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APPLYING LEAN PRINCIPLES TO ACHIEVE CONTINUOUS FLOW IN 3PLs OUTBOUND PROCESSES

Introduction*

The concept of continuous flow is closely associated with the lean management philosophy. Lean management is defined as "(…) a system of measures and methods which when taken all together have the potential to bring about a lean and therefore particularly competitive state, not only in the manufacturing division, but throughout the entire company" (Warnecke, Hüser, 1995, p. 38). The objective of lean is to streamline the flow of production while continuously seeking ways to add value by accomplishing "more with less". Any obstacles in the system inhibiting flow are referred to as waste (Womack, Jones, Roos, 1990). Flow, in terms of lean management, is conceptualized as the continuous movement from products and materials from one process to the next throughout the supply chain. It is closely linked to the well-known pull principle, to make sure that only the products required by customers are forwarded. Lean management principles and practices have been traditionally applied to manufacturing systems. In view of this, the primary aim of the present paper is twofold. First, we argue that the lean management concept and principles can also be applied to operations performed by logistic service providers (LSPs). Second, focusing on the outbound processes of a large LSP, we empirically investigate whether the principles identified by Womack and Jones (1996) to make products flow through the supply chain without interruptions indeed help accomplish flow.

1. Lean management of flow in logistics operations

Supply chains consist of distinct, yet to some extent integrated, production facilities linked by transport and storage services. A recent trend is that companies outsource internal logistic processes more and more to third party logistics providers (3PLs). As a consequence, the supply chain becomes more complex because the direct flow of goods and information between the OEM and end customers is diverted via the 3PLs. Interestingly, the outsourcing trend also brings about a different conception of the added value of logistic processes. While storage in the tradition of Just In Time used to be perceived as a non-value adding and costly activity, covering up production defects (Harrison, van Hoek, 2005), outsourcing this function to a 3PL enables the OEM to concentrate on its core activities. Thus, as a result of the strategic outsourcing decision, logistic services performed by 3PLs have turned into value adding activities for an OEM (De Haan et al., 2011). At the operational level lean practices may be em-

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ployed to reduce waste in internal processes, thereby enhancing the added value of logistics even more. An LSP's internal processes can be subdivided in inbound processes (receiving and storing goods) and outbound processes (picking, value added services, and shipping). To limit the scope of our study, we concentrated on the outbound processes. Thus, the primary research question is whether and how lean management principles and practices can help accomplish continuous flow in an LSP's outbound processes, such that goods demanded by customers are handled by these processes without obstacles, and storage can be kept to a minimum. Table 1 shows the characteristics of input, process content and output of each of the outbound activities, showing that the output of one activity becomes input for a subsequent activity.

Table 1

Input-process-output model for outbound processes of a public warehouse

	Input	**Process**	**Output**
Picking	Customer order	Move the products out of storage and into value – added services area or shipping area	Products ready for application of value-added services or shipping
Value-added services	Products in need of value-added services	Apply different value--added services: label, kit, configure, etc.	Products ready for shipping
Shipping	Products ready for shipment	• ready products for shipment • select appropriate carrier • loading products into truck	Truck with loaded customer orders ready for transport

Womack and Jones (1996) identified three conditions for making products flow through the supply chain. First, "focus on the actual object" requires demand management that balances the customer's requirements with the capabilities of the process (Croxton et al. 2002). At the strategic level demand management means that the LSP should not aim to serve clients whose demands cannot be met. At the operational level, demand management is concerned with forecasting and scheduling of orders and accompanying outbound processes. Second, "rethink work practices" requires that processes become standardized and more predictable. Standardization of operations and the times needed for those operations are probably the most well-known forms of standardization. However, even the work in progress can be standardized by consolidating and re-dividing customer orders in the service of predictability. Third, "ignore traditional boundaries" means that employees who are multiskilled contribute to flow because they can easily switch between processes. The necessary skills need to be determined and training and recruitment need to ensure that workers actually possess these skills. The aforementioned prerequisites for continuous flow equally apply to the outbound processes picking, value-added services, and shipping. Combining the conditions for flow with these processes, we arrive at the theoretical framework shown in Table 2.

Table 2

Theoretical framework

			Outbound processes		
			Picking	**Value-added services**	**Shipping**
Continuous flow prerequisites	**Demand management**	Strategic demand management	Order drop fit	Value-added services fit	Shipping requirements fit
		Operational demand management	Value-added services trigger scheduling	Shipping triggers scheduling	Order triggers scheduling
	Standardization	Standardized work	Processing	Processing	Processing
		Standardized time	Batch time	Batch time	Batch time
		Standardized work in process	Batch size	Batch size	Batch size
	Multiskilled workers	Skill association	Order triggers	Value-added services and order trigger	Order triggeres
		Training and recruitment	Picking capacity requirements trigger	Value-added services capacity requirements trigger	Shipping capacity requirements trigger
		Compensation	Gainsharing	Gainsharing	Gainsharing

2. Empirical Research Design

To further narrow down the scope of the research, the focus in this study is on the operational aspects of achieving a continuous flow, hence not on the strategic and human resource aspects. In Table 2, this area is highlighted by the bold border. Hence, the effects of operational demand management and all forms of standardization on the accomplishment of flow in the outbound processes are considered. The research was conducted with a facility of a large international LSP in the Netherlands (further LSP). Next to receiving, storing, and shipping services, it offers cross-docking opportunities and various value-adding services such as kitting, labeling and configuration. Nine different clients (accounts) are hosted, with different characteristics and customized service requirements. For the present research the account (further X) that exhibited the largest variation in terms of the required value-added services was chosen. Three methods of data collection were used: documentation, interviews, and observations. Documentation includes internal documents provided by LSP, such as training materials and standard operating procedures. Interviews were conducted with employees responsible for supervision, planning, picking, value-added services, and shipping for this particular account. Observations consist of employee-per-process and inventory measurements on site during 2 weeks every half an hour, as well as time measurements per process during another 2 weeks up to 51 measurements per process.

3. Conditions for continuous workflow at LSP

LSP is able to handle all demands made by account X in terms of requested services and capacity. At the end of each quarter additional capacity is required which is supplied by temporary labour and employees from other accounts. LSP has fixed working hours from 8:30 till 17:00, with a 15 minute morning (10:30) and afternoon break (15:15) and 30 minutes lunchtime (12:15). Once an order is ready for shipping, a pre-alert is sent to the client of X. When required, clients can pick up orders at LSP. Most of the time it takes several days for the customer to collect the order. These orders are stored separately, taking up additional warehouse space. Figure 1 shows the average inventory during the day for account X at LSP.

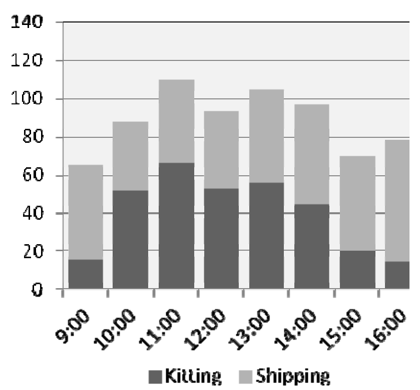

Figure 1. Average inventory levels for account X at LSP

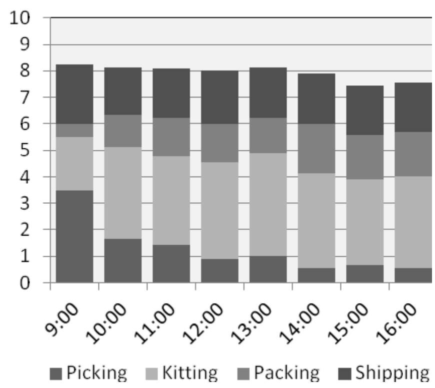

Figure 2. Average number of people per process for account X at LSP

The regular sequence of processes for an order is picking/checking→kitting (optional)→ packing→shipping, but inventory was only measured before the kitting and the shipping stages. LSP applies a forward scheduling system. As the picking process is initiated by the customer order, goods are pushed from one process to the next. All employees are able to perform all the outbound processes and rotate between these processes. Figure 1b shows the average number of employees active in each of the processes at different moments of time during the day.

As LSP has standardized processes, account X is served on the basis of standard operating procedures and standard work instructions for all processes. Observations have shown that these work instructions are followed quite literally. LSP has a system in place for calculating the cycle time of customer orders based on the number of lines. This system is used to consolidate the customer pick orders into batches that have a cycle time of thirty minutes. At the moment LSP is collecting data to develop the same system for the other processes. As this is not yet complete, there is no use of a standard work in process throughout the whole organisation for X. Based on the inventory levels and observations at LSP. Table 3 shows our general assessment of the conditions for continuous flow at LSP.

Table 3

Conditions for continuous flow at LSP

	Picking	**Value-added services**	**Shipping**
Demand management			
Strategic	+	+	+/-
Operational	+/-	+/-	+/-
Standardization			
Work	+	+	+/-
Time	+	+/-	--
Work in progress	--	--	--
Multiskilled workers			
Skill association	--	--	--
Training and recruitment	--	--	--

For account X, picking is the dominant process. The number of people allocated to the processes influences inventory levels between the processes. Adapting the number of people allocated to a process to the actual workload reduces the fluctuation of inventory. This requires flexibility which is provided by multiskilled workers.

4. Creating continuous flow at outbound processes for account X

Our observations suggest that for this account LSP is on its way to achieve a continuous flow. However, the high level of inventory between the various processes and the division of employees over processes during the day (Figures 1 and 2) indicate remaining problems.

The main problems identified are:

– No standard batch time for all processes, nor process scheduling;
– Lack of process control such as visual management.

Table 4 relates these problems to the three conditions to facilitate continuous flows.

Table 4

Process characteristics and conditions for continuous flow

Problem\ \Condition	Demand management	Process standardization	Multiskilled workers
No standard batch time		X	
No scheduling	X	X	
Lack of visual management		X	
Lack of process control	X	X	

Table 4 shows that all problems can be related to standardization, hence this condition should be addressed first. The data from account X were used to generate solutions for the problems that were identified. Especially the relatively high and fluctuating inventory levels between the processes makes backward scheduling cumbersome. Moreover, high inventory is indicative of lack of flow. Therefore, our point of departure for the proposed changes in the system is the concept of "heijunka" taken from the lean literature: inventories will be minimized and flow will be maximized if all processes produce exactly the same volume of output per unit of time (De Haan et al., 2011). Orders are consolidated in batches of thirty minutes of work and are then given to the pickers. For this example we assume 240 orderlines in total, which is representative of the daily activities for account X. Because a working day is 7:5 hours, i.e. 15 blocks of 30 minutes. LSP starts with zero inventory in the morning and finishes with zero inventory in the evening which implies 12 blocks per activity as kitting only can start after a first batch has been picked etc. At the end of the day the last shipping determines the last picking option. Consequently, 240/12 = 20 order lines should be processed per block in each process. The time per order line for each process is shown in Table 5.

Table 5

Process times account X (new)

Process	Time per orderline (minutes)	# Orderlines / 30 minutes
Picking / checking	1.54	15
Kitting	2.12	13
Packing	1.27	20
Shipping	4.54	6

Table 5 also allows to calculate the number of employees needed for each process, picking and checking e.g. requires 20/15 = 1.33. Tables 6 and 7 now show the allocation of staff to processes and the output of the processes producing a continuous flow by taking into account the aforementioned recommendations.

Table 6

Allocation of workers (in FTEs) to processes

	Picking/checking	Kitting	Packing	Shipping	Total
08:30-09:00	1.33				1.3
09:00-09:30	1.33	1.54			2.9
09:30-10:00	1.33	1.54	1		3.9
10:00-10:30	1.33	1.54	1	3.33	7.2
10:45-11:15	1.33	1.54	1	3.33	7.2
11:15-11:45	1.33	1.54	1	3.33	7.2
11:45-12:15	1.33	1.54	1	3.33	7.2
12:15-13:15	1.33	1.54	1	3.33	7.2
13:15-13:45	1.33	1.54	1	3.33	7.2
13:45-14:15	1.33	1.54	1	3.33	7.2
14:15-14:45	1.33	1.54	1	3.33	7.2
14:45-15:15	1.33	1.54	1	3.33	7.2
15:30-16:00		1.54	1	3.33	5.9
16:00-16:30			1	3.33	4.3
16:30-17:00				3.33	3.3

Table 7

Output (# orderlines) per process per 30 minute block

	Picking/checking	Kitting	Packing	Shipping	Total
09:00	20				20
09:30	20	20			40
10:00	20	20	20		60
10:30	20	20	20	20	80
11:15	20	20	20	20	80
11.45	20	20	20	20	80
12:15	20	20	20	20	80
12.45	20	20	20	20	80
13.15	20	20	20	20	80
14:15	20	20	20	20	80
14:45	20	20	20	20	80
15:15	20	20	20	20	80
16:00		20	20	20	60
16:30			20	20	40
17:00				20	20
Orderlines	240	240	240	240	

The proposed solution has two major advantages. First, in comparison to the inventory levels shown in Figures 1 and 2, the level of inventory during the day has decreased, has become much more stable, and the system is "clean" at the end of the day and, accordingly, at the beginning of the next day. Second, the flow of orders has now become completely predictable. For instance, an order picked between 8:30-09:00 is ready for dispatch between 10:00-10:30. Numerous advantages derive from enhanced system predictability in terms of warehouse space occupied, transport and, ultimately, client satisfaction. This case shows that the standardization of processes and process times can bring about gains in terms of number of workers needed (7.2 versus about 8 in the original situation) and a significant drop in order lines in process (maximum 80 versus 110). In addition, the standardization allows minimizing inventory or the number of employees needed.

5. Two extreme scenarios

Figures 3 and 4 depicts the average number of people needed in each of the processes throughout the day (b) in case the inventory is to be minimized (a). When comparing with the original situation the inventory is now about 20% of what it was, with only inventory before 2 processes instead of 3 now. Hence, the space needed between the processes has been reduced considerably whereas the visibility of the flow has been increased. Also compared with the ideal situation in Table 7 the inventory has been reduced. From a lean perspective where excessive inventory is seen as waste, this is a positive result. The number of workers has been reduced as well when compared with the original situation from then 8 throughout the day to maximum 8 now but only in three timeslots but less in all the other. However, when compared to the ideal situation the number increased from 7.2 maximum to maximum 8 at certain moments during the day, although in the other slots the figure is less than 7.2. In both cases the number grows and declines slowly, i.e. capacity is more in line with need than in original situation with a flat capacity. This is typically a result of the standardization.

As labour is the most important cost driver in a labour-intensive industry like warehousing, the minimal number of employees required to do the job should be calculated as well. Figures 5 and 6 summarizes the numbers needed for each of the processes throughout the day (b) and shows the inventory levels (a). The minimal number of employees is 6 throughout the day, hence capacity is not adjusted to the needs similar as in the original situation, but unlike the other scenarios. The number now is 25% less than in the original situation and even less than in the ideal situation. This low number has strong negative influences for the inventory levels compared to any of the scenarios and even compared with the original situation. Now they have a peak of 190 almost twice as much as the maximum in the original situation and even 10 times the minimal level. In the morning inventory is before the kitting and the packing process respectively, whereas in the afternoon it is before shipping. Consequently, additional space is needed before each of the processes and even more than in the original situation, creating waste. Needless to say that planning complexity will increase substantially to achieve these results. However, this complexity may allow to increase efficiency in operations and benefits will outweigh efforts.

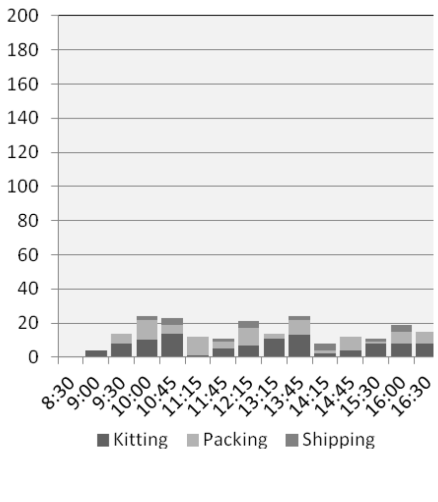

Figure 3. Inventory levels for scenario minimal inventory

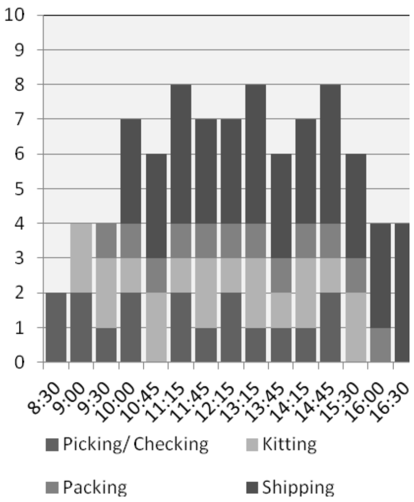

Figure 4. Number of people per process for scenario minimal inventory

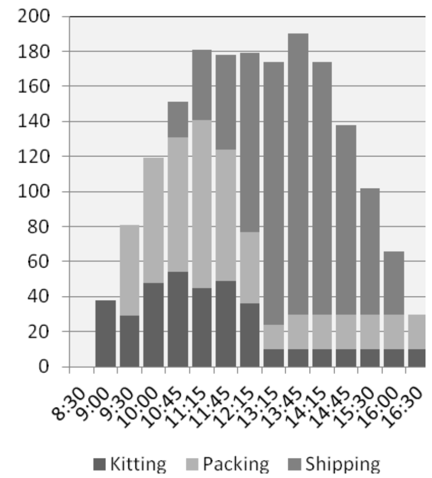

Figure 5. Inventory levels for scenario minimum number of people scheduled

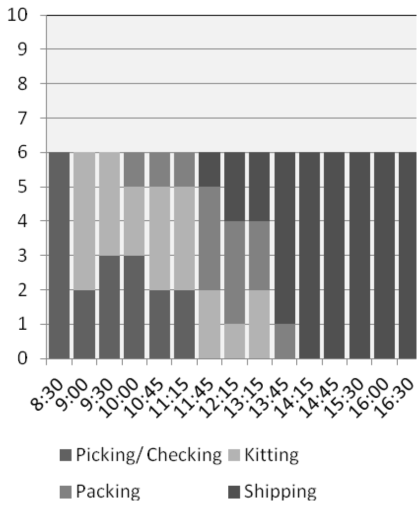

Figure 6. Number of people per process for scenario minimum number of people scheduled

6. Pull planning

So far we, implicitly, assumed that all products would be transported upon finalizing the processes and that our working hours could determine this. Hence we applied a forward planning, push system. However, lean logistics would assume a pull strategy with backward planning starting from actual transportation time. In our next scenario we introduce a pull strategy with 3 moments of transportation during the day: 11:15, 13:45 and 16:30, each of 80 order lines. Table 8 shows the number of employees for each of the processes throughout the day. As we want to plan as realistic as possible, we have to deal with round numbers of employees instead of broken ones. This causes that in each time slot more orderliness may be processed than actually needed to use the full capacity of an employee to avoid shortages in later processes. In the next round this inventory will be used to reduce the number of workers needed.

At 9:00 5 employees start picking and create a small inventory before kitting as figure 4 a shows. Figure 4b shows that we need not start at 8:30 but only at 9:00, with 5 employees instead of 2 in the minimal inventory scenario. However, compared to that scenario we see more (6 instead of 5 levels) but smaller fluctuations, ranging from 4 to 9 versus from 2 to 8. Finally, now we can stop 1 time slot earlier at 16.30 instead of 17.00.

Table 8

People scheduling per process per 30-minute block, scenario pull planning

Process / Timeslot	Picking/ /Checking	Kitting	Packing	Shipping	Total number of people per timeslot
8:30					0
9:00	5				5
9:30	2	5			7
10:00		3	3		6
10:45			2	7	9
11:15	2			7	9
11:45	4	2			6
12:15		4	1		5
13:15			3	6	9
13:45	1			7	8
14:15	3	2			5
14:45		3	1		4
15:30			2	6	8
16:00				7	7
16:30					0
Total number of man hours per process	8.5	9.5	6	20	44

The dips in the capacity needed are mainly caused by packing as this process requires only a limited amount of time to carry out. On the other the peaks are caused by shipping, in particular when carried out in combination with other processes. Shipping requires most time to carry out. With respect to the inventory in the pull scenario versus the minimal inventory scenario figure 4 a shows that inventory before kitting is less in the pull scenario, that before shipping is larger. This could be the result of ‘idle’ capacity in the packing process as adding one person in this “small” process has a relatively large impact on its capacity and hence on the creation of inventory. On average kitting requires 2 employees, but e.g. at 10:00 hrs. 3 are needed whereas at 12:15 only 1. LSP might consider whether reshuffling of activities, such e.g. labeling, from shipping to packing might be possible.

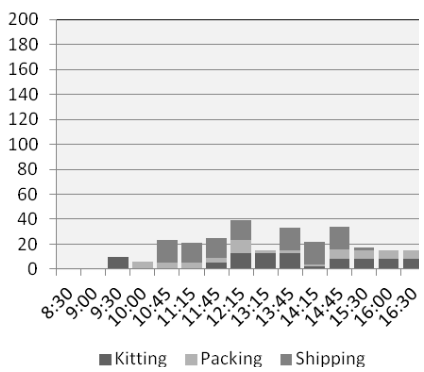

Figure 7. Inventory levels for scenario pull planning

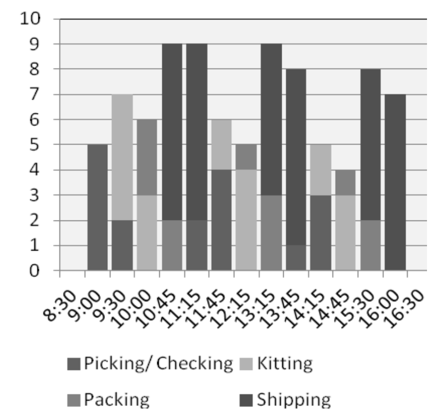

Figure 8. Number of people per process for scenario pull planning

7. Discussion

From literature (Womack, Jones, 1996) it is clear that three conditions have to be met to implement flows: demand management, standardization and multi-skilled employees.

Demand management did not play a role at first, because of the implicit assumption that goods are shipped immediately upon finalizing the shipping process. Another assumption could have been that shipment of all goods would be at 16:30. However, in the lean pull system demand is known and has been included in managing the internal flow. This would allow to balance customer’s requirements with the capabilities of the processes (Croxton et al., 2002). Planning backwards, starting from known shipment times determines when to start the first process: picking. Nevertheless no full flow occurs because of constraints in the flexibility of capacity adaptation.

Standardization can refer to process' content, time and work-in-progress. Here we concentrated on standardized time, for which we took the average time needed for each process as a proxy. Standardized process' content is a prerequisite for actual standardization of time, but was still to be done at LSP. In a lean setting this will be done on a step-by-step basis applying continuous improvement by means of Kaizen-groups.

The results of our scenarios show that standardization of time allows to:

- calculate capacity in an accurate way,
- allocate orders as to reduce the number of workers,
- identify and reduce wasted space in the warehouse,
- implement pull-based flows.

Although in theory flows should be possible in a push-base environment, the scenario results show that in this situation it was not possible to realize it. However, in the pull-based scenario inventories of work-in-progress in between processes could not be eliminated, because of limitations in the flexibility of capacity adaptation. Now this is known LSP might consider to reduce the consequences of this cause by reshuffling activities from one process to another. Compared to the original situation the example shows that:

- Less labor is needed respectively more labor is available for other processes or activities, although the employees need not worker faster. This is elaborated under multi-skilled.
- Less space is needed in between the process which can create room to attract new clients in the same warehouse or do more business for the existing ones. Hence, the objective of lean to do 'more with less' (Womack et al., 1990) can be achieved.

Although multi-skilled was not dealt with explicitly in the scenarios, the results show that the moment standardization of time allows determining capacity needed per time slot reshuffling becomes an attractive option. For workers job rotation, job enlargement and even job enrichment become more feasible. For management hidden idle capacity becomes visible and could be assigned to other clients, primary processes or supporting processes. Pickers could pick not only for customer X, but also for Y or Z. Employees could start the with picking and then continue with kitting, etc., or they might do supporting processes such as cleaning or some (quality) control activities e.g. participate in Kaizen-groups. In the pull scenario, e.g., 7 employees might be assigned to account X and at peaks in workloads people from other accounts could be assigned to this account, whereas in time slots with dips 'redundant' employees could do some cleaning. Another option could be introducing shifting time frames where some employees work from 9:00 to 15:30 and others work from 10:00 to 16:30.

Conclusions

Lean management emerged in the (automotive) industry but can be applied in other industries as well (Womack, Jones, 1996). Logistics seems to be one of these industries especially implementation of flows could be advantageous as the number of employees as well as the space needed can be reduced without sacrificing the value created for the customer. However, this requires that the three conditions known from literature are in place:
– time of shipment by a carrier should be known,
– content of and time needed for processes should be standardized,
– employees should be multi-skilled.

Standardization allows 3PLs to use the capacity much more efficient, hence creating more value with less input, as lean management claims is possible (Womack et al., 1990). This would improve the margins for the companies in this industry which are now pretty poor (De Haan et al., 2011), if the improvements are not "given away" to customers.

However, in addition to these desk-based scenarios, fed with empirical data real life experiments have to be done to really prove their relevance.

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