2	1	0
43	3	2	0	2	0	1	3	2	3	2	0	3	2	2
44	2	1	0	3	2	1	0	1	2	2	1	1	2	3
45	1	2	3	0	1	2	3	0	3	1	2	0	3	2
46	3	0	1	2	3	0	1	2	1	3	0	2	1	0
47	0	1	3	1	3	2	0	3	2	1	3	2	3	3
48	2	1	2	0	3	0	3	3	3	1	1	1	3	0
49	3	2	2	1	1	0	0	2	3	0	3	0	1	3
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52	1	0	2	0	2	3	1	2	2	1	1	0	2	2
53	1	1	3	2	0	0	2	0	2	1	0	3	1	1
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57	1	3	2	2	3	1	0	3	2	3	1	0	3	2
58	0	1	1	2	2	3	3	3	2	3	0	1	0	2
59	2	0	3	2	1	3	0	3	2	2	3	3	2	1
60	3	0	3	1	2	1	2	2	1	1	3	1	2	1
61	1	2	3	0	1	2	3	2	0	2	1	3	1	0
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63	1	2	1	3	0	3	0	2	0	0	0	2	2	1
64	2	3	3	0	0	1	1	0	2	0	3	1	3	3
65	2	1	0	3	2	1	0	0	0	1	2	3	3	2
66	1	0	0	3	3	2	2	0	1	2	1	2	3	1
67	3	2	2	1	1	0	0	0	0	1	2	3	3	1
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69	2	1	2	0	3	0	3	0	0	3	3	0	2	1
70	1	1	3	2	0	0	2	3	0	0	1	1	2	0
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87	2	1	2	0	3	0	3	1	2	0	2	2	1	2
88	0	0	2	3	1	1	3	3	1	0	1	0	2	2
89	3	3	3	3	3	3	3	1	2	0	2	0	1	1
90	0	3	2	1	0	3	2	2	2	3	0	1	1	0
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92	1	0	2	0	2	3	1	3	3	3	3	3	1	3
93	2	3	3	0	0	1	1	3	1	2	1	2	0	2
94	0	0	0	0	0	0	0	3	1	2	2	3	1	3
95	0	0	0	0	0	0	0	2	3	1	3	1	2	2
96	2	2	2	2	2	2	2	1	3	0	0	1	3	1

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