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Managing the last mile of the supply chain for spare parts*

**Gestión de la última milla de la cadena de
suministro para piezas de repuesto**

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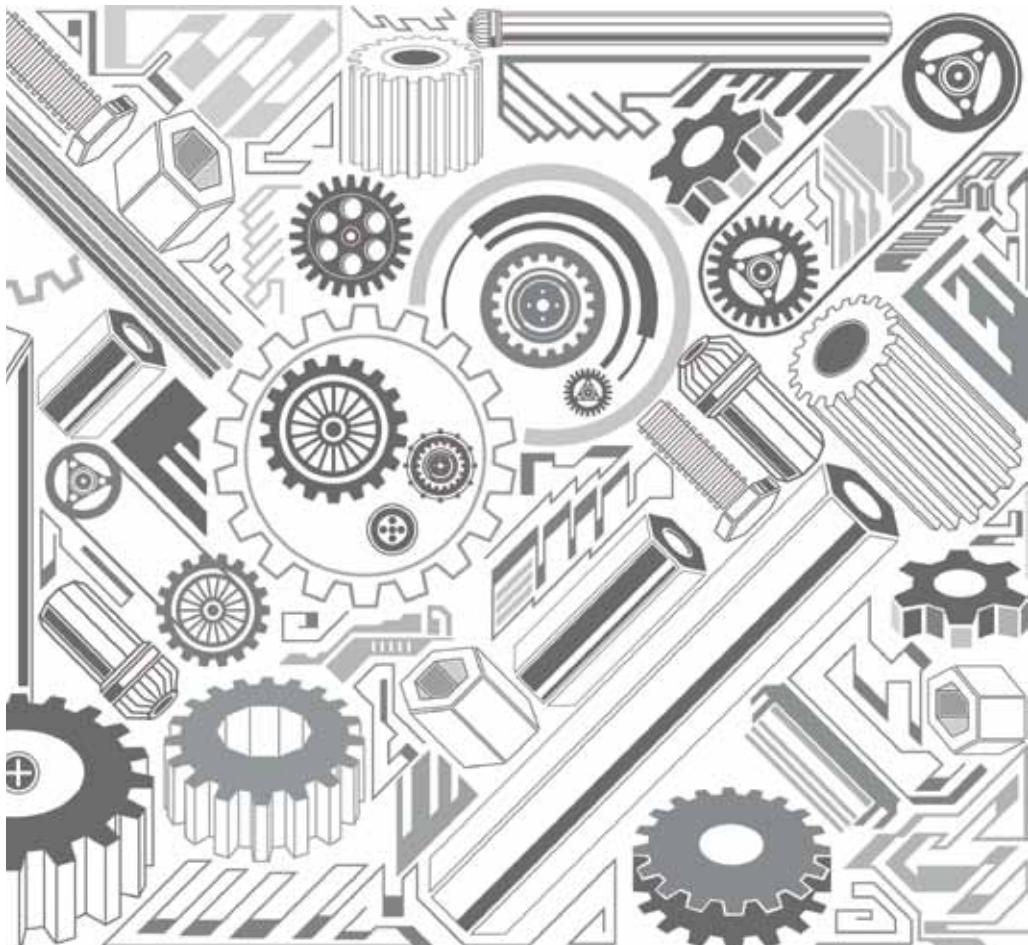


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I. INTRODUCTION

The last mile - the last link in the supply chain to the consumer - forms an important component in physical distribution. Several studies express the importance of physical distribution on consumer loyalty and consumer satisfaction (de Koster, 2002; Thirumalai and Sinha, 2005). Heim and Sinha (2001) found that variables underlying the order fulfillment process such as ease of return, timeliness of delivery and product availability are significantly correlated with consumer loyalty. Somewhat the same is signaled by Thirumalai and Sinha (2005) who found on-time delivery, order tracking/status information, products meeting expectations and consumer support as variables measuring satisfaction with order fulfillment. Bromage (2001) especially mentions that for consumer satisfaction and loyalty, the last mile in the fulfillment process may be one of the most important.

Furthermore, physical distribution activities are very important from a cost perspective because e-fulfillment is one of the most expensive and critical operations of internet sellers (de Koster, 2002). The addition of the online channel makes the last mile more complex, by creating more search, order and after sales options for consumers and by creating more delivery possibilities in the last mile. Unique to e-fulfillment is that inventories may be decoupled from what is displayed to consumers. This increases



EXECUTIVE SUMMARY

In this paper we investigate the last mile of the supply chain for spare parts that consumers use for Do It Yourself (DIY) repair activities. We deploy a survey among Dutch consumers to identify preferred delivery methods and part ordering characteristics. We find a general willingness among Dutch consumers to perform DIY repair activities. Consumers furthermore prefer spare parts delivered directly to their house. Preferred part ordering characteristics depends on situational characteristics such as age and parts criticality.

RESUMEN DEL ARTÍCULO

En este trabajo se analiza el diseño de la cadena de suministro en la última milla para las piezas de repuesto que usan los consumidores en las actividades de reparación que llevan a cabo ellos mismos. Se distribuyó una encuesta entre consumidores holandeses para identificar los métodos de entrega preferidos y las características de los pedidos. Los resultados indican que existe un deseo general entre estos consumidores de realizar actividades de reparación ellos mismos y prefieren la entrega directa de las piezas de repuesto. En cuanto a las características de los pedidos, depende de características coyunturales tales como la edad o lo críticas que sean las piezas.

When using the direct delivery method, products are delivered to a given location, mostly to the home, where the consumer accepts the delivery. The personal contact with the consumer increases delivery time but also offers an opportunity to have face-to-face contact

flexibility in locating inventory (Agatz et al., 2008). The absence of inventory on display even makes it possible for retailers to avoid inventory altogether, by delivering consumer orders directly from their suppliers inventories, which is called drop-shipping (Agatz et al., 2008).

In this research, we focus on after sales service supply chains, and in particular on spare parts because after sales service is generally seen as an important source of differentiation, additional revenue and also as essential for increasing consumer satisfaction and loyalty (e.g. Cohen and Lee, 1990; Goffin, 1999). Spare parts management is considered one of the most important areas in after sales services (Gaiardelli et al., 2007).

Little research has been done on spare parts distribution in business to consumer (B2C) settings. In practice this area is rapidly expanding as examples of companies supplying spare parts to their consumers show. Large companies like Philips² and Siemens³ for example are already extending after sales services by offering the opportunity to buy spare parts for their consumer products via their websites. These companies offer consumers not only access to repair centers or the option of sending mechanics to your home, but also support replacing failed components yourself. Literature on consumer self-servicing in the home improvement and maintenance sector shows a broad consumer willingness in doing work themselves without the paid services of a professional (Adriaenssens and Hendrickx, 2009). No research however is known that focuses on the specific consumer requirements and last mile supply chain design for do-it-yourself (DIY) part replacement activities.

In this paper we take a consumer centric view on spare part management and investigate last mile supply chain design to support consumer DIY repair. Literature noted some motivations for performing DIY activities (Wikström, 1996; Williams, 2004; Etgar 2008; Wolf and McQuitty, 2011): economic constraints, a lifestyle choice (sense of freedom, of power, of craftsman, flexibility, pleasure, self-identity, uniqueness, etc.), lack of access to, or lack of reliability and quality of professionals. We investigate delivery methods and ordering characteristics in the last mile of the supply chain for spare parts that consumers intend to use for DIY repair activities.

2. DELIVERY METHODS AND ORDERING CHARACTERISTICS OF THE LAST MILE

The last mile is deemed critical in supply chain success and hence critical to manage well. For this last mile, many delivery options and corresponding designs of physical distribution exist (cf. Agatz et al. 2008). In this research we focus at three common delivery methods: direct delivery to a home or job address, in-store pick up from a dealer, and pick up from a post office.

When using the direct delivery method, products are delivered to a given location, mostly to the home, where the consumer accepts the delivery. The personal contact with the consumer increases delivery time but also offers an opportunity to have face-to-face contact. In this kind of delivery, consumers may sometimes also choose a time window. In this case, both delivery and picking timetables become more inflexible (Kämäräinen et al., 2001). High demand for certain time slots, travel time uncertainties and short time windows further complicates the delivery task (Hays et al., 2004), and failures in actual delivery success vary considerably among carriers (Edwards et al., 2010), depending on the carriers' policies for dealing with no-one-at-home. To deal with this, parcel delivery companies offer a second delivery attempt. Dutch parcel deliver company PostNL for example has a website "www.mijnpostnl.nl" where you can indicate how you would like to receive your parcel for the second delivery attempt. Consumers may also call to set up a new delivery appointment. There is also a possibility to indicate a physical location to pick up a product; DHL for example has designated pick-up and delivery points inside stores of Dutch bookstore chain Bruna.

In case of in-store pick up from a dealer the products are shipped to retailer/agent locations and consumers travel to the store to pick up the products they ordered. Requirements for this approach are that the products are easy to carry (for example a part such as a wheel from a stroller) and that the retail/agent stores are located near consumers; it must be convenient to participate. Some Internet-only companies therefore partner with retailer channels in order to make this approach feasible (Lee and Whang, 2001). The downside of in-store pickup is that the service experience is not as good as with other delivery methods because consumers have to travel to and from the store. On the other hand, total delivery costs are lowered compared to home delivery (Hays et al., 2004) and cost savings

KEY WORDS

Last mile, Supply chain, Spare parts, Do it yourself repair

PALABRAS CLAVE

Última milla, Cadena de suministro, Piezas de repuesto, Reparaciones realizadas por el consumidor



may be realized with the possibility of aggregating multiple orders and combining such shipments with regular store replenishments (Steinfield et al., 2002; Agatz et al., 2008). The in-store pickup model also solves problems of traditional retailers like the inability to offer 24-hour shopping while at the same time solving problems of internet firms such as the lack of access to local delivery and repair services (Pyke et al., 2001). Furthermore, according to case studies done by Steinfield et al. (2002) the in-store pickup model also drives in-store foot traffic and helps overcoming concerns about the perceived security of online payment since consumers may pay in the store. It enhances consumer trust and reduces buyer risk further by the presence of physical outlets that can accept product returns.

Pick up from a post office or another third party parcel carrier location could be interpreted as a kind of in-store pickup model. This may be a solution in serving rural areas where the density of retailer outlets is low. In Japan, convenience stores like 7-Eleven have been used for some time and in the USA office parks and train stations are known pick-up locations (Lee and Whang, 2001; Hays et al., 2004). In Holland, post offices and so-called 'Kiala points' (pickup and delivery points in local shops that are part of a shipping & delivery network) may be used to pick up products.

The drawbacks and advantages of this delivery method are almost the same as with the in-store pickup model. An important difference between the methods is that personnel at the associated retailer/dealer possess product or brand specific experience and knowledge, while personnel at a third party pick up locations do not. Also the return of products may be considered as being part of the last mile. Of course it is best to avoid returns at all but if returns are inevitable three general return options exist. First, products may be passed to a parcel delivery company who collects the item as part of the usual delivery round and/or organizes separate pick up runs (Edwards et al., 2010). Second, consumers can send items back using standard postal services. Third, a collaborative approach like the in-store pickup method may be used: goods can be returned at retail stores or at third party pick up/return locations (Lee and Whang, 2001; Agatz et al., 2008). This practice reduces return handling costs and its popularity depends also here on the density of (return) locations (Edwards et al., 2010).

However, no one best strategy exists. As Lee and Whang (2001) point out the right last mile delivery strategy depends on a

company's business environment and on the characteristics of its products. In line with this, Thirumalai and Sinha (2005) conclude that consumer expectations of order fulfillment vary across product types, e.g. customer expectations of order fulfillment for specialty goods such as cameras are relatively higher than that for convenience goods such as groceries or personal care products. Similarly, findings of Mentzer et al. (2001) suggest that consumers' perceptions about aspects of logistics service quality and the relative importance they play in consumer satisfaction differ by product segment.

Consumers are likely to order a critical part directly after failure. Similar to B2B environments where 24/7 processes (continuing around the clock, 24 hours per day, 7 days per week) are common, the ability to order 24/7 is likely to be valued by consumers, particularly for critical spare parts. Furthermore, if criticality of a part increases consumers may be more involved in the process to obtain the right parts on time. Highly involved consumers appreciate high levels of service (Wallace et al. 2004). Receiving detailed order status information will be appreciated more as part criticality increases – and is possible with the infrastructure of parcel delivery companies. Appreciation is also expected when more expensive products are ordered. People feel more risk buying an expensive part; this negative feeling may be somewhat reduced by receiving order status information as this removes uncertainty and gives the consumer more peace of mind.

Another relevant ordering aspect is the extent to which consumers prefer to order spare parts at the original manufacturer. Consumers may find it less risky ordering a part at the original equipment manufacturer (OEM), compared with a retailer. The risk to receive an incompatible part or to receive incorrect advice may be smaller in case of an OEM. One may therefore reason that criticality as well as the value of a spare part relate positively to the preference of ordering at the (OEM). Last, also time pressured consumers may find it more attractive to order at the (OEM), as they don't want to spend time considering other options or companies.

Therefore, this paper seeks to respond to two main questions:

- Q1. What is the effect of spare parts characteristics on the attractiveness of last mile delivery methods?
- Q2. What is the effect of spare parts characteristics on last mile ordering characteristics?

3. CONSUMERS PREFERENCES FOR DIY REPAIR

A web-based survey has been developed to test the questions. The development and distribution of the questionnaire took place in close cooperation with a company specialized in child safety seats. We cooperated with this company to ensure that we could target an audience that is familiar with a product. Furthermore, the replacement of some key parts of the product (such as wheels) is relatively easy to execute. The target population consisted of 3000 young Dutch parents. These people were invited by e-mail to participate in the survey. The electronic survey was visited by 253 persons and questionnaires were fully completed by 151 respondents; 122 of them indicated they are willing to replace parts themselves. The empirical analysis was made using information of these 122 respondents. This yields a final response rate of 4.07%.

Table 1 shows the general respondent information from the research sample. The number of female respondents is quite high but our response is in line with normal patterns since woman typically shop online much more.

Table 1. Sample characteristics (N=122)

AGE	%	URBANIZATION [*]	%
23-29	28.69%	No urbanization	9.17%
30-34	52.46%	Low urbanization	23.33%
35-39	9.01%	Average urbanization	24.17%
40+	9.84%	Strong urbanization	31.67%
Average	31.74 year	Very strong urbanization	11.67%
EDUCATION	%	FAMILY STATUS	%
Secondary school	9.92%	With partner, youngest child 0-10	89.26%
Vocational training	38.84%	With partner, youngest child >10	2.48%
Professional higher education	36.36%	Single partner, youngest child 0-10	4.91%
University	14.88%	With partner, without children	3.31%
GENDER	%		
Female	95.08%		
Male	4.92%		

^{*} Same classes used as the region address density classes of Dutch Central Bureau of Statistics (CBS, 2011).

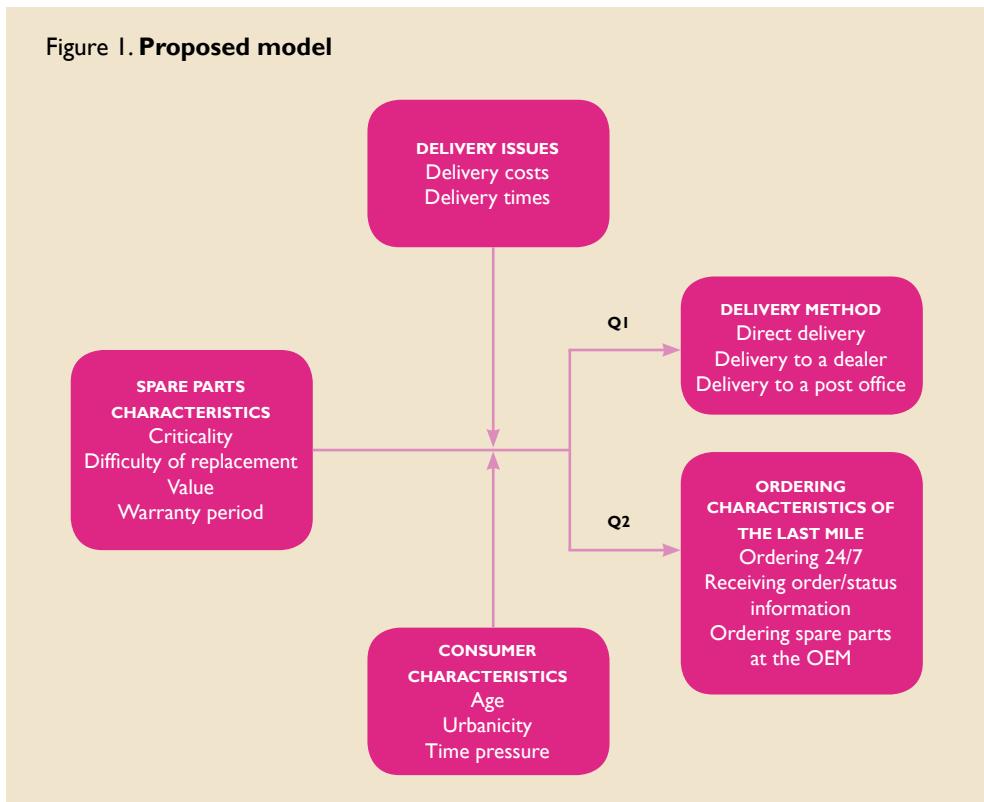
The questionnaire starts with the presentation of a spare part replacement situation. This situation sketch contains a stroller with a specific defective part that could be replaced. In the accompanied text, the respondent is told whether tools are needed for the replacement and whether the defect is within warranty or not. 14 different part replacement situations have been designed; the survey software randomly assigns only one situation to each questionnaire, so each respondent is confronted with only one situation. The designed situation differs in the nature of the defect, in the spare part to be replaced, in the criticality of the defect, spare part value (price) and the difficulty of replacement.

Respondents are asked to rate the attractiveness of some logistical preferences and how they perceive some spare part characteristics. Specifically, respondents were asked to indicate the attractiveness of three delivery methods for delivery of a specific type spare part described in the situation sketch (e.g. a defective wheel from a stroller needs to be replaced): direct delivery (to the home or to the office), picking up the spare part at a dealer location, or picking up the part from a post office. With regard to ordering characteristics, respondents were asked to rate on a 7-point scale the importance of being able to order this spare part 24/7, and the importance of being informed in detail on the progress of the order. Finally, respondents were asked to indicate on a 7-point scale whether they preferred to order the spare part at the original manufacturer (OEM) rather than at another company. This question enables us to examine the relation between spare part characteristics and the loyalty towards the original manufacturer of the product for which consumers seek spare parts.

Understanding that there are many characteristics of spare parts that may influence delivery methods and ordering characteristics, we decided to include the following four: criticality, difficulty of replacement, value, and warranty period. After reviewing the situation sketch, respondents are asked to rate on a 7-point scale to what extent they agree with a few statements related to these issues. The spare part characteristic warranty is described in the accompanied text of the situation sketch (it is indicated whether the defect described occurs within –takes the value 1- or outside warranty –takes the value 0-). Two groups of control variables were introduced: (1) consumer characteristics (more specifically: age, urbanicity, and time pressure) and (2) delivery issues (more specifically: delivery costs and delivery times). **Figure 1** summarizes the model of this study.



Figure 1. Proposed model



With regard to consumer characteristics, age is simply measured with an open-ended question. Urbanicity is measured by asking the four numbers of the zip code. Each zip code is linked to a geographical region, which can be connected to national population data (CBS, 2011). Then for each region the corresponding region address density is recorded using additional population data (CBS, 2011). This results in a continuous variable measuring urbanicity. Finally, in relation to time pressure, respondents were asked to indicate their personal attitude towards time on a 7-point scale.

With respect to delivery issues, respondents were asked for the acceptability of longer delivery/pick up times (delivery within 7 days) measured on a 7 points scale, and what they think the maximum shipping costs should be (the answer options range from free delivery to maximal 15 euro of shipping costs).

The demographic background information of respondents shows that the research sample can be considered as representative for the targeted population, Dutch (young) parents. No remarkable

differences were found, so the answers by the research sample are generalizable for the targeted population. The results of the multiple linear regressions on delivery methods and ordering characteristics are showed in **table 2**. We observed that some adjusted R² values are relatively low for the delivery methods, which indicates that the attractiveness of delivery methods is determined by other variables not included in the model; this issue requires more investigation.

Table 2. Multiple linear regressions on the delivery methods and ordering characteristics (standard error in parentheses)

	DIRECT DELIVERY	DELIVERY TO A DEALER	DELIVERY TO A POST OFFICE	ORDERING 24/7	RECEIVING ORDER/STATUS INFORMATION	ORDERING SPARE PARTS AT THE OEM
INTERCEPT	6.60*** (0.60)	n.s.	4.37* (1.94)	7.47*** (1.27)	7.50*** (1.14)	3.22+ (1.73)
CRITICALITY	n.s.	n.s.	n.s.	0.21*** (0.08)	n.s.	0.31*** (0.11)
DIFFICULTY OF REPLACEMENT	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
VALUE	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
WARRANTY PERIOD	n.s.	-0.63+ (0.37)	n.s.	n.s.	n.s.	n.s.
AGE	n.s.	n.s.	-0.08+ (0.04)	n.s.	-0.05** (0.03)	n.s.
URBANICITY	-0.09+ (0.05)	n.s.	n.s.	n.s.	n.s.	n.s.
TIME PRESSURE	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
DELIVERY COSTS	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
DELIVERY TIMES	n.s.	0.28* (0.13)	n.s.	-0.37*** (0.10)	n.s.	n.s.
F	n.s.	n.s.	n.s.	6.06***	4.77***	2.76**
R ²	0.06	0.12	0.08	0.33	0.28	0.18
AJUSTED R ²	-0.01	0.05	0.02	0.28	0.23	0.13

***p≤0.001; **p≤0.01; *p≤0.05; +p≤0.1
n.s.: not significant.

4. CONCLUSIONS AND MANAGERIAL IMPLICATIONS

One of the main findings is that there is a general willingness to replace spare parts among consumers for the types of spare parts we investigated: 80.79% of our respondents indicated they are willing to perform DIY repairs. Hence there will be a demand for services that provides spare parts to consumers, which may also open up new avenues for companies active in after sales.

Careful investigation of the rough sample data revealed that almost all respondents rated the attractiveness of direct delivery higher (82,8%) than the attractiveness of the other two (pick-up) options (6,62% each one). Therefore it may be concluded that independent of consumer characteristics and independent of delivery cost and times, consumers prefer to obtain the types of spare parts we investigated by direct delivery to the requested address as opposed to collection from a dealer or a post office. This may relate to the fact that consumers need to make a physical effort (customers have to travel to and from the store or the post office) to collect items and hence see it as an inconvenience for this type of item, in line with what Lee and Whang (2001) suggested. Our investigation furthermore shows that, on the one hand, consumers living in rural areas feel less attracted to pick up spare parts due to the limited accessibility of dealers and post offices; they therefore prefer direct delivery. In contrast, consumers living in urban areas feel less attracted to delivery method. This might be due to opportunity cost, i.e., consumers cannot spend their free time on the great variety of activities that big cities offer when waiting at home for delivery. On the other hand, if a part failure takes place after warranty expiration (implying that consumers need to pay for spare parts themselves), consumers are more attracted to picking up spare parts themselves at dealers. Consumers may prefer this kind of delivery method due to the possibility of personal communication and face-to-face contact. Consumers can discuss their issues with a knowledgeable person face-to-face and therefore may be able to reduce their perceived risk. Finally, consumers who accept longer delivery times prefer pick up of spare parts at a dealer. We also found that, compared to younger customers, older consumers feel less attracted to pick up spare parts at a post office. Normally older consumers are more accommodated and less active than younger consumers. Hence, a round trip to the post office when picking up a product can be an inconvenience for older consumers. Our research furthermore reveals the situational relevance of ordering characteristics. The more consumers perceive a part as critical - implying a larger problem caused by the part failure – the more consumers rate the ability of 24/7 ordering as important. Furthermore, the less they accept longer delivery times, the more consumers rate the ability of 24/7 ordering as important. With regard to obtaining status information during the order to delivery process we find that age has a negative influence on the importance of receiving this information. Receiving up to date last mile order information is a relatively recent development. One may expect that, as we mentioned before, older consumers are more accustomed to traditional methods compared to younger consumers and younger people actually expect more information on their order.

Finally, in relation to ordering spare parts at the OEM, consumers are more loyal to the original manufacturer of the product if a critical spare part is needed. The potential consequences of receiving an incompatible part, still having to deal with a broken product and a possible financial loss are larger if criticality increases. For less critical parts, consumers rather refer to go to a variety of potential suppliers. Value, warranty period and difficulty of replacement do not have an influence on the attractiveness to order at the OEM.

This preference for obtaining spare parts from OEMs implies that local retailers or dealer stores are to some extent skipped in the supply chain. This gives manufacturers the opportunity to take more control over the spare part supply chain. Direct delivery of spare parts provides a manufacturer with valuable information on consumer demand and on consumer wishes. This information on sales is normally not directly visible as it comes from the dealers, but is especially valuable in spare part supply chains. Managing spare parts demand is one of the main problems in spare part management because demand is often infrequent, interspersed by periods of no demand at all or very variable in size (Fortuin and Martin, 1999). Receiving better sales data of spare parts is for a manufacturer extra valuable as it may also reveal problems with products earlier. More efforts from OEMs to provide the opportunity for consumers to obtain spare parts directly may therefore be expected – although this not necessarily means that the OEM will also execute fulfillment. Given the availability of experienced companies in global online order fulfillment we expect that many OEMs will outsource the fulfillment part. On the other side, skipping local retailers in the DIY spare parts supply chain could also entail in an increased possibility of multichannel conflict. Concurrent channel use can benefit consumers but might create conflict through competition between the channels (Neslin et al., 2006), because demand is actually rerouted directly to an OEM instead of via intermediary parties. Compensation agreements between channel partners may have to be considered by OEMs to overcome potential conflicts in the supply chain.

The preference for obtaining critical spare parts directly from an OEM also enables companies to centralize a large part of spare parts stock. Keeping spare parts decentralized at local retailers is however infeasible in practice because the number of spare parts to be kept in stock is enormous. The OEM is better suited to store the parts, with the added advantage that centralization of stock makes it possible for companies to reduce demand variability by aggregating demand and thus reduce safety stocks. It has to be noticed that having consumers order spare parts directly at OEMs implies a changed way of working in the OEM warehouse, compared



to taking and processing orders from stores or companies. Direct consumer deliveries result in many small transactions and many order lines to be planned and managed. This may call for execution of the warehousing and fulfillment activities by a third party company.

Our research results must be interpreted with some caution since the research has its limitations, which are largely derived from small sample size and geographical scope (the Netherlands). Furthermore, the sample primarily consisted of females. Another limitation is related to the object of research. Respondents are only asked for their preferences with regard to spare parts of child safety products such as strollers. The selection of more product groups may generate more generalizable results. Furthermore, in this research respondents have been interrogated on their intended choices and preferences; once spare parts supply chains for DIY repair become more common it would be beneficial to test actual choices instead of intentions. Last it should be noticed that the survey method we used, an internet questionnaire for which the invitation was sent by e-mail, could lead to a bias towards more experienced internet users. Summarizing, future research should focus at analyzing actual choices of consumers in the shopping for spare parts (not only preferences and intended choices), at testing of consumer choices and preferences for spare parts of other household applications, and at including additional consumer and spare part characteristics.

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NOTES

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