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# THE ROLE OF TRANSPORTATION IN CUSTOMIZED SUPPLY CHAINS

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This paper empirically explores the role of transportation in creating a customized supply chain using postponement. Based on a survey among manufacturers in three countries, it was found that a reconfiguration is needed for the creation of a customized supply chain. In this reconfiguration process, transportation considerations are extremely important, resulting in supply chains and distribution channels that are globalized and reliant on international transport. Postponement is increasingly applied in both manufacturing and distribution. Thus, through the facilitation of postponement and customization activities in the distribution channel, much business is to be gained for transportation and logistics companies.

## INTRODUCTION

Mass customization is argued to be a "new competitive paradigm" (Kotha 1995). Numerous authors have stressed the importance of interactively marketing and manufacturing products (McKenna 1995) and customizing products in response to individual customer orders, while retaining cost effectiveness in operations (Pine 1993; Gilmore and Pine 1997). For this mass customization of products, the supply chain has to be organized in such a manner that it allows for customer responsive and cost competitive operations (Kotha 1995; Feitzinger and Lee 1997). Bundles of supplementary services such as customer-specific product configuration, the adding of product features or specific packages and product displays are often used to customize product/service offerings (Anderson and Narus 1995). Postponing product finalization is also

used for achieving customization. Having postponed final assembly, configuration, or even packaging, allows a company to be more able to align products and shipments to the individual customer (Feitzinger and Lee 1997). Pine (1993) stated that modularizing products into generic components and assembling them into customer specific products is one of the best methods for realizing mass customization. Also, Lampel and Mintzberg (1996) state that, to achieve customization, varying activities in the supply chain may be customized and postponed, and others may be standardized.

Postponement is the concept that centers around the delay of activities in the supply chain until customer orders are received. These activities can include, as mentioned, shipment and packaging, but also assembly and even procurement. Postponing these activities allows them to be customized for specific customers. In

order to assure speed of delivery and interaction with customers, the postponed activities are often positioned close to the final market. This brings us to the role of transportation.

One of the consequences of this development is that customization is increasingly performed in the distribution channel. Daugherty et al. (1992), state that a number of activities can be placed in the distribution channel in order to contribute to the offering of customized services at competitive cost levels to the end-customer in the supply chain. In the distribution channel, displays can be assembled, customized delivery services can be offered and products can even be assembled to order. This is confirmed by the CLM (1995) which states that the application of postponement operations has increased over a five year period. Further, Morehouse and Bowersox (1995) state that, at least in food supply chains, postponement is increasing. In particular they predict that by the year 2010 no less than half of all stock will be stored until final customer specifications have been received and goods can be finalized and packed for shipment.

With these customizing activities placed in the distribution channel, it is not surprising that third party logistics services providers and transport companies consider these as a viable extension of their service offerings. Third party logistics service providers have, by operating warehouses and transportation systems for manufacturers, successfully earned a position in distribution channel operations. Cooper et al. (1998) mention the facilitation of postponement as one of the possible contributions of transport companies to supply chain management.

Based upon the above reflections in literature, the objective of this paper is to empirically explore the role of transportation in the development of customized supply chains using

postponement. The main question for this study is *what is the role of transportation in a customized supply chain*. Specific research questions are:

- To what extent is postponement applied in the distribution channel,
- What is the role of transportation in structuring a customized supply chain,
- What is the structure of the transportation and distribution channel in a customized supply chain,
- What are the roles of transport companies and logistics service providers in performing customizing activities in a customized supply chain.

The objective is to contribute to a further understanding of mass customization and postponement from a transportation angle, and to contribute to an understanding of the role of transport companies and logistics service providers in facilitating postponement and mass customization. The next section will outline the survey methodology used in this study. Results will then be presented, including applications of postponement, considerations used in structuring the customized supply chain, the structure of the customized supply chain, and the role of transport companies and logistics service providers in performing customizing activities. The final section will draw conclusions and reflect on the implications of these findings.

## METHOD

An international survey was conducted among internationally operating manufacturers in the Netherlands, Germany and Belgium. Four industries were selected for the study: electronics, automotive supply, clothing and

food. The four selected industries also represent theoretical categories of postponement applications mentioned by Cooper (1993) (see Figure 1). Cooper uses a set of operational characteristics as criteria for assessing the viability of different types of postponement. The postponement applications range from postponed distribution from a global factory (on the left) through postponed assembly and postponed final manufacturing in a warehouse or European factory to postponed packaging in a regional warehouse (on the right). For all structures a global brand is needed. For products with varied peripherals (such as packages and labels) postponed assembly or packaging may be viable. For products with varied formulation (such as different voltages or product form and function) bundled manufacturing and deferred assembly may be viable, resulting in significant customization through product formulation. The electronics and automotive industries can be positioned in these segments, while the clothing industry fits in both the unicentric and deferred packaging application. Food fits into the deferred packaging application due to its homogenous product formulation and variations in peripherals (packages etc.), resulting in customization at a lower level. In studying these industries, the intent was to be able to assess a broad spectrum of postponement applications in the context of customization.

The questionnaire used in the study was developed through a search for items in the literature and discussions with a steering group of funding companies in the logistics business. The questionnaire was then tested in 25 interviews in the three countries. Based upon the remarks of experts interviewed, several

non-relevant items were deleted and missing items were added. The survey was mailed to 520 companies in the Netherlands. After one follow-up mailing, 78 companies responded (15%). In Belgium and Germany, 71 companies responded to the first mailing to 1450 companies. As a result of the low response rate in Belgium and Germany, the analysis in the following sections will concentrate on Dutch respondents. German and Belgian responses will be used, however, as a reference. The low response level of course does not allow for statistical comparisons of differences between the three countries.

### THE APPLICATION OF POSTPONEMENT IN THE DISTRIBUTION CHANNEL

Figure 2 shows the level at which postponement is applied in the supply chains studied. Postponement was measured along the supply chain, from engineering to distribution, without limiting the measurement to manufacturing as done in Dröge et al. (1995). Lampel and Mintzberg (1996) state that customization can be applied throughout the entire supply chain. Respondents were asked to specify the share of activities, out of the total of annual orders, that are performed based upon customer orders. This allowed for precise measurement of the level in the chain at which postponement is applied and the extent to which it is applied at this level. The reasoning behind this measurement was that postponement can not only be applied at multiple levels in the chain, but also to varying degrees (van Hoek 1998).

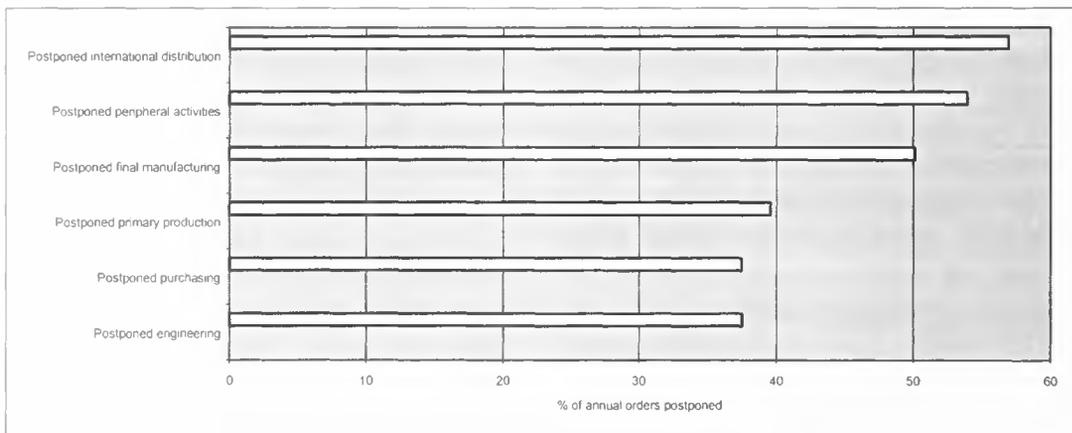
Figure 2 displays the average levels at which postponement is applied throughout the supply chain. On average, 44.05% of activities are postponed, with a concentration in the

**FIGURE 1**  
**THE SELECTION OF SUPPLY CHAINS TO BE STUDIED**

	Unicentric Central production & distribution	Bundled manufacturing Design product so that customization can take place at the latest possible stage of production process	Deferred assembly Final assembly and final configuration in central warehouses	Deferred packaging Labeling and packaging at regional warehouses
Brand: is it global?	Yes	Yes	Yes	Yes
Formulation: is it common to all markets?	Yes	No	No	Yes
Peripherals: are they common to all markets?	Yes	Yes	No	No
Spatial position of final manufacturing	Global plant	Europlant	European Distribution center	Regional warehouse
Chains in this study:	Clothing	Electronics/ automotive	Electronics/ automotive	Food/ clothing

Source: adapted from Cooper (1993)

**FIGURE 2**  
**THE APPLICATION OF POSTPONEMENT**



downstream stages of the chain. Distribution and final manufacturing activities are postponed to a larger extent than purchasing and primary manufacturing. Thus, distribution plays an important role in the application of postponement. Tables 1 to 3 further detail the findings. Table 1 displays the postponement applications across the industries studied. For the measurement of postponement, both the single items and a multi-item construct containing all the postponement applications in the survey (with a reliability of alpha 0.89) were used. The single items reflect specific postponement applications, whereas the construct is used to reflect the overall application along the supply chain.

Comparing average levels, the electronics and automotive supply chains apply postponement at higher levels, and food and clothing at lower levels, than the average of 44.05%. The levels of application were compared using oneway Anova. Consistent with the reasoning of Cooper (1993), it was found that the electronics and automotive supply chains also apply postponement at a higher level in the upstream stages of the supply chain, resulting in higher levels of customization at a product formulation level. No significant difference was found for peripherals (packaging, labeling and documents) and distribution postponement, despite the higher levels of application in electronics (excluding distribution) and automotive. Apparently electronics and automotive supply respondents outscore food and clothing respondents in the application of postponement along the entire supply chain.

Table 2 displays the application of postponement through time and compares the application by Dutch respondents with that of Belgian and German respondents. Respondents were asked to specify the application of postponement along the supply chain three years ago to the expected application three years from now, and in comparison with the current application. The general pattern displayed in the table is one in which postponement increases for each of the activities in the supply chain over time and in each of the countries studied. A slight difference is found in the application of postponement across the countries studied, in favor of Belgian and German respondents. These figures, however, should be interpreted with some caution, as the response rates differ between countries.

Respondents were then asked which activities are used to customize products in the supply chain. It was found that manufacturing activities, such as final assembly and the adding of product features, score high. These findings shed some additional light on the findings presented in Figure 2 and Table 2. Even though it was found that international distribution is postponed at the highest level in the supply chain (products are shipped based on customer orders), final manufacturing activities are most important in customizing products. Thus, distribution plays an important role in postponement, but for customization manufacturing is most relevant.

**TABLE 1**  
**THE APPLICATION OF POSTPONEMENT IN TOTAL AND BY INUSTRY**  
**(% OF ANNUAL ORDERS)**

	Electronics	Automotive	Food	Clothing	Other	Significance	Total average
Postponed product engineering	59.62	51.25	19.00	13.20	61.43	<0.01	37.49
Postponed purchasing	51.56	60.63	18.41	44.29	45.00	<0.01	37.42
Postponed primary production	54.86	55.63	21.65	24.80	63.33	<0.05	39.55
Postponed final manufacturing	71.00	71.88	29.68	30.57	66.67	<0.01	50.12
Postponed peripheral activities	71.07	52.14	45.92	36.00	67.50	n.s.	53.95
Postponed international distribution	47.00	72.14	57.83	53.80	55.00	n.s.	56.93
Postponement (overall average)	51.67	57.98	34.34	10.94	66.25	<0.10	44.05

Key: One-way Anova analysis

**TABLE 2**  
**THE DEVELOPMENT OF POSTPONEMENT OVER TIME AND BY COUNTRY**  
**(% OF ANNUAL ORDERS)**

	Past (3 years ago)		Present		Future (in 3 years)	
	NL	Bl & Germ	NL	Bl & Germ	NL	Bl & Germ
Postponed engineering	34.91	36.25	37.49	38.92	41.39	41.51
Postponed purchasing	33.89	40.44	37.42	43.08	40.76	44.96
Postponed primary production	38.00	36.88	39.55	38.86	40.31	39.85
Postponed final manufacturing	46.27	53.21	50.12	58.88	53.29	60.89
Postponed peripheral activities	49.73	54.69	53.95	62.27	58.02	64.25
Postponed international distribution	52.50	50.40	56.93	58.88	59.88	58.44

### TRANSPORT CONSIDERATIONS IN THE CUSTOMIZED SUPPLY CHAIN

Lee, et al. (1993), explain how the implementation of postponed manufacturing at Hewlett Packard involved a reconfiguration of the supply chain. Final manufacturing activities were relocated downstream in the chain, closer to market areas. Also, cross-functional relations may have to be reshaped. Pine (1993) outlines how sourcing, production and logistics are involved in performing modular production, with the intention of better serving marketing objectives. Production now becomes a

significant marketing function and production activities are performed in the distribution channel. The creation of a customized supply chain, using postponement, thus requires structural reconfiguration along the supply chain. In fact, the structural reconfiguration requirements can be expected to hamper the effectiveness of postponement implementation programs (van Hoek et al. 1998).

In order to assess the role of transportation in the reconfiguration of the supply chain, respondents were asked to specify which considerations are critical for them in

structuring the supply chain. Considerations along the entire supply chain, from sourcing to distribution, were used, given that postponement involves cross-functional input. Also, this allows for the comparison of the relevance respondents assign to transportation considerations, in comparison with the relevance they assign to non-transportation considerations. Table 3 lists a set of considerations expected to be relevant in structuring the supply chain in general. The items include supply (product availability, JIT supplies etc.), manufacturing (manufacturing costs, responsiveness regarding order-quantities), logistics (costs of storing finished goods, delivery reliability) and transport and distribution considerations. On a seven point Likert scale (from not important in structuring the supply chain to very important in structuring the supply chain), customer service considerations (consistency and reliability of delivery, speed of delivery, and product availability) are ranked highest. These considerations have a clear transportation and distribution dimension attached to them. Speed, consistency, and reliability of delivery along the supply chain, including that of suppliers, are top considerations in structuring the supply chain.

In order to assess the specific relevance and role of these considerations in the context of customization, the correlation coefficients between these items and the application of postponement were calculated. Negative relations were found between the application of postponement and the importance of freshness, prevention of economic obsolescence of products, responsiveness in ordering quantities, cost of storing finished goods and costs of physical distribution. This final point suggests that transport considerations are less relevant in the context of postponement. On the other hand, positive correlation coefficients were found between the application of postponement

and responsiveness in product specification, a high frequency and delivery speed of suppliers, import duties and global sourcing considerations. Whereas responsiveness in order quantities is negatively related to postponement, responsiveness in product specification is positively related to postponement. Apparently, it is not so much the volume as it is the product formulation and the presentation that is customized through postponement. Whereas physical distribution costs are not a leading consideration in the sphere of postponement, supplier distribution performance is. This is reasonable, based on the notion that postponing (final-) manufacturing results in order-driven manufacturing, as opposed to storage of finished goods. The postponement of manufacturing makes the delivery of parts and components a critical success factor in meeting the required lead-times. Unavailability of parts will result in back-orders and lowered customer service levels to final customers. Additionally, the application of postponement is positively related to sourcing from third parties. Other distribution related considerations are import duties and global sourcing structures. Importing parts and modules instead of finished products in a postponement system allows for avoidance of duties as lower value goods are imported.

### THE STRUCTURE OF THE DISTRIBUTION CHANNEL

The reconfiguration of the supply chain needed for the implementation of postponement involves a spatial element, in that activities are relocated in the supply chain. In the example of Hewlett-Packard (Lee et al. 1993), final manufacturing activities were decentralized, moving downstream in the supply chain. Alternatively, the implementation of postponement can involve the centralization of inventories, combined with a relocation of other

**TABLE 3**  
**AVERAGE IMPORTANCE OF CONSIDERATIONS IN STRUCTURING**  
**THE SUPPLY CHAIN BY COUNTRY**

	NL	Bl & Germ
Delivery-reliability of suppliers	6.43	6.14
Consistency, reliability of delivery (maintaining promised schedule)	6.21	6.32
Lead/delivery time (speed)	6.08	6.15
Delivery speed of suppliers	5.93	5.58
Product availability	5.82	5.71
High percentage of inputs is purchased from third party suppliers	5.70	4.57
Flexibility regarding required lead times	5.68	5.89
Responsiveness regarding product specification	5.51	5.78
Manufacturing costs (including labor)	5.44	5.56
Responsiveness regarding order quantities (volume-flexibility)	5.44	5.45
Low cost of suppliers	5.43	5.14
Costs of storing finished goods	5.43	4.48
JIT-supply	5.16	4.66
Physical distribution costs	4.85	4.70
High frequency supply (by external parties)	4.81	4.62
Preventing economic product obsolescence	4.36	3.50
Costs of storing semi-finished goods	4.16	3.80
Import duties/preferential duty systems	3.49	2.84
Freshness of product (technical/economical)	3.42	4.12

Key: mean scores on a Likert scale from 1 (not important at all) to 7 (very important)

activities in the supply chain, including sourcing (directly to the distribution center) and distribution (van Hoek 1998). This suggests that not only the spatial structure of the distribution channel is affected, but that wider segments of the supply chain may have to be restructured to create a customized supply chain.

Table 4 lists average levels of centralization for activities along the entire supply chain in countries studied and over time. Given the potential impact of spatial restructuring throughout the entire supply chain, the question

was not limited to distribution only. Respondents were asked to specify the level of centralization on a four point scale for activities along the supply chain. Table 6 indicates how centralization is increasing for most activities along the supply chain, not just for distribution. This indicates how supply chains are globalizing and that transportation, like the distribution channel is, as a logical consequence, becoming more and more international throughout the entire supply chain. With the advance of globalization, transport linkages among activities and facilities in the supply chain are extended and,

**TABLE 4**  
**CENTRALIZATION IN THE SUPPLY CHAIN OVER TIME AND BY COUNTRY**

	Past		Present		Future	
	NL	Bl & Germ	NL	Bl & Germ	NL	Bl & Germ
R&D	3.08	2.58	2.94	2.41	2.73	2.22
Purchasing	2.93	2.68	2.71	2.39	2.77	2.12
Primary manufacturing (parts and components)	4.21	2.97	3.13	2.83	3.06	2.70
Final manufacturing	3.23	2.96	3.20	2.79	3.14	2.64
Packaging	3.32	2.90	3.54	2.72	3.18	2.60
Distribution	2.99	2.59	2.89	2.45	2.67	2.27
Sales	2.93	2.51	2.89	2.35	2.62	2.24

Key: Scores on a Likert scale; 1 (global level of operation), 2 (continental level), 3 (international level), 4 (local level)

with distance, increase in relevance given the increased dependence on cross-border shipments.

Respondents were asked which selection factors they used in locating operations in the supply chain, in order to assess the role of transportation factors in the spatial reconfiguration involved in the implementation of postponement. Apart from quality of labor, telecommunication facilities, and access to suppliers, transport and distribution related considerations were ranked highly. These considerations include the availability of transportation modes and customs facilities. Immediate proximity of sea- and air-ports is less critical than the availability of transportation modes to connect ports.

In order to assess which location selection factors are specifically relevant in structuring (and centralizing) the customized supply chain, a correlation analysis was conducted. Significant correlation coefficients were found between the application of:

- Postponed engineering and proximity of raw materials; -.260 (0.01 level),
- Postponed primary manufacturing and customs facilities; .288 (0.05 level),
- Postponed packaging and the availability of IT-networks; -.311 (0.01 level),
- Postponed distribution and the proximity of seaports; .392 (0.05 level), the quality of telecommunication; -.330 (0.05 level) and the availability of IT-networks; -.388 (0.01 level).

These coefficients indicate that telecommunication infrastructure and the availability of IT networks are negatively related to the application of postponement in packaging and distribution. The proximity of seaport and the availability of customs facilities, as distribution related considerations, are important considerations in locating activities in the customized supply chain. Thus, while advanced distribution related considerations (data distribution through IT

networks) are not related to the location of activities in the customized supply, traditional distribution related considerations are.

### THE ROLE OF TRANSPORT AND LOGISTICS COMPANIES IN THE CUSTOMIZED SUPPLY CHAIN

If there is indeed is a role for transport companies in facilitating postponement, as Cooper et al. (1998) suggested, what are the considerations manufacturers use in selecting third parties? Insights both in the pattern of outsourcing and the third party selection criteria are relevant in assessing the role of third party logistics service providers in facilitating and performing postponement. There may be some counter forces working against the role of third parties, the most prominent being the fact that final manufacturing activities are not the traditional core business of third party logistics service providers. Despite the fact that third parties in a trade-overview (PD group 1998) indicated a willingness to perform final manufacturing activities for customers, hardly any had extensive experience in doing so.

Table 5 lists the share of customizing activities outsourced over time. Apart from the traditional areas of outsourcing, transportation and (to a lower extent) warehousing, customizing activities are outsourced to a relatively low level. Still, the levels of outsourcing are expected to increase over the following 3 years. Across industries studied some variations are found. A statistical test of differences, however, indicates that only warehousing is outsourced at a significantly higher level by respondents from the clothing and food industry, whereas product configuration is outsourced at a higher level by respondents from the clothing and electronics industry. At an overall level, the levels of outsourcing of customizing activities are relatively low across industries. A slight difference between countries is displayed in Table 5. Dutch respondents outsource customizing activities at a higher level. Again these figures should be interpreted with some caution, given the lower response level from Belgian and German companies.

**TABLE 5**  
**OUTSOURCING OF CUSTOMIZING ACTIVITIES, DEVELOPMENT IN TIME,**  
**AND BY COUNTRY (IN %)**

	Past (3 years ago)		Present		Future (in 3 years)	
	NL	Bl & Germ	NL	Bl & Germ	NL	Bl & Germ
Final assembly	11.48	7.38	13.69	8.53	15.59	13.13
Configuration	11.53	6.83	9.55	8.92	13.02	10.10
Final processing	9.83	3.94	8.57	4.60	10.86	6.33
Sizing adjustments	8.09	5.78	6.29	6.98	9.20	7.38
Packaging	13.14	9.83	13.13	11.81	16.86	13.41
Inserting manuals	8.80	2.33	10.71	2.91	14.34	6.55
Warehousing	21.62	15.07	26.67	18.51	33.64	25.33
Transport	79.29	66.27	86.55	72.05	87.60	76.15

**TABLE 6**  
**THE RELATION BETWEEN OUTSOURCING AND POSTPONEMENT**

Outsourcing of :	Postponement (overall)
Final assembly	0.3077 <sup>b</sup>
Configuration	0.3505 <sup>b</sup>
Final processing	0.4446 <sup>a</sup>
Sizing adjustments	0.3254 <sup>b</sup>
Packaging	0.1909
Inserting manuals	0.2185
Warehousing	-0.1166
Transport	-0.1855

Key: Pearson direct correlation coefficients      a:  $p < 0.05$     b:  $p < 0.10$

Table 6 shows correlation coefficients between the outsourcing of customizing activities and the application of postponement (using the multi-item construct for all the postponement applications). The positive correlation coefficients between the final manufacturing activities and the application of postponement indicates that these activities are considered candidates for outsourcing in the customized supply chain. The negative correlation between the outsourcing of transport, warehousing and the application of postponement is not significant. It does provide an indication of how the outsourcing debate in the customized supply chain differs from that in the traditional supply chain, where transport is outsourced at a very high level. This is also reflected in Table 7.

In order to assess which type of service providers are earning the business of performing outsourced customizing activities, respondents were asked to define the types of company they outsource these activities to. Respondents that mention the use of a specific service supplier for a customizing activity were divided by the total number of respondents, resulting in the share of respondents that

outsource to the type of service supplier. Figures are presented by industry. From this analysis, it can be deducted that industrial service providers, instead of transportation and logistics service providers, are mentioned most frequently for customizing activities. Electronics companies often mention logistics service providers and clothing companies often mention the use of transport companies for performing customizing activities. For warehousing and transportation, logistics service providers and transport companies are mentioned most frequently. These figures suggest that final manufacturing activities used to customize products are a different business than traditional transport and logistics services. This is despite the general relevance of distribution related criteria used in selecting third parties.

Table 8 displays averages scores of selection criteria used (on a seven point Likert scale ranging from not important at all to very important). In all three countries studied, reliability and speed of delivery rank highest. This is in line with the top importance of the customer service considerations used in structuring the supply chain. Given the

**TABLE 7**  
**SHARE OF RESPONDENTS, BY INDUSTRY, THAT REPORT TO BE OUTSOURCING**  
**ACTIVITIES TO SPECIFIC SERVICE PROVIDERS**

	Logistics service supplier					Transportation company					Industrial service supplier					Other				
	EL	AT	FD	CL	O	EL	AT	FD	CL	O	EL	AT	FD	CL	O	EL	AT	FD	CL	O
Final assembly	23.5		6.7			17.6		3.3	11.1		29.4	25.0	23.3	44.4		5.9		6.7	11.1	
Configuration	11.8								11.1		11.8			22.2					3.3	
Final processing	23.5					5.9					5.9	25.0	6.7	11.1	14.3	5.9		3.3		
Sizing adjustments	5.9										5.9	12.5	6.7						3.3	
Packaging	11.8		10.0	11.1		5.9		3.3	11.1				30.0	11.1	14.3	11.8		3.3		
Adding documents	11.8								11.1		5.9	12.5	3.3	11.1		5.9		3.3		
Warehousing	17.6	12.5	43.3	22.2	28.6			16.7	11.1	42.9			3.3	11.1						
Transport	23.5	25.0	6.0	11.1	28.6	52.9	75.0	70.0	33.3	85.7	5.9		6.7					3.3	11.1	

Key: EL = electronics, AT = automotive supply, FD = food, CL = clothing, O = other

**TABLE 8**  
**THE AVERAGE RELEVANCE OF THIRD PARTY SELECTION CRITERIA BY COUNTRY**

	NL	BI & Germ
Reliability of delivery by third party	6.26	6.39
Speed of delivery provided by third party (order cycle time)	5.84	5.97
Cost of third party	5.64	5.65
Flexibility in time-fluctuating delivery by third party	5.61	5.66
Third party's active assistance in problem solving	5.52	5.31
Volume-flexibility in delivery by third party	5.42	5.51
Third party's willingness to long term relationships (long term contracts)	5.39	5.00
Quality of personnel	5.31	5.30
Third party's proactive attitude concerning potential problems	5.25	4.94
Operating flexibility in response to requests (handling change)	5.08	5.49
Geographic location of third party	4.98	4.41
Third party is willing to make dedicated investments	4.72	4.51
Third party's top-management support	4.62	5.14
Technological capabilities of third party (manufacturing related activity)	4.62	4.55
Relevant product knowledge/experience of third party	4.62	4.46
Prior experience with third party. performance history	4.56	4.38
Contribution to logistics and production process innovations	4.56	4.56
Availability of compatible information systems	4.43	4.51
Ability of providing periodic performance reports	4.39	4.30
Wide range of logistics capabilities	4.21	4.82

Key: mean scores on a Likert scale from 1 (not important at all) to 7 (very important)

tendency to outsource customizing activities in the context of postponement, and the expected increase of postponement applications, transport companies and logistics service suppliers may earn larger shares of this growing market, given their strength in distribution. However, due to the low number of respondents that outsource customizing activities, it was not possible to calculate significant correlation coefficients between the outsourcing of customizing activities and third party selection criteria.

### CONCLUSIONS AND IMPLICATIONS

The application of postponement was found to increase along the supply chain, in those chains where postponed distribution is applied at the highest level in distribution. For the customization of product formulation and presentation, however, final manufacturing activities are more important than postponed distribution. Electronics companies and automotive suppliers apply postponement at a higher level than food and clothing companies, especially in manufacturing. The application of postponement is increasing for each of the activities in the supply chain measured, in the three countries studied.

In general, transport and distribution elements (speed, consistency and reliability of delivery along the supply chain, including that of suppliers) are top considerations in structuring the supply chain. In the context of postponement applications, import duties, global sourcing and supplier delivery issues are important considerations used in structuring the supply chain.

Supply chains in the European countries studied are being centralized, resulting in more international transportation between operations, in the distribution channel and other segments of the supply chain. Both for the

general location of activities in the supply chain and the establishment of postponement operations, various transport and distribution related factors are ranked highly (including availability of transport modes and availability of customs facilities). Thus, transportation considerations are actively used in structuring the customized supply chain. Cooper et al. (1998) appear to be correct when they state that transportation companies can facilitate postponement applications. But to what extent are they actually involved in performing postponement application and customizing activities?

Despite the expected increase of outsourcing of customizing activities and the relation between the application of postponement and the outsourcing of customizing activities, outsourcing is practiced at a relatively low level to date. For warehousing and transportation, logistics service providers and transport companies are used most frequently, whereas industrial service providers are used most frequently for manufacturing activities. These figures suggest that final manufacturing activities, used to customize products, are a different business than traditional transport and logistics services. Such manufacturing activities are currently outsourced more often to industrial service providers than to transport and logistics service providers.

Related to the objective of developing a further understanding of mass customization and postponement in the supply chain, the findings presented in this paper contain various implications for transportation managers. First, the creation of customized supply chains indeed seems to be a critical management consideration (as predicted by Gilmore and Pine 1997; Kotha 1995 and Lampel and Mintzberg 1996). In the context of postponing (final) manufacturing and reconfiguring the supply chain, management should not limit its

focus to manufacturing operations and supply considerations. Cross functional concepts such as postponement deserve a supply chain-wide focus. In that respect, transportation and transportation considerations prove to be among the top ranked considerations in this paper. Given the relation between postponement and a tendency to outsource final manufacturing activities, third party service providers should consider focussing on the development of customizing capabilities outside their direct operating experience in warehousing and transport. In doing so, they may focus on food and clothing industries that have a greater tendency to outsource. Alternatively, third party providers may concentrate on electronics and automotive supply firms that are more focused on postponement, and persuade them into more outsourcing. The third party selection criteria found to be relevant may guide these efforts.

Findings presented in this paper also hold a number of consequences for research. The share of respondents outsourcing customizing activities to third parties was measured by asking them whether or not they outsourced to these companies. Measurement of these frequencies does not say anything about the volume of the business outsourced and level of involvement (dedicated services, ad-hoc temporary services etc.). The pattern of outsourcing and outsourcing relations deserves further study, especially given the correlation between the application of postponement and outsourcing found. This relation suggests that as postponement is increasing, so will outsourcing. Further study may also target the use of multivariate models that go beyond the empirical exploration and move into formal hypothesis testing and validation. A larger study, including a larger sample from more countries is needed. Adding experiences and patterns from other continents (US, Asia, ...) may be a valuable expansion of the study area.

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