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## ► To cite this version:

Warse Klingenberg, Jacob-Douwe Boksma. A conceptual framework for outsourcing materials handling activities in automotive: differentiation and implementation. *International Journal of Production Research*, 2010, 48 (16), pp.4877-4899. 10.1080/00207540903067177 . hal-00599852

**HAL Id: hal-00599852**

**<https://hal.science/hal-00599852>**

Submitted on 11 Jun 2011

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Journal:	<i>International Journal of Production Research</i>
Manuscript ID:	TPRS-2008-IJPR-0828.R3
Manuscript Type:	Original Manuscript
Date Submitted by the Author:	07-May-2009
Complete List of Authors:	Klingenberg, Warse; University of Groningen, Department of Operations Boksma, Jacob-Douwe; University of Groningen, Department of Operations
Keywords:	OUTSOURCING, MATERIALS HANDLING, MANUFACTURING STRATEGY, MANUFACTURING MANAGEMENT
Keywords (user):	Outsourcing, logistics, materials handling, transaction cost economics, resource-based, network-based, framework



**A conceptual framework for outsourcing of materials handling activities in automotive: differentiation and implementation**

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**Abstract**

This article discusses the outsourcing of materials handling activities and investigates different options for its implementation. The article uses descriptive case studies found in literature from the Western European automotive industry to map out differences in current practice and to evaluate frameworks found in the literature. These frameworks appear to be limited to decision making at a strategic level. In addition, they only allow decisions relating to the outsourcing of the logistics function in general, not of materials handling in particular. Based on this study and other descriptions of materials handling practice in the literature, a new conceptual framework for outsourcing of materials handling is proposed, which facilitates decision making at a tactical/ operational level. The functionality of the framework is tested in a series of cases at a major production and logistics facility of Scania.

**Keywords:** *Outsourcing, logistics, materials handling, transaction cost economics, resource-based, network-based, framework*

**1. Introduction**

Outsourcing, in particular the make-or-buy decision, has received much attention in practice and in the academic literature over recent years. Such descriptions usually focus on the outsourcing of parts manufacturing (Venkatesan, 1992, Gilley, 1994, Quinn & Hilmer, 2000, Wu et al. 2005, Holcomb & Hitt, 2007, Reichart & Holweg, 2008). Examples of such frameworks include C   ez et al. (2000) and Platts et al. (2002). Outsourcing of materials handling activities is less well covered, although a number of researchers have reported on the outsourcing of logistics in general (Rabinovich et al., 1991, Aertsen, 1993, Bolumole, 2000, Mathisson-  lmertz & Johansson, 2000). Logistics is defined as "that part of supply chain management that plans, implements and controls the efficient, effective forward and reverse flow and storage of goods, services and related information between the point of origin and the point of consumption in order to meet customers' requirements" (Bolumole 2007, p. 35). Materials handling is an element of the logistics function, and is defined as the operational procedure that takes place when the materials are handled along a materials flow (Mathisson-  lmertz & Johansson, 2000). Materials handling excludes supply chain planning and supply chain management.

The focus of this article is on the outsourcing of materials handling of parts in automotive production. Industrial practice, as witnessed by the authors and also described by Mathisson-  lmertz & Johansson (2000), shows that materials handling covers a confined set of relatively labour-intensive activities, which may not necessarily be core elements of the primary function of a production company. Materials handling may therefore be a good area for intensive study for companies seeking to minimise waste (Liker, 2004). Outsourcing may be an option worth considering, but the existing literature offers little guidance. Most of the authors mentioned generally describe the decision whether to outsource the (broader) logistics function or not. Possible options for outsourcing of materials handling specifically (including the choice of supplier/service provider, location of the activities, integration with other activities) have not been given much attention.

**Aim**

The aim of this article is to help managers and engineers in structuring and deciding upon options for outsourcing of materials handling. For this purpose a conceptual framework (consisting of two dimensions) is proposed for use in the automotive industry. The aim of the framework is to structure the available options. The use of the framework is tested in six cases at Scania Production Zwolle (SPZ) in The Netherlands. SPZ is a typical full-service automotive plant (logistics, parts assembly, truck assembly) operating a production system, the Scania Production System, which is similar to other lean production systems applied by major automotive production plants (Liker, 2004). Since all of the cases are with SPZ, the influence of the operational environment is equal in each case. Van Aken (2004) calls this type of research 'design science'. Holmstr  m et al. (2009) state that two phases can be distinguished in design

science, i.e. exploration and explanation. Within these two phases, further steps can be distinguished. The current article essentially covers the refinement of existing solutions (frameworks) and explanation and evaluation of the solution. The result is a novel framework, which is explained and tested to some extent. The next and final step (Holmström et al., 2009), development of formal theory/ statistical generalisation, is outside of the scope of this article.

In Section 2, a brief overview of the literature on existing outsourcing frameworks will be provided and descriptive case studies from the literature are mapped out. In section 3, a new framework is proposed. In section 4, the new framework is evaluated using the case studies. Section 5 reflects the discussion and conclusions.

## 2. Available theory and literature examples

This section reviews existing theory on outsourcing and the frameworks found in the literature. During this review, we have searched for frameworks on outsourcing of materials handling specifically, but have only found frameworks of outsourcing of logistics in general. However, we did find descriptive case studies of outsourcing of materials handling. In order to appreciate the current frameworks and the case studies, it is necessary to first summarise the currently known approaches to outsourcing, since the frameworks use elements of these approaches.

### 2.1. Outsourcing approaches

There appear to be three commonly used approaches to outsourcing decisions (as also noted by Bolumole et al., 2007): transaction cost economics, resource based theory, and network theory. Other researchers have explained differences between these approaches (e.g. Mayer & Salomon, 2006), which can be summarised as follows.

The transaction cost economics theory (TCE) insists that operations should take place wherever the sum of production and transaction costs is minimised (Williamson, 1975, 2008, Riordan & Williamson, 1985). Transaction costs represent the costs of physical and human resources incurred in order to complete an exchange of goods and services between parties. The TCE theory was described in detail by other researchers (Walker & Weber, 1984, Ghoshal & Moran, 1996, Hobbs, 1996, Grover & Malhortra, 2003, McCarthy & Anagnostou, 2004).

The resource based theory (RBT) principally describes a firm as a set of resources, with resources defined as “those (tangible and intangible) assets which are tied semi-permanently to the firm” (Wernerfelt, 1984, p.172). According to its principles, an organisation must secure an efficient set and organisation of the right type of resources in order to survive and improve its operational performance. Competitive advantage results from the ownership of – or unrestricted access to – inimitable assets, innovations, and resource barriers, which enable the firm to shift market positions (Grant, 1991, Connor, 1991, Bolumole et al., 2007). The concept of having a number of core competences, skills or capabilities which are prominent in helping a firm to achieve its purpose (Prahalad & Hamel, 1990) is very much in line with RBT. The desire to focus on core competences may be a potent reason for firms to turn to outsourcing of ‘non-core’ competences (Espino-Rodriguez & Padron-Robaina, 2006). In addition, the ability to achieve economies of scope and economies of scale is relevant in this respect (Kulkarni et al., 2004).

The network theory (NT) of the firm focuses on the formation of external relationships, organisational structures and alliances required to support the integration of the firm in its network. The cooperative act of outsourcing should result in benefits for the entire network, of which the firm is an integral part (Bolumole et al., 2007, Kulkarni et al., 2004, Ellram, 1990, Ford, 1990, Mody, 1993, Varadarajan & Cunningham, 1995).

Table 1 summarises these three approaches.

### Insert Table 1 here

### 2.2. Logistics outsourcing

General frameworks for logistics outsourcing decisions have been proposed by other authors (e.g. Spear, 1997, Bolumole, 2001). Spear's framework uses ‘critical success factors’ and ‘core competences’ for evaluating logistics outsourcing decisions. This appears to be based on the resource based theory, which sees strategies as emanating from company resources and capabilities. Figure 1 shows Bolumole's (2001) framework, which is another example of the type of outsourcing framework proposed in the literature. Bolumole uses the guiding factors ‘(perceived) business value of logistics to supply chain &

competitive strategy', which Bolumole described in terms of logistics being a critical success factor or not, and 'resource availability & operational performance of in-house logistics'. Bolumole (2001) appears to use high-level descriptions constituting several aspects for these two dimensions (for example, the term 'business value' could include various aspects). One could argue that the use of the framework hinges upon the exact definitions and the weighing of the aspects.

In Bolumole's framework (Figure 1), the option 'smart source' refers to a 'smart' choice, to be made on the basis of resource, cost and control justifications, which separately or jointly influence an organisation's outsourcing decision (Bolumole, 2001). Other variants of such logistics outsourcing frameworks were proposed by Sink (1997), Dekkers (2000) and Bolumole et al. (2007).

**Insert Figure 1 here**

*Validity in practice*

A relevant question for assessing typical decision frameworks currently available in the literature is whether the terminology used is sufficiently strictly defined and whether the frameworks are sufficiently detailed for making operational decisions related to materials handling. In section 2.3, we will try to answer this question with a specific focus on outsourcing of materials handling using relevant cases described in the literature. In our view, it is sensible to focus on a certain confined set of activities and debate these in detail, since this is the level at which engineers and managers will need to operate ('the devil is in the detail').

*2.3 Literature cases of outsourcing of materials handling*

In this section, the literature describing examples of outsourcing of materials handling in the Western European automotive industry is reviewed.

*Materials handling activities defined*

In the literature, several different materials handling activities were described. These are summarised in Table 2. From the descriptions, it becomes apparent that an important denominator for materials handling activities is the position of the customer order decoupling point (CODP). This separates decisions made under certainty from decisions made under uncertainty concerning customer demand (Wikner & Rudberg, 2005). It is important to make a distinction between pre-CODP and post-CODP operations, since these have fundamentally different characteristics (Olhager, 2003, Olhager & Östlund, 1990). A materials handling activity could be the point in the supply chain where the CODP is located. Materials handling activities could also be upstream or downstream of the CODP. To allow for this difference, the dimension 'pre-, at or post-CODP' is added.

**Insert Table 2 here**

Warehousing and repacking could concern all types of parts. However, order picking is by definition positioned at the CODP. For simplicity, we have assumed kitting to be the same thing as order picking (both concern parts being picked for a specific order) (De Koster et al., 2007, Mathisson-Ölmertz & Johansson, 2000, Bozer & McGinnis, 1992). Sequencing requires order-information, so it can only take place at or downstream of the CODP. It is interesting to review the options for buffering. Buffers upstream of the CODP consist of parts, which are not related to a customer order (Olhager, 2003, Olhager & Östlund, 1990). This buffer or inventory is therefore generic. A buffer downstream of the CODP consists of parts, which are related to a customer order, and is therefore specific to that customer order. This is illustrated in Figure 2.

**Insert Figure 2 here**

A generic buffer can be used to cope with the delivery of parts with an incorrect specification in a batch, late delivery or the delivery of parts of insufficient quality. Absent, late or faulty parts can be replaced by parts from the generic buffer. A specific buffer can be used only to cope with the late delivery of exactly the items in the buffer. Other problems, such as incorrect or faulty parts are much less likely to allow the use of a specific buffer, since each part in the buffer is required for a certain customer order (taking into account the impossibilities or disadvantages of 'cannibalising' between orders). This means that a specific buffer is of less value in coping with irregular or unreliable delivery than a generic buffer. Absence of generic buffers is one of the reasons why Lean systems require perfect quality and accurate delivery. This difference, determined by the position of the CODP, is relevant for the organisation of materials handling activities.



### *Options for outsourcing materials handling*

The literature describing automotive industry cases reveals several options for outsourcing materials handling activities for parts supply to, or inside an OEM plant. The two dimensions in which the descriptions in the literature were found to differ are: (1) the location of the materials handling activities; and (2) the type of service provider to which materials handling is outsourced. One should add that there may be other differences and choices to be made, e.g. the way the material is controlled.

- (1) For the location of the activities, there appear to be three options: at a supplier, at an additional node in the supply network or at the facility of the OEM (Mathisson-Ölmertz & Johansson, 2000). In general, an additional node in the network is known as a 'cross docking facility' or an 'intermediate facility', and the difference appears to be somewhat arbitrary. Cross docking facilities are characterised by the process of moving a product through distribution centres without storing it. Cross docking facilitates economies of scale by enabling the transportation of goods through the distribution channel in full truck loads (Apte & Viswanathan, 2000). An intermediate facility is defined as a facility in which additional materials handling activities, such as order picking and sequencing take place (Mathisson-Ölmertz & Johansson, 2000). The decision for a certain location lies with (the supply chain staff and management) of the OEM, who may be advised and assisted by suppliers and service providers. One should add that there will always have to be some materials handling at the OEM plant.
- (2) Either a supplier or a third party (i.e. a party other than the OEM and the supplier) can be used as service provider. A firm offering logistics services is called a logistics service provider (LSP). If the LSP is a third party, it is commonly called a third party logistics (3PL) provider (Rabinovich et al., 1991). In a case study at General Motors (Howard et al., 2006) some suppliers were reported to perform materials handling activities for parts delivered from other suppliers. These were denoted in Table 3 as 'supplier+'. In the cases described here, the OEM appeared to take the initiative to contract the service provider.

Descriptions of the car manufacturers Seat, Volvo, General Motors, Saab, the former MG Rover group (which ceased trading in 2005) and some anonymous cases obtained from the literature are summarised in Table 3. In the summary of the cases, order picking and kitting were regarded as similar, as parts are collected for a production order (De Koster et al., 2007, Mathisson-Ölmertz & Johansson, 2000, Bozer & McGinnis, 1992).

### **Insert Table 3**

Several car manufacturers in Western Europe were reported to make use of an intermediate facility for components, where both manufacturing and materials handling activities are carried out (Howard et al., 2006). The description of intermediate facilities appears to have similarities with typical materials handling facilities at supplier parks (Mathisson-Ölmertz & Johansson, 2000, Howard et al., 2006), which appear to be increasingly common in automotive and other industries (Howard et al., 2006). Supplier parks are usually in close proximity to the OEM (in a Japanese context supplier parks may be linked to Keiretsu relationships, Ahmadian and Lincoln, 2001). The reasons for locating facilities at a supplier park are: to enable sequential just-in-time deliveries (Larsson, 2002); to increase delivery reliability due to shorter transport distances (Reichhart & Holweg, 2008); to decrease transport cost (Millington et al., 1998); to increase face-to-face contact and to enable quicker problem resolution and better mutual understanding (Frigant & Lung, 2002).

The differences in the outsourcing/organisation of materials handling activities for the cases in the literature (summarised in Table 3) were not described in the logistics outsourcing frameworks referred to in section 1 (which relate to decision making at a more strategic level). Given that the aim of this article is to differentiate between the available options when considering outsourcing of materials handling, a new framework is necessary.

### **3. A framework of outsourcing of materials handling**

This section introduces a new conceptual framework that will facilitate decisions on the outsourcing of materials handling. In the previous section, it was shown that the outsourcing decision frameworks found in the literature were aimed towards strategic decision making relating to logistics in general, but they do not specifically assist with operational/tactical materials handling decisions.

#### **3.1. Dimensions**

In the previous section, a number of alternatives for outsourcing of materials handling were reported. It was noted that it is relevant to differentiate between activities upstream, at or downstream of the CODP, since these have fundamentally different characteristics (Olhager, 2003, Olhager & Östlund, 1990). In our

framework, we have therefore included this dimension. Secondly, the location of the materials handling activity was reported as a relevant aspect, with three options: at the supplier, at an additional node, or at the OEM.

In the materials handling cases found in the literature, different options were described for the choice of a partner: supplier, 'supplier+' (as described before) or 3PL. We have ignored this aspect in our framework for three reasons: (1) differences between the potential partners would not fundamentally impact the outsourcing decision, merely the choice of partner; (2) the choice of provider (i.e. supplier or 3PL) may not be independent of the choice of location and; (3) abilities/ performance of the service provider is not used for further analysis, since it is specific to each individual case. One could simply say that only parties with sufficient capabilities should be considered.

The six options in the new framework are depicted in Figure 3. As will be shown later, each of the materials handling activities included in Table 2 can be organised within more than one section of the framework. The framework does not prescribe the way in which the activities should be organised. It merely facilitates discussion and structures the options. A company manager or supply chain specialist could use this framework (or a customised version) to differentiate between options and analyse the business case for each option considered.

**Insert Figure 3 here**

*3.2. Assessing options for outsourcing materials handling*

One may take a principled approach and select a certain method based on a deeply rooted concept (e.g. TCE, RBT or NT, see Table 1). In this article, we simply base our selection on maximising operational performance (arguably, this overlaps with elements of TCE, RBT and NT). Stock et al. (2000) proposed four operational performance criteria: cost, delivery speed and reliability, flexibility, and quality. Stock et al. (2000) did not appear to differentiate between types of flexibility, but in this article some differentiation will be necessary. Slack (1983) identified five different types of manufacturing system flexibility; new product flexibility, product mix flexibility, quality flexibility, volume flexibility and delivery flexibility.

*Cost*

The first criterion, cost, is used in the TCE approach, and is extensively considered by other researchers. A number of different cost elements may be relevant when appraising outsourcing decisions. Normally in logistics, personnel cost, transport cost, stock holding cost and overhead/facility costs are important cost elements which may be influenced by the approach adopted. The cost of capital and depreciation needs to be taken into consideration. Outsourcing reduces the need for capital equipment, reducing depreciation, while the type of risk changes. Overhead cost depends on the specifics of each individual case (in which the OEM is to be compared with the potential service provider). It will therefore not be reviewed in general terms in the current article. A few general comments on personnel cost and transport cost will be made. As well as cost, one should assess the value added by each activity. Value-adding materials handling activities "change the configuration of the materials and their packaging so that it attains the state required when the materials leave the defined materials flow system, i.e. the final state. This final state can be expressed in terms of position, mix, orientation and number of components, and it often includes several packaging levels. Practical examples of value-adding materials handling activities are kitting or sequencing of materials according to customer demand, in packaging required by the customer." (Matthisson-Ölmertz & Johansson, 2000, p 27). Naturally, one should always strive to eliminate non-value adding activities (for example by managing the supplier to avoid unnecessary re-packing).

*Delivery speed and Reliability*

This is influenced by the performance of the service provider, the transportation distance to the OEM (an increase in distance is likely to cause decreased reliability, Howard et al., 2006), the buffer size at the OEM, and the buffer type at the OEM based upon the position of the CODP (Olhager, 2003, Olhager & Östlund, 1990). This is visualised in Figure 4.

**Insert Figure 4 here**

The delivery reliability to the assembly line of the OEM is often ascertained by introducing a (small) buffer. It is noted that buffering is not preferable, not 'lean', but it may be necessary to allow a continuous flow (Liker, 2004). A buffer is defined here as a small inventory of parts, used to cope with irregular or unreliable delivery. In the strictest sense, a small buffer is almost inevitable as it would be uneconomic for the supplier to deliver parts individually. Requirements with regards to the buffer will determine choices

related to materials handling. The buffer size determines how long a process can be continued in case of irregular delivery. The type of buffer determines which aspects of unreliable delivery can be counteracted. The type of buffer can be characterised by the position of the customer order decoupling point (CODP), as explained previously.

Order Picking and Sequencing will by definition (Table 3) happen at or downstream of the CODP. In theory (and practice), the activities Warehousing, Repacking and Buffering may be carried out either upstream or downstream of the CODP. However, if these activities are carried out downstream of the CODP, the question arises if the activities cannot be avoided at all, given the limited use of having order-specific buffers.

#### *Flexibility*

Of the different types of flexibility (Slack, 1983), delivery flexibility appears to be most influenced by the way materials handling is organised (e.g. the location of the activities and position of the CODP). The reason is that the delivery flexibility refers to the ability of the system to shorten or lengthen its delivery lead time (Slack, 1983). If the supplier base is located across a wide area (e.g. Europe), transportation time is likely to be (much) longer than the materials handling process lead times (i.e. the lead times of the materials handling activities). The ability to optimise the delivery lead time is largely determined by the transportation distance (and the mode of transport used), since this determines the transportation lead time. Transportation distance should therefore be used as one of the determinants of delivery flexibility. Naturally, delivery flexibility is also determined by the abilities of the service provider. As mentioned, abilities/ performance of the service provider is not used for further analysis, since it is specific to each individual case.

The influence of materials handling on volume flexibility appears to be limited to the use of smaller or larger buffers, which may not affect the outsourcing decision. The requirements for product mix flexibility may affect e.g. required warehouse space. The influence on new product flexibility and quality flexibility appears to be limited.

#### *Quality*

Quality as an operational performance criterion is mainly related to the manufacturing processes. Although materials handling activities can affect the quality of parts handled, this criterion will not introduce differentiation amongst different materials handling outsourcing options upfront. Therefore this criterion is neglected in the further analysis.

### *3.3. Assessment on operational performance criteria*

The next step is to map out the possible influence of the six outsourcing options. A company manager or engineer could do this by analysing and considering each of the options. To a large extent, such an exercise will be company specific. Some aspects will have a generic nature, which we will comment on in this section. It should be noted that the framework can be customised to a specific situation if the assumptions we propose here do not represent a particular situation in practice. This will be discussed in the final section of this paper. Table 4 presents an overview.

## **Insert Table 4 here**

### **4. Case studies at Scania**

This article presents a new conceptual framework for outsourcing of materials handling activities in automotive. The article starts with a discussion/ evaluation of existing theory, and proceeds with the examination of the cases found in literature of outsourcing of materials handling practice in automotive. Subsequently the new framework is presented, which is then explained and evaluated using six practical cases. Van Aken (2004) calls this type of research 'design science'. Holmström et al. (2009) state that two phases can be distinguished in design science, i.e. exploration and explanation. Within these two phases, further steps can be distinguished. The current article essentially covers the refinement of existing solutions (frameworks) through a.o. inductive and deductive reasoning (the second step in exploration, Holmström et al., 2009), and explanation and evaluation of the solution (the first step of explanation, Holmström et al. (2009). The result is a novel framework, which is explained and tested to some extent. The next and final step, development of formal theory/ statistical generalisation (Holmström et al., 2009), is outside of the scope of this article.

Appropriate for evaluating a novel theory is case study research (Yin, 1994, Meredith, 1998, Eisenhardt, 1989). To evaluate the applicability of the framework proposed here (Figure 3, Table 4), materials handling was investigated at Scania Production Zwolle (SPZ) in The Netherlands, one of Scania's three truck assembly factories in Europe.



SPZ consists of an assembly centre with two production lines and a logistics centre. The operational strategy is based on the Scania Production System, which is based on the principles of the Toyota Production System (Liker, 2004). Therefore, there is a continuous effort to eliminate or minimise non-value added activities.

The supplier base of SPZ is mainly continental European. Currently, intermediate facilities (cross-docks) are used for transport optimisation (i.e. transport of full truckloads from the cross dock to the factory). Material handling activities are required for many of the parts presented to the assembly lines. These are traditionally performed in-house at SPZ. The management of SPZ is considering outsourcing of materials handling. Since all of the six cases discussed are with SPZ, the influence of the operational environment is equal in each case.

4.1. Strategic assessment (Figure 1)

During a number of structured interviews, the management of SPZ was asked to discuss outsourcing at a strategic level, and to apply the strategy to logistics activities by (1) discussing the business value of logistics (as described in the framework of Bolumole, 2001); and (2) assessing resource availability and operational performance of in-house logistics activities. The interviewees generally rated the business value (Bolumole, 2001) of logistics at SPZ as high, since it enables the production of a wide variety of trucks to customer order at short delivery lead times. The findings from the second question indicated some problems with regards to availability of resources. In despite of the current economic slow-down, the availability of resources and facilities (incl. floor space at SPZ) may continue to be a challenge locally.

These findings would place SPZ in the quadrant 'Smart sourcing' of the general framework of Figure 1. Outsourcing could perhaps solve current resource limitation problems. A prerequisite would be that the reliability of line supply would have to be kept at the current level.

4.2. Tactical and operational assessment (using Figure 3 and Table 4)

Secondly, an additional set of structured interviews was held to discuss details according to the framework proposed here. Operational team leaders, management and engineers were asked to discuss the options for outsourcing of materials handling for various parts. We will present some of the highlights of these interviews first, and will then discuss six cases of materials handling outsourcing projects at SPZ. In some cases, the level of detail in the descriptions of the activities/ decisions is somewhat restricted for reasons of confidentiality. The results are summarised in Table 5.

First, the matrix in Figure 3 was customised and redrawn for SPZ. This led to the following conclusions:

- Materials handling activities required categorisation before the framework could be applied. Categorisation was done according to pre/post CODP and supplier transport distance;
- For a number of part categories, options 2 and 4 were regarded as unsuitable, since currently generic buffers would become order-specific, which would mean that the buffer would be of less value in coping with unreliable deliveries (which appear to be related with long transport distances);
- Options 5 and 6 could introduce savings on personnel cost, while the delivery reliability is not expected to decrease. The processes are of such type that the performance of SPZ can be matched without much risk;
- For some part categories, options 1 and 3 were deemed suitable. The best options in this group largely depend on decisions relating to transport routes, location of a cross dock or intermediate facilities and the way in which buffering at SPZ is carried out. Figure 5 shows these options. Elements of the discussion on each of the options are reported below. This illustrates the use of the framework, which is to facilitate discussion at a level of detail suitable for decision making at a tactical/operational level.

Insert Figure 5 here

Case 1: Outsourcing of pre-CODP activities, carried out at supplier location (option 1)

Lack of space at SZP's logistics centre was the primary motivation for investigating the outsourcing of materials handling activities. A Pareto-analysis on space consumption by parts (measured in m<sup>3</sup>) showed that a small number of parts consumed a relatively large share of the available space. Outsourcing the warehousing of such parts, in particular cross members, noise shields and air tanks, was investigated in detail. Warehousing (a pre-CODP activity) of these parts could be (partially) outsourced to a supplier facility. This means that inventory levels at SPZ would decrease whilst inventory levels at suppliers would increase. The supplier should have the parts available for transport pickup (like in the current situation), but should hold extra inventory as a buffer.

The SPZ suppliers of the parts mentioned are located across continental Europe, most of them at a distance of several hundreds of kilometres from SPZ. Having the buffer stock at a large distance from SPZ was tested and resulted in a significant reduction in delivery reliability (due to the distance). Personnel cost at SPZ would decrease, however this would cause higher personnel costs at the supplier facility. Transportation costs were not affected, because the frequency of the deliveries was not changed. The large transport distance made it impossible to significantly shorten the delivery lead time, which resulted in limited delivery flexibility. Because of the reduced delivery reliability, there was an expectation of limited cost savings and limited delivery flexibility. SPZ eventually decided not to outsource warehousing to the suppliers.

*Case 2: Outsourcing of activities at the CODP, carried out at supplier location (option 2)*

Scania is currently preparing for an increase in radiator and intercooler variants. An increase in variants of these parts means that more storage space is needed at the pre-assembly areas. Radiators and intercoolers are currently supplied in batches that consist of several identical parts on a pallet. The variants are sub-assembled near the assembly lines according to the production sequence.

In order to save space and reduce material handling at SPZ, radiators and intercoolers could also be delivered in the production sequence from the supplier facility to SPZ. This requires the parts to be picked according to the SPZ sequence of production orders, which causes the picking activity to become the CODP. Instead of having several pallets each containing a part variant, a single pallet with multiple part variants could then be stored at the pre-assembly area. This saves both space and walking distance at the pre-assembly area.

A major drawback of this solution is a decrease in delivery reliability and an increase in transport cost. Delivery reliability decreases significantly as the suppliers are located at considerable distances and SPZ has only specific buffers of radiators and intercoolers on site. If parts were to experience damage during unloading at SPZ, it would take a significant time before replacement parts would arrive from the supplier. In the meantime, the buffer at SPZ is of limited value as it only consists of part variants needed for specific customer orders (trucks) to be produced in the near future. Furthermore, transport costs would increase because several part variants in a pallet would be packed less efficiently than a batch of identical parts. Personnel costs are expected to decrease under the assumption that picking parts in the correct sequence can be carried out more efficiently at the supplier than at SPZ.

*Case 3: Outsourcing of pre-CODP activities, carried out at intermediate location (option 3)*

Space consuming parts, such as cross members, noise shields and air tanks (described in the first case) could also be stored at an intermediate facility. This involves warehousing (a pre-CODP activity) at a facility between the supplier and SPZ. The intermediate facility could be located near suppliers, for example using an existing cross-dock facility, or near SPZ. The latter alternative, an intermediate facility at a maximum distance of 20 km from SPZ, was investigated in detail.

An intermediate facility close to SPZ, which was also called 'external warehouse' by the interviewees could ensure that the delivery reliability is acceptable. The buffer of parts near the assembly line at SPZ can be delivered reliably and frequently due to the short transport distance. The buffer would be generic, which further adds to the delivery reliability. Delivery flexibility would be strongly determined by the transport time, which is short. However, preliminary cost calculations showed that using an intermediate facility would increase logistics operating costs for SPZ for two reasons: (1) the use of the facility would introduce non-value added activities as parts would need to be unloaded and loaded at the facility. This would increase total personnel costs for delivering parts to the assembly line; (2) the introduction of a frequent transport loop between the intermediate facility and SPZ would introduce additional transport cost. Due to the calculated increase in costs, management concluded the investigation by deciding against this option for the time being. However, in the future, if additional capacity demands were to increase, this option would not be ruled out.

*Case 4: Outsourcing of activities at the CODP, carried out at intermediate location (option 4)*

The process of order picking the springs consumes many floor square meters at SZP's logistics centre. Several spring variants are stored at pallets on the floor and placed on a mobile fixture with a manipulator. The fixture can hold eight springs and is transported to the assembly line. At the assembly line the various part variants are buffered. The spring variants in the buffer are coupled to a certain customer order (truck), making the buffer specific. Outsourcing this activity was considered because there is a lack of space in the logistic centre, as well as at areas more closely to the assembly lines.

Order picking the springs at an intermediate facility was investigated. During order picking, the parts are sequenced. The production sequence is aligned with the sequence of customer orders, which means that order picking /sequencing of the springs happens at the CODP. A logistics service provider was asked to make a quotation for order picking the springs at their facility, located several hours away from SPZ. An evaluation of the quotation showed that the personnel/ handling cost would increase, which is not surprising due to the fact that extra unloading and loading is needed. Transport costs would also increase. This increase is explained by the fact that the springs need to be transported on fixtures instead of being stacked on a pallet. This results in less efficient transportation and therefore significantly higher transport cost per spring. Delivery reliability and flexibility decreased also due to the distance between the intermediate facility and SPZ. In fact the minimum transportation time from the generic inventory to production at SPZ would increase from a few minutes to more than three hours. Due to the lower delivery reliability and the higher costs, it was decided not to outsource the order picking of springs in this way.

*Case 5: Outsourcing of pre-CODP activities, carried out at SPZ (option 5)*

Outsourcing the warehousing of parts to a service provider operating a warehouse located on the premises of SPZ could be an alternative for the option described in case 3. Warehousing at an intermediate facility seems infeasible due to the increase in costs. However, if space restrictions could be addressed (for example by re-arranging or extending current SPZ facilities) materials handling could still be outsourced to a logistics service provider (operating at the premises of SPZ). The impact of this option is limited. A plan was drawn up, involving the use of a facility at SPZ which is further removed from the assembly lines than the current warehouse. Internal transport cost would therefore increase somewhat, but the increase is much smaller than in case 3. The decision whether to outsource operations from this warehouse to a service provider would be based largely on personnel costs. Delivery reliability and flexibility would remain unchanged, as all activities and inventories are still carried out on the premises of SPZ. An additional argument at a strategic level for outsourcing these operations could be the decision to focus on core activities only.

*Case 6: Outsourcing of activities at the CODP, carried out at SPZ (option 6)*

This is similar to case 5: SPZ could decide to outsource materials handling of parts downstream of the CODP at the facility of SPZ. Given the limited use of having order-specific (post-CODP) buffers, such activities would mostly involve value-adding activities in the supply of the assembly lines. The operation of the Scania Production System involves a continuous and stringent effort to eliminate any non-value-adding activities. Scania has decided not to outsource the remaining value-adding activities, since they are considered part of the core business at SPZ.

**4.3. Implementation**

The assessment of each of the methods on operational performance suggests that the framework can be useful for identifying and weighing up possibilities for outsourcing. The eventual decision can be taken based on further detailed performance evaluations (as well as management activities to optimise these).

**Insert Table 5 here**

**5. Summary and conclusions**

The aim of this article is to help company managers and engineers in structuring and deciding upon options for outsourcing of materials handling. The main contribution of the new framework is its *tactical/operational* focus and specific applicability to outsourcing of materials handling activities. The article started off by reviewing the currently available outsourcing frameworks, which allow decision making a *strategic* level (e.g. Spear, 1997, Bolumole, 2001, Bolumole et al., 2007, Sink, 1997, Dekkers, 2000). Based on a literature survey of cases in the automotive industry, the possibilities and nuances on a tactical and operational level are discussed. The investigation revealed that the decision criteria used in these cases differed from the ones in the strategic outsourcing frameworks. The new framework is aimed at filling that gap. Different types of materials handling activities were distinguished as repacking, order picking, sequencing and buffering. Since the framework was newly developed, its usefulness first needed to be evaluated. This was achieved through a series of case studies at Scania Production Zwolle (SPZ) in The Netherlands. The result is a novel framework, which is explained and tested to some extent. The next possible step, development of formal theory/ statistical generalisation (Holmström et al., 2009), is outside of the scope of this article.

The new framework distinguishes between two dimensions, which determine options for outsourcing materials handling activities; (1) the location where the materials handling takes place and (2) the type of

materials handling activities which are to be outsourced. The service provider could be a supplier or a 3PL, which performs activities at either the site of a supplier, at an intermediate facility, or at the site of the OEM.

Options distinguished by the framework were assessed and the results were found to differ in terms of the performance criteria cost, delivery speed and reliability and delivery flexibility. An important denominator is the location of the CODP. One important finding is explained through the explanation of the difference between generic (pre-CODP) or specific (post-CODP) buffers. A generic buffer can be used generally to cope with a variety of supply problems. A specific buffer can be used only to cope with the late delivery of exactly the items in the buffer. Other problems, such as incorrect or faulty are much less likely to allow the use of a specific buffer, since each part in the buffer is required for a certain customer order. A specific buffer is therefore of less value in coping with irregular or unreliable delivery than a generic buffer. This difference is very relevant for the organisation of materials handling activities.

If the activities are carried out off-site, delivery reliability can only be assured by outsourcing activities upstream of the customer order decoupling point (CODP), as is the case with warehousing and picking. If the activities are located at the OEM site, both pre-CODP and post-CODP activities could be considered for outsourcing. More detailed choices can be made by including transport routes, location of cross docks and/ or other intermediate facilities, and the way in which buffering at the OEM is organised.

Conclusions from the study of the six cases were that: (1) For Scania, a decision framework at strategic level was insufficient to structure and decide upon outsourcing of materials handling. Structured evaluation and decision making at a tactical and operational level appeared to be necessary; (2) the current framework offered structure to the discussion, based on which alternatives could be either eliminated or progressed to a further level of detail; (3) finally, one of the options was progressed on an operational level.

### Acknowledgements

The authors wish to sincerely thank Ton Vollebregt, Logistics manager, André Rook, Logistics engineering manager, Harry Gruben, Materials handling manager, Marcel Beij, Material planning manager, Hillebrand Diever, Transport manager and the other interviewees at Scania Production Zwolle, The Netherlands, for giving freely of their time. In addition, the authors owe gratitude to the two reviewers and the editor for their valuable time and outstanding suggestions.



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	<b>TCE perspective</b>	<b>RBT perspective</b>	<b>NT perspective</b>
Factors influencing outsourcing decision	Transaction and production costs	In-house resource availability	Supply chain and network wide control
Focus of outsourcing decision	Mainly operational	Mainly tactical	Mainly tactical and strategic
Reason for outsourcing	Cost reduction	Resource acquisition	Value creation through supply chain integration
The firm's strategic orientation	External	Internal	External

Table 1. Relevant theories for the (logistics) outsourcing decision (amended from Bolumole et al., 2007)

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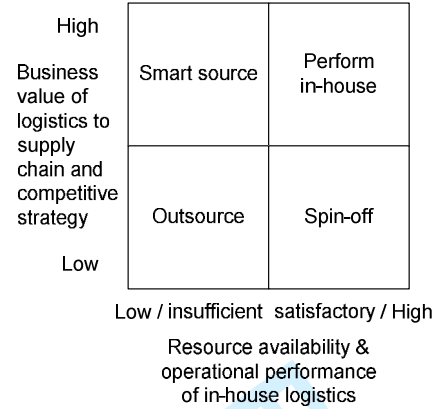


Figure 1. Framework for outsourcing the logistics function (Bolumole, 2001)

Activity	Description	Pre, at or Post CODP
Warehousing <sup>1</sup>	Storing of parts including basic administration, internal transport and arranging /lifting activities necessary for keeping parts in a traceable place in a warehouse	All types (but usually pre-CODP)
Repacking <sup>2</sup>	Changing the packaging of parts for transportation or presentation at the assembly line	All types
Order picking, kitting <sup>3</sup>	A package of parts is picked/ configured for a specific order	At the CODP
Sequencing <sup>3</sup>	Parts are placed in the sequence of orders in which they will be used at the assembly line	At the CODP or post-CODP
Buffering <sup>4</sup>	Temporarily storing of parts	All types (but usually pre-CODP)

<sup>1</sup>De Koster et al. (2007), <sup>2</sup>Nicholas (1998), <sup>3</sup>De Koster et al. (2007), Mathisson-Ölmertz & Johansson (2000), Bozer & McGinnis (1992), <sup>4</sup>Nicholas (1998)

Table 2. Definitions of materials handling activities



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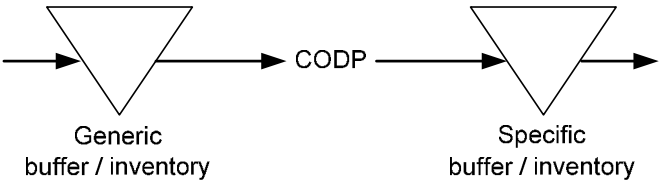


Figure 2. Buffer types as determined by the CODP

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Materials handling LOCATION	Materials handling SERVICE PROVIDER			
		Supplier	Supplier+	3PL provider
	Supplier	Anonymous <sup>1</sup> (order picking) Anonymous <sup>1</sup> (sequencing)		
	Intermediate facility or cross-docking facility	Seat <sup>2</sup> (warehousing) Volvo <sup>2</sup> (sequencing) Anonymous <sup>1</sup> (sequencing)	GM <sup>2</sup> (sequencing)	GM <sup>2</sup> (sequencing) GM <sup>2</sup> (warehousing) Seat <sup>2</sup> (sequencing)  Saab <sup>3</sup> (sequencing) Anonymous <sup>1</sup> (order picking)
	OEM facility	MG Rover <sup>2</sup> (sequencing)		Nissan <sup>4</sup> (warehousing) Nissan <sup>4</sup> (sequencing) Nissan <sup>4</sup> (order picking)

<sup>1</sup>Mathisson-Ölmertz & Johansson (2000), <sup>2</sup>Howard, Miemczyk & Graves, (2006), <sup>3</sup>Larsson (2002), <sup>4</sup>Ogle (2008)

Table 3. Literature examples of outsourcing of materials handling.

Materials handling LOCATION

Supplier	Option 1	Option 2
Intermediate facility	Option 3	Option 4
OEM facility	Option 5	Option 6

Pre-CODP      At or post-CODP

Type of ACTIVITY

Figure 3. Materials handling outsourcing framework

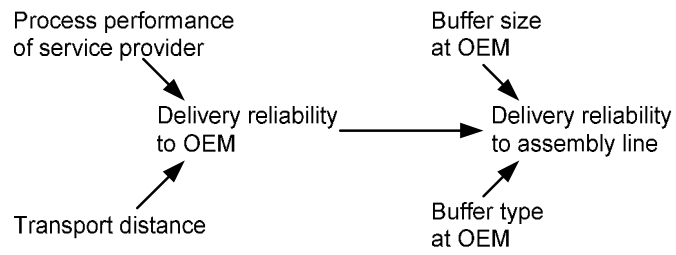


Figure 4. Factors related to delivery reliability

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Option	Description	Comment	Delivery Speed and Reliability	Cost	Flexibility
1	Outsourcing of pre-CODP activities, carried out at supplier location	Maximise any materials handling of generic materials at supplier. Optimise materials handling for convenience at the OEM. Generic inventory at supplier. Also the transport container (/trailer) may serve as generic buffer.	Dependent on transport distance and availability of (supplier as) service provider.	Possible improvements due to avoidance or incurrence of cost by supplier and differences in personnel cost. Transport cost may be adversely impacted (dependent on distance to OEM).	Dependent on transport distance and flexibility of supplier/ service provider. Some flexibility due to generic inventory in container/ trailer.
2	Outsourcing of activities at or post-CODP, carried out at supplier location	All materials handling at supplier location. Supply to OEM on to-order basis.	As 1.	As 1.	Dependent on transport distance and flexibility of the supplier/ service provider. Specific inventory (stored remotely) may limit flexibility.
3	Outsourcing of pre-CODP activities, carried out at intermediate location	Location of the intermediate facility could be chosen based on (a) transport optimisation, (b) optimisation of materials handling/ supply processes and (c) labour and other cost	Dependent on processes/ systems of the service provider. Possibility of locating the facility (with generic buffer) close to the OEM.	Dependent on the extent to which the costs for use of the facility is compensated by a reduction in transport, labour and overhead cost and/or improvements in the materials handling processes	Dependent on the flexibility of service provider. Possible flexibility due to generic inventory at facility (dependent on transport distance).
4	Outsourcing of activities at or post-CODP, carried out at intermediate location	As 3.	Dependent on processes/ systems of the service provider.	Dependent on the extent to which the costs for use of the facility is compensated by a reduction in transport, labour and overhead cost and/or improvements in the materials handling processes	Dependent on transport distance and flexibility of the service provider. Specific inventory (stored remotely) may limit flexibility.
5	Outsourcing of pre-CODP activities, carried out at OEM location	Service provider to work at the OEM location.	Differences related to performance of service provider vs. OEM.	Personnel cost: depends on any wage difference between OEM and service provider. Other cost differences solely related to any differences in way of working.	None, other than differences related to processes/ systems of service provider.
6	Outsourcing of activities at or post-CODP, carried out at OEM location	Service provider to work at the OEM location.	Differences related to performance of service provider vs. OEM.	Personnel cost: depends on any wage difference between OEM and service provider. Other cost differences solely related to any differences in way of working.	None, other than differences related to processes/ systems of service provider.

Table 4. Materials handling outsourcing framework



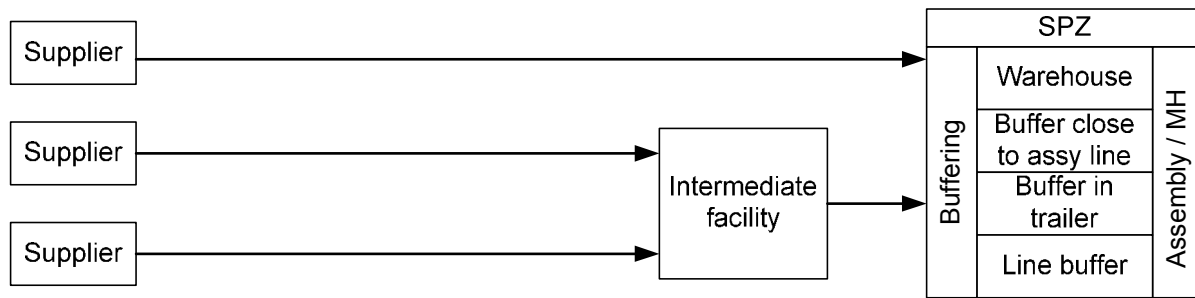


Figure 5. Parts supply options

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Case	Description	SPZ part	Cost	Delivery Speed and Reliability	Delivery Flexibility	Result
1	Outsourcing of pre-CODP activities, carried out at supplier location	Cross members, noise shields, and air tanks	SPZ personnel cost decrease, increase at supplier	Decrease	Decrease	Tested, not broadly implemented
2	Outsourcing of activities at or post-CODP, carried out at supplier location	Radiators, intercoolers	SPZ personnel cost decrease, transport cost increase	Decrease	Decrease	Investigated, not broadly implemented
3	Outsourcing of pre-CODP activities, carried out at intermediate location	Cross members, noise shields, and air tanks	Personnel and transport cost increase	Acceptable/ no major change	Acceptable/ no major change	Investigated, not implemented
4	Outsourcing of activities at or post-CODP, carried out at intermediate location	Springs	Personnel and transport cost increase	Decrease	Decrease	Investigated, not implemented
5	Outsourcing of pre-CODP activities, carried out at SPZ	Cross members, noise shields, and air tanks	Dependent on cost of service provider	Acceptable/ no major change	Acceptable/ no major change	Investigated and considered suitable
6	Outsourcing of activities at or post-CODP, carried out at SPZ	Various	Dependent on cost of service provider	Acceptable/ no major change	Acceptable/ no major change	Not implemented for strategic reasons (considered core business)

Table 5. Summary of performance indicators and results of the six cases at Scania Production Zwolle