

## A model for store handling : potential for efficiency improvement

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**A Model for Store Handling  
Potential for Efficiency Improvement**

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**Abstract**

In retail stores, handling of products typically forms the largest share of the operational costs. The handling activities are mainly the stacking of the products on the shelves. While the impact of these costs on the profitability of a store is substantial, there are no models available of the different drivers influencing store handling. In this paper, a study of the shelf stacking process is presented. First, a conceptual model based on warehouse operations is derived. It is shown that handling costs are non-linear with the number of consumer units stacked. Secondly, by means of a motion and time study, data has been collected in four grocery stores of two different European retail companies. The model clearly demonstrates the impact of the most important drivers for handling efficiency: case pack size, number of case packs stacked simultaneously, and the stacking regime. Efficiency gains of 8-49% by changing the driver parameter value are identified. Based on the presented insights both retail companies have decided to structurally change their current operations.

**Keywords:** Retail operations; Handling; Store; Shelf stacking; Motion and time study

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**Date:** May 12, 2005

## 1. Introduction

In times of severe competition, many retailers recognize the importance of controlling costs. Cost knowledge is thus a foundation for improving supply chain relationships (Norek and Pohlen, 2001). With known supply chain costs, the information needed to most effectively structure the supply chain can be provided. Moreover, different opportunities needed to simultaneously reduce costs and increase performance can be identified. In Figure 1 (from Broekmeulen et al., 2004) the logistical costs made in the part of the supply chain that includes the warehouse and the store are presented. It can be seen that the majority of the operational costs are handling costs. In another empirical study by Saghir and Jönson (2001) the same trend was observed: they found that 75% of the handling time in the retail chain occur in the store<sup>1</sup>. In their paper efficiency improvements through the integration and development of new packaging systems are described. In this article, the potential to improve handling efficiency is discussed by identifying the drivers for store handling (i.e. given the packages and the inventory replenishment rules). Handling costs in the stores in the two retail chains investigated in this paper are equal to around 50 million euro per year, indicating that efficiency gains can lead to substantial euro savings as well.

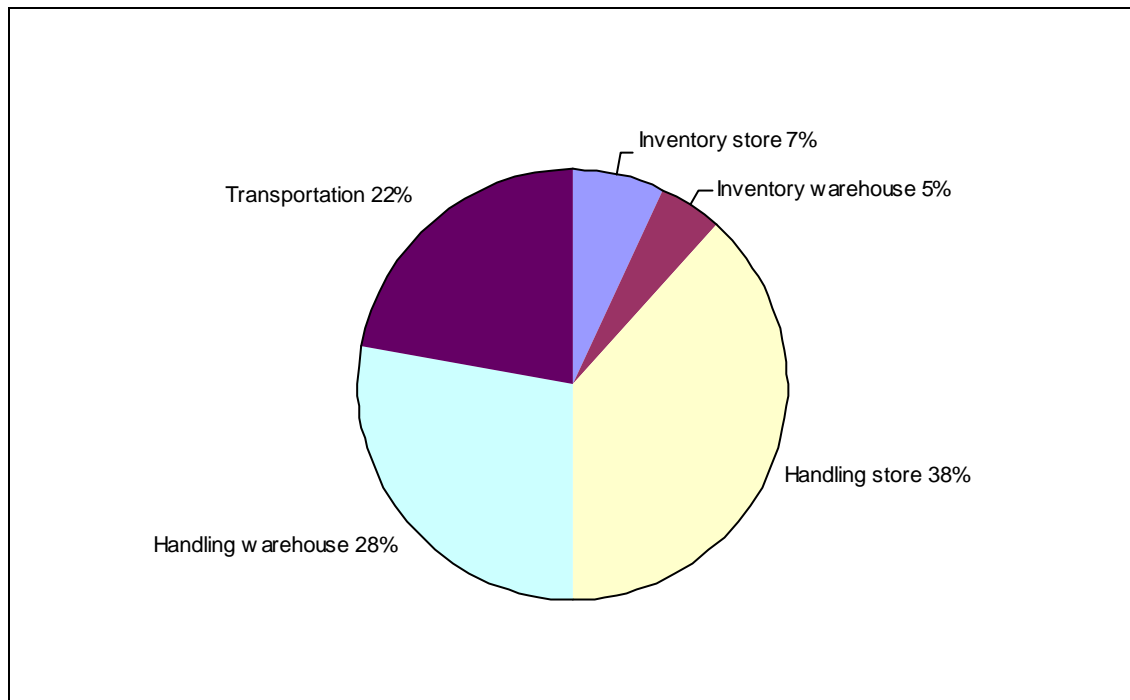


Figure 1: Operational costs in the retail supply chain

Since handling costs are significantly higher than inventory cost, it is worthwhile to assess the drivers of the handling costs. This shows the need for a model which adequately describes the handling process and its related costs in the store. Today, no complete models are available to get an estimation of the handling costs. Consequently, no realistic estimation can be made about the effect of potential improvements in order to reduce handling time and the related costs. Although it is a major part of the profit equation, little literature is available on handling costs in retail stores. The scarce literature which is available, originates from the 1960's. Only a few papers in the literature focused on minimizing operating costs and reducing both inventories and handling

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<sup>1</sup> The fact that the ratio 'handling costs in the store over handling costs in the warehouse' presented in Figure 1 is below the ratio 75:25 is due to the large difference in salaries: in stores, replenishment is often done by (young) part-timers.

costs (see Chain Store Age (1963) and (1965)). SLIM (Store Labor and Inventory Management) was the most widely promoted system in the mid-1960's for minimizing store handling expense by reducing backroom inventories and the double handling of goods (Chain Store Age, 1965). Today, no models for handling activities in retail stores are available and research in the area is lacking as well.

The main contributions of this paper are twofold.

First, while the body of literature that studies the efficiency of handling in warehouse operations is substantial, the literature on handling related to store operations is scarce. Most of the literature on retail stores focuses primarily on the demand side, and less on the cost side. When there is a focus on cost, most attention is devoted to inventory holding costs. Little research is available on the assessment of handling costs in retail stores. This paper is a new entry into this almost unexplored domain. Starting from handling models used in warehousing literature, a conceptual model for handling activities in the retail store is derived.

Secondly, the conceptual model is validated using data collected at two retail companies in the grocery sector. Regression analysis using the conceptual model with the empirical data, quantifies the effect of the different important drivers for handling time in the stores: (1) the number of case packs per order line; (2) the case pack size (3) the way the shelves are stacked (i.e. stacking regime); (4) the worker doing the actual stacking. Using these empirical results, the efficiency gains can be quantified. Moreover, based on the results both retail companies have decided to adjust their current operational processes.

The organization of the paper closely follows the methodology presented by Mitroff et al. (1974). First the problem is conceptualized and the main variables to be studied are identified. Then the model is built and analysis is conducted based on the model. The model is then validated using the real life data that were collected in the stores on the actual handling process. As such this approach fits the concept of model-based empirical research where empirical data are analyzed based on quantitative models, and results can thus be interpreted within a validated modeling context (Bertrand and Fransoo, 2002). In section 2, the conceptual model for the handling activities in the store is derived from the warehouse handling models. In section 3, the research methodology is described in detail. In section 4, the analysis and the results of the model are discussed using the data collected at two retailers; section 5 explains the implications for efficiency improvement in the stacking process of a store. Finally, section 6 concludes and further research options are described.

## **2. Conceptual Model**

The following replenishment process is observed for the items on the shelves in the different stores: after unloading the truck, the store clerks move the deliveries to the shelves, unpack the case packs and put the consumer units on the shelves. To promote *First In First Out* retrieval from the shelves by customers and to improve the display, the consumer units on the shelves are sometimes rearranged, putting the oldest inventory in front (depending upon the specific product category). Although this handling process in the store is similar to the order picking process at a warehouse, literature on store handling operations is very scarce, while literature on handling in warehouses is abundant.

Handling activities are explicitly modeled in warehouse models (Rouwenhorst et al., 2000). These models are very useful as they consider each article or Stock Keeping Unit (SKU) separately and they include handling costs explicitly as part of the objective function. Moreover, different decisions (e.g. routing policies, picking, etc.) and parameters (e.g. productivity of the workers) can be modeled explicitly in these warehouse models. Therefore, the activities needed for

stacking SKU's into the shelves of a grocery store are compared with order picking in a warehouse. As such, shelf stacking is seen as the reverse of order picking, i.e., instead of unloading a container with different SKU's in the store, an order picker in the warehouse loads different SKU's in a container for shipment<sup>2</sup>.

In this paper, a shipment to be stacked in the store is considered as the equivalent of a customer order which has to be picked in the warehouse. In this analogy, shelf stacking at a store, where the relatively large shipments are divided over several store clerks and these store clerks move the goods to the storage locations on the shelves, resembles zone picking in a warehouse. Zone picking is defined by Frazelle and Apple (1994) as an order picking method where a warehouse is divided into several pick zones, order pickers are assigned to a specific zone and only pick the items in that zone, orders are moved from one zone to the next (usually on conveyor systems) as they are picked (also known as "pick-and-pass"). To reflect this resemblance, shelf stacking at the store is referred to as *zone stacking* in this paper. Zone stacking assumes that the incoming goods are already sorted at the supplier according to the different aisles of the stores. This separation along product characteristics is called family grouping. An order pick cycle in zone picking is the process of loading a container that is part of a shipment to a customer.

According to Tompkins et al (2003), an order pick cycle consists of the fixed setup activities that are related to the start and end of the cycle, such as getting the instructions and transferring the loaded container to the dock boards, and variable activities related to the number of order lines. An order line is defined as an instruction to pick a requested number of units from a specific SKU in the zone. The following activities depend on the number of order lines: traveling (to, from, and between the storage locations), searching for the location, and reaching and bending to access the location (included in activity "Other" in Figure 2). The actual pick activities such as extracting items from the location and packing the items for shipment depend on the number of requested units. Figure 2, based on Tompkins (2003), shows a typical distribution of an order picker's time based on a single order picking strategy, where each order picker completes one order at a time.

Note that in zone picking, traveling and searching within a zone are less important than in single order picking, since a zone is relatively compact and the order picker is familiar with the locations in the zone. As a result, traveling and searching in zone stacking in a store may also be less dominant than suggested by figure 2.

The time required for accessing the location can still be relevant in a warehouse. However, in a store accessing the location is an important activity, because it includes maintenance of the location such as preparing the shelves and removing old inventory. If one wants to promote First In First Out (*FIFO*) retrieval by the customers of the store, the items have to be shifted or removed before one can stack the new items behind them. In a warehouse, (gravity) flow racks, which are replenished from the back, can easily maintain *FIFO* retrieval. Normally, a store has no space for these kinds of racks or not all types of products are suited for these racks. A more costly solution is assigning more slots to a SKU, such that one slot is the active picking location and the other slot holds the backup inventory.

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<sup>2</sup> Note that the design of an order pick lane in a warehouse is quite different from an aisle in a store (Broekmeulen, 1998), since the locations and the storage space allocations of the SKU's (slots) in a warehouse are optimized for the handling activities, while the slot allocations in a planogram try to optimize the sales (Corstjens and Doyle, 1981; Urban, 1998).

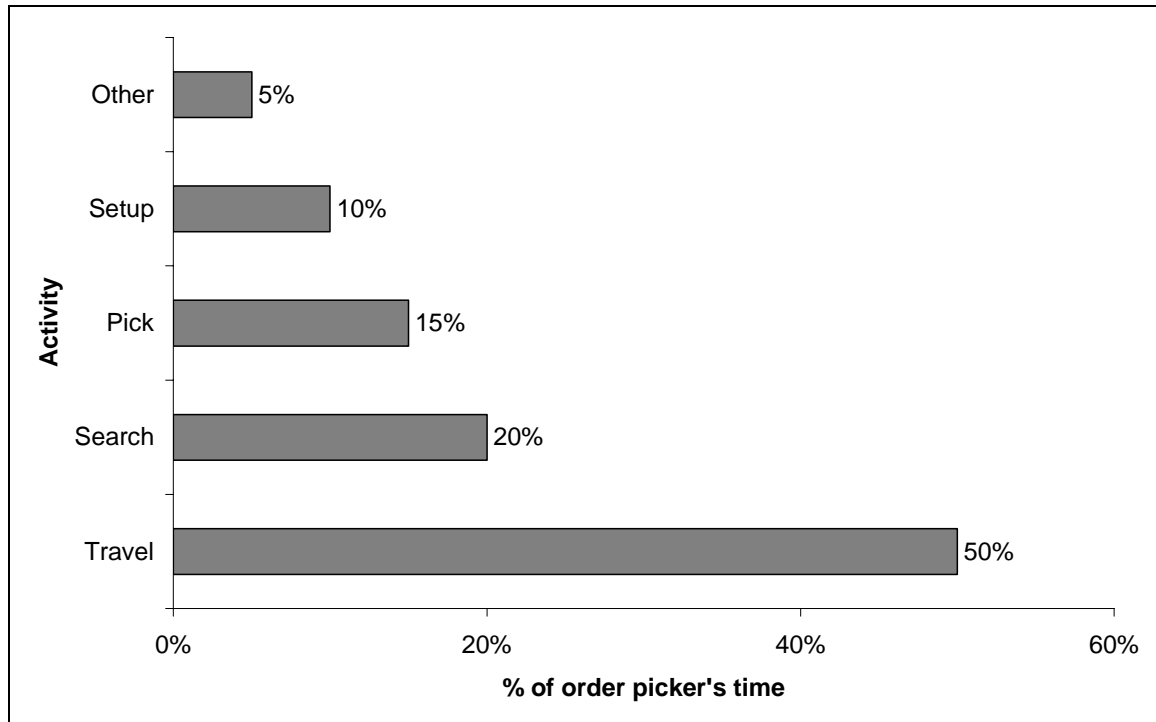


Figure 2: Typical distribution of an order picker's time.

As mentioned before, stacking in the store is considered as the mirror activity of picking in the warehouse. There are three different ways a shelf can be stacked with items in the store. The basic stacking regime *Unit* is stacking the individual consumer units on the shelf. The stacking regime is referred to as *Tray* if the complete case pack can be put directly on the shelf. In the stacking regime *Loose*, the items can be dumped on the shelf without rearranging. This requires normally the availability of a type of crate on the shelf. While the picking time in a warehouse is related to the number of requested units, the stacking time in the store is expected to be dependent on the number of consumer units (if stacking regime is *Unit*) or the number of case packs (if stacking regime is *Tray* or *Loose*).

Another important activity in zone stacking is grabbing and unpacking the items. Unpacking is necessary when the store wants to present the individual items or when the case pack does not have the same physical dimensions as the storage location. This activity resembles the replenishment operation in a warehouse. During replenishment in a warehouse, the same type of problems are encountered when one wants to put a full pallet in a slot that is less than a pallet or that has still items at the location.

The review by Rouwenhorst et al. (2000) indicates that most of the research in warehousing is related to automated storage systems (AS/RS systems) and little research has been done discussing conventional warehouses (e.g. with manual picking). Since stacking in the store is done by store clerks, one needs to take into account their work pace in the model too. Only few researchers have reported on the difference in work pace in a warehouse environment. (see for example, Bartholdi and Eisenstein, 1996; Bartholdi et al., 2001).

Most SKU's follow the stacking regime *Unit*, so it is expected that the time needed for stacking depends on the number of consumer units (CU's). Other activities like grab and unpack a case pack or travel from and to the shelf location, depend on the number of case packs stacked:

Finally, preparing the shelves and searching are done only once for each SKU, independent of the number of case packs or consumer units. These insights of the stacking process indicate that the number of Consumer Units ( $CU$ ) and the number of Case Packs ( $CP$ ) are expected to have an influence on the Total Stacking Time ( $TST$ ). The dependent variable is the Total Stacking Time expressed in seconds. The explanatory variables are hypothesized to have the following influence on the  $TST$ :

1. The higher the number of consumer units to be filled ( $CU$ ), the higher the  $TST$  will be;
2. The higher the number of case packs, the higher the  $TST$  will be.

The basic starting equation is then as follows:

$$TST = \alpha + \beta CU + \chi CP$$

Rewriting this specification by dividing the Total Stacking Time by the number of consumer units filled ( $CU$ ) and making use of the fact that  $CU=CP*Q$ , where  $Q$  stands for the case pack size, results in the following revised model:

$$\begin{aligned} \frac{TST}{CU} &= \frac{\alpha}{CU} + \beta + \chi \frac{CP}{CU} \\ \Rightarrow \frac{TST}{CU} &= \beta + \alpha \frac{1}{CP * Q} + \chi \frac{1}{Q} \end{aligned}$$

It is important to be aware of differences in working pace of store clerks when interpreting the data, i.e. not every employee works equally fast. Consequently,  $n$  dummies for store clerks are added ( $D_{wi}$ ), with  $n$  the number of store clerks considered. It is expected that the stacking regimes Tray and Loose will have a different effect than the stacking regime Unit. Consequently, two extra dummies are added for the stacking regime Tray ( $D_T$ ) and the stacking regime Loose ( $D_L$ ) which leads to the following general model:

$$\frac{TST}{CU} = \beta + \alpha \frac{1}{CP * Q} + \chi \frac{1}{Q} + \delta D_T + \gamma D_L + \sum_{i=1}^n \eta_i D_{wi}$$

Do note that the resulting model for the Total Stacking Time per CU is non-linear in the number of consumer units and in the case pack size. This is in contrast to most literature where it is assumed that handling activities are a constant and linear rate in the number of consumer units. Ketzenberg et al. (2000) and Cachon (2001) describe models to optimize the replenishment decisions in the absence of a backroom and assuming handling costs that are linear with the number of consumer units. Three basic store types can be distinguished: stores which receive crates composed of multiple SKUs (where each SKU is less than a case pack size, like dense retail outlets); stores which receive case packs and stack consumer units; and stores which receive and stack case packs (like discounters). This research is based on the second type of stores, resulting in nonlinear handling cost, effectively focusing on a different type of store than those studied by Cachon (2001) and Ketzenberg et al (2000).

### 3. Research Methodology

#### *Experimental design*

The research in this paper focuses on the stacking process for which data is collected. The data is collected by means of a motion and time study, which is defined by Barnes (1968) as: "the systematic study of work systems with the purposes of (1) developing the preferred system and method – usually the one with the lowest cost; (2) standardizing this system and method; (3) determining the time required by a qualified and properly trained person working at a normal pace to do a specific task or operation; and (4) assisting in training the worker in the preferred

method". The two main parts in this definition are motion study (or methods design) and time study (or work measurement). The first part is for finding the preferred method of doing work, that is, the ideal method or the one nearest to it. The second part is for determining the standard time to perform a specific task. Besides determining a certain normal time required for a task, time studies are done to detect work method improvements. In such a way, one can analyze a given process to eliminate or reduce ineffective movements, and facilitate and speed up effective movements. Through a motion study, the work is performed more easily and the rate of output is increased.

In the experiment, for each SKU the time needed by a store clerk for stacking the items on the shelf is measured for a delivery (an *order line*). In the zone stacking process, each order line consists of taking a case pack from a container, unpacking the case pack and putting the consumer units on the shelf at the assigned location. As timing an entire operation as one element is seldom satisfactory, the Total Stacking Time (*TST*) for an order line has been separated into different sub-activities. The division should be such that the elements are as short as can be accurately timed and that constant elements can be separated from the variable elements (Barnes, 1968). The total stacking time is divided into the following sub-activities:

- grab and unpack the case pack;
- search for the assigned location on the shelf;
- travel to the shelf;
- check the shelf life of the inventory on the shelf;
- prepare the location on shelf for stacking;
- put the new inventory on the shelf;
- put the old inventory back on the shelf;
- dispose the waste;
- and any other activities.

Since Saghir and Jönson (2001) mention the lack of standards and definitions on the handling (sub-)activities in a store, Appendix 1 contains the definitions which have been used in this research project.

#### *Data collection*

Empirical data on the stacking process in two grocery retail companies is collected. In four stores (two of each retail company) employees were followed while stacking the shelves. During the data collection period, the stores were not allowed to change their current operations and were asked to let the most qualified and properly trained qualified personnel do the shelf stacking. Moreover, the days were carefully selected such that the period of measurement did not include any periods of expected demand peaks/drops (e.g., no holidays). The data were gathered for product groups, which meet the following criteria:

1. The product groups should contain both fast- and slow movers;
2. The product groups should contain SKU's from all three stacking regimes (Tray, Loose, and Unit);
3. The product groups should contain different case pack sizes;
4. The product groups should contain SKU's for which sufficient shelf space is available to accommodate more than one case pack in a delivery (see also Broekmeulen et al., 2004).
5. All selected product groups should contain items that are comparable in terms of the handling process and productivity. For this reason, we did not consider product groups such as soft drinks, beers as well as dairy products.

The store clerks are followed during the shelf stacking with a camcorder. Advantages of using a camcorder are that any short cyclical activities can be measured, the stacking process can easily



be reviewed and different aggregation levels can be looked at. After the recording process, the Total Stacking Time (*TST*) per order line was registered using a computerized time registration tool, resulting in an extensive database.

#### 4. Analysis and Results

Figure 3 shows the distribution of the *TST*. In the zone stacking process at the stores, putting the items on the shelves ('Stack new inventory') is the most important activity. For descriptive statistics on the different variables, refer to Appendix 2.

When comparing Figure 2 and Figure 3, a difference between the travel time for order picking in a warehouse and the travel time for zone stacking in a store is observed. The first reason is that the typical distribution of an order picker's time as given in figure 2 is not based on the zone picking strategy but on the single order picking strategy in a warehouse. In the zone picking strategy, travel time is reduced at the expense of increased sorting, which is not included in Figure 2. The second reason is that the data collection was restricted to the movements within the aisle, which can directly be attributed to the stacking process of an order line. The time needed to bring the container to the right aisle is not part of the travel time in our total stacking time model and has therefore not been measured, i.e., only the time needed for traveling between the container and the shelf is registered.

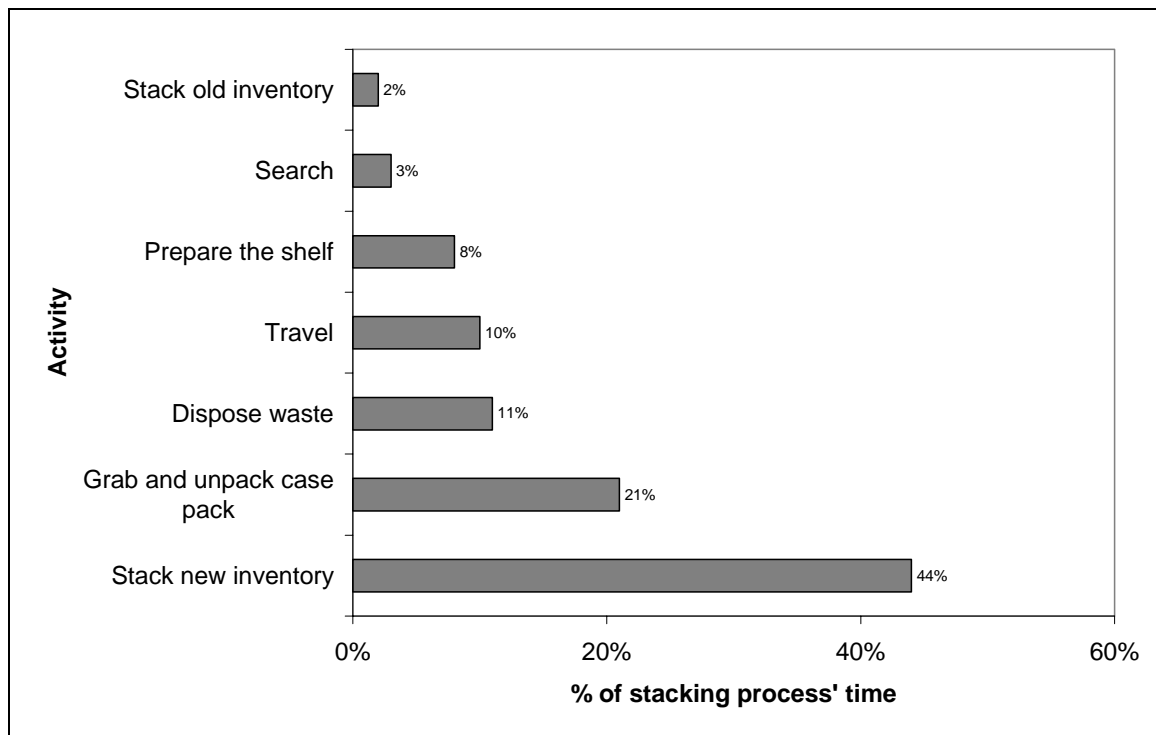


Figure 3: Distribution of the time of the stacking process.

The general model is analyzed using regression analysis. The effect of the work pace of a store clerk is compared with the median store clerk in the dataset, which was store clerk 8. Consequently, 8 dummies  $D_{wi}$  for the remaining store clerks are added. The results of the Ordinary Least Squares estimation are shown in Table 1. All relevant collinearity tests (e.g. correlation coefficients, variance inflation factors) performed indicated no problems with regards to multicollinearity for the estimated model. The F-statistic indicates that the model is valid.

Almost 40% of the Total Stacking Time per Consumer Unit for each order line is explained with this model. Table 1 confirms the a-priori expectations: the signs of all coefficients are as expected. Looking at the standardized coefficients one can see that most of the explanatory power comes from the variables  $1/(CP*Q)$  and  $1/Q$ . The stacking regimes Tray and Loose are faster than the stacking regime Unit. The stacking regime Tray reduces the Total Stacking Time per CU with 0.454 seconds per CU (1.805 seconds per CU for the stacking regime Loose). The Total Stacking Time per CU is equal to 1.758 seconds per CU (see constant term in the table). Looking at the different store clerks, Store clerk 1 appears to be the fastest as he stacks on average 0.562 seconds faster per CU. Although some store clerk dummies are not significant the group of the dummies related to the store clerks is significant as a whole (as confirmed by an F-test; see Gujarati, 1995).

Explanatory Variable	Coefficient	t-statistic	Standardized Coefficient
<i>Constant</i>	1.758	15.613 **	
$1/(CP*Q)$	11.126	8.724 **	.275
$1/Q$	10.464	8.767 **	.273
$D_T$	-0.454	-4.074 **	-.080
$D_L$	-1.805	-5.262 **	-.097
$D_{W1}$	-0.562	-4.372 **	-.094
$D_{W2}$	-0.292	-0.996	-.018
$D_{W3}$	2.800	11.145 **	.211
$D_{W4}$	-0.321	-2.129 *	-.046
$D_{W5}$	0.143	0.971	.020
$D_{W6}$	0.328	3.199 **	.077
$D_{W7}$	1.252	7.803 **	.160
$D_{W9}$	-0.091	-0.308	-.006
<i>R2a</i>	0.379		
<i>N</i>	1922		

Table 1: Estimation results TST/CU model  
 (\*\*significant at 1% and \*significant at 5%)

An alternative model specification where product specific characteristics were included to test the effect of product heterogeneity on the Total Stacking Time per CU did not improve the specification. Product heterogeneity was tested by adding physical volume of an SKU (and its interactions with the other variables). Estimation results indicated that physical volume and the interaction variables were highly insignificant indicating that product heterogeneity did not have a proven influence based on this dataset.

The specification is used to quantify the effect of (1) increasing the case pack size; (2) increasing the number of case packs ordered; (3) changing the stacking regime. For example, focusing on the median store clerk 8 (i.e. all dummy variables for the store clerks are thus zero) and looking only at the stacking regime Unit (i.e.  $D_T=0$  and  $D_L=0$ ), the effect of an increase in the number of case packs ordered and the case pack size can be evaluated (Figure 4). It can be seen that the Total Stacking Time in seconds per CU decreases if the case pack size increases. Case pack sizes typically occur around the following three values: 6, 12, and 24 CU's. This analysis advocates using the biggest possible case pack size for a SKU.

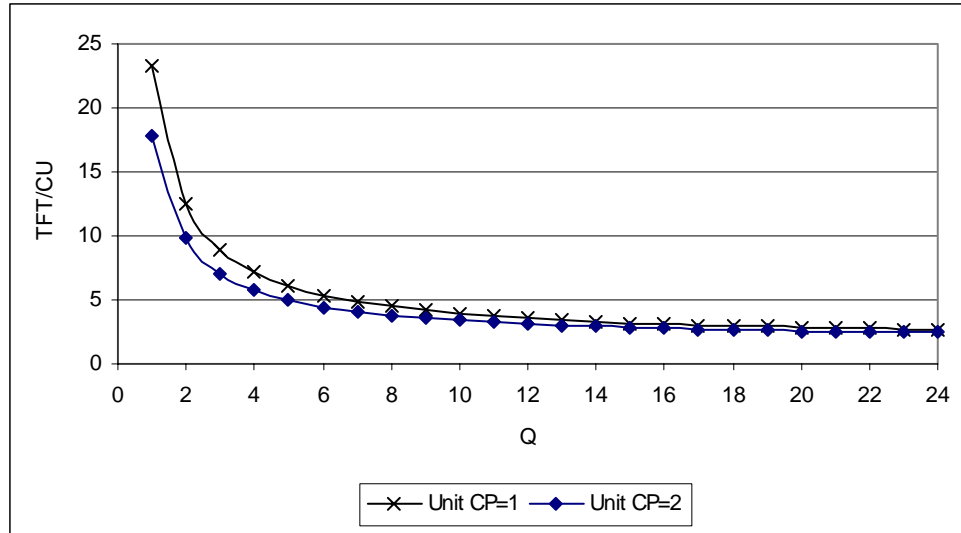


Figure 4: Influence of case pack size and number of case packs on Total Stacking Time per CU [sec/CU].

Table 2 shows the effect of increasing the case pack size from 6CU to 12CU and from 12CU to 24CU for the three different stacking regimes. On average, when stacking in units the time gain is 28%, stacking in trays results in an efficiency gain of 31% and stacking in Loose gives a 49% time reduction when the case pack size is increased. A second observation involves the number of case packs ordered: the more case packs per order line, the higher the time gains, suggesting that more case packs per order line is more efficient.

	Unit		Tray		Loose	
	6CU-12CU	12CU-24CU	6CU-12CU	12CU-24CU	6CU-12CU	12CU-24CU
W1	37.53%	30.03%	41.45%	35.40%	60.19%	75.58%
W2	35.53%	27.55%	39.02%	32.00%	55.20%	61.61%
W3	22.06%	14.15%	23.36%	15.24%	28.33%	19.76%
W4	35.73%	27.80%	39.27%	32.33%	55.70%	62.86%
W5	32.72%	24.31%	35.66%	27.71%	48.70%	47.47%
W6	31.65%	23.15%	34.40%	26.22%	46.38%	43.25%
W7	27.23%	18.71%	29.23%	20.66%	37.46%	29.94%
W8	33.59%	25.29%	36.70%	28.99%	50.66%	51.34%
W9	34.17%	25.95%	37.39%	29.86%	51.99%	54.15%
<b>Average</b>	<b>32.24%</b>	<b>24.11%</b>	<b>35.17%</b>	<b>27.60%</b>	<b>48.29%</b>	<b>49.55%</b>

Table 2: Potential gains of increasing the case pack size

Table 3 shows for each worker the gains that can be achieved when stacking two case packs rather than one case pack for the same SKU. As can be seen from the table, significant gains can be realized when products are not ordered with only one case pack at the time, but with 2 case packs per order line. Depending upon the fill regime the average gains are 12% (Unit), 14% (Tray) and 26% (Loose).

	Unit			Tray			Loose		
	$Q=6$	$Q=12$	$Q=24$	$Q=6$	$Q=12$	$Q=24$	$Q=6$	$Q=12$	$Q=24$
W1	19.34%	15.48%	11.06%	21.36%	18.24%	14.12%	31.02%	38.95%	79.77%
W2	18.31%	14.20%	9.80%	20.11%	16.49%	12.13%	28.45%	31.75%	41.35%
W3	11.37%	7.29%	4.25%	12.04%	7.85%	4.63%	14.60%	10.18%	6.35%
W4	18.41%	14.33%	9.92%	20.24%	16.66%	12.31%	28.70%	32.39%	43.60%
W5	16.86%	12.53%	8.28%	18.38%	14.28%	9.88%	25.10%	24.46%	23.28%
W6	16.31%	11.93%	7.76%	17.73%	13.51%	9.16%	23.90%	22.29%	19.63%
W7	14.03%	9.64%	5.93%	15.07%	10.64%	6.71%	19.30%	15.43%	11.01%
W8	17.31%	13.03%	8.72%	18.91%	14.94%	10.52%	26.11%	26.46%	27.19%
W9	17.61%	13.37%	9.03%	19.27%	15.39%	10.97%	26.79%	27.91%	30.44%
<b>Average</b>	<b>16.62%</b>	<b>12.42%</b>	<b>8.31%</b>	<b>18.12%</b>	<b>14.22%</b>	<b>10.05%</b>	<b>24.88%</b>	<b>25.54%</b>	<b>31.40%</b>

Table 3: Potential gains of Stacking two case packs instead of one case pack

The last observation made is that the stacking regime has a clear influence on the gains that can be achieved: The stacking regimes Tray and Loose are more favorable. Moreover, store clerks that are faster than the median worker have larger gains when using the stacking regime Loose. These results can partially be derived from the above tables; next to this, table 4 shows the efficiency gains for different case pack sizes if the stacking regime changes from Unit to Tray (U->T) and from Tray to Loose (T->L). On average, the stacking regime Tray is 12% faster than Unit and the stacking regime Loose is on average 42% faster.

	U->T			T->L		
	$Q=6$	$Q=12$	$Q=24$	$Q=6$	$Q=12$	$Q=24$
W1	9.47%	15.16%	21.66%	31.13%	53.16%	82.30%
W2	8.96%	13.90%	19.19%	29.30%	48.06%	70.67%
W3	5.57%	7.14%	8.32%	17.54%	22.89%	27.00%
W4	9.02%	14.03%	19.43%	29.49%	48.56%	71.76%
W5	8.26%	12.27%	16.21%	26.78%	41.62%	57.57%
W6	7.99%	11.69%	15.21%	25.83%	39.37%	53.37%
W7	6.87%	9.44%	11.61%	21.95%	31.02%	39.10%
W8	8.48%	12.76%	17.08%	27.56%	43.54%	61.31%
W9	8.62%	13.10%	17.69%	28.08%	44.85%	63.95%
<b>Average</b>	<b>8.14%</b>	<b>12.17%</b>	<b>16.27%</b>	<b>26.41%</b>	<b>41.45%</b>	<b>58.56%</b>

Table 4: Potential gains of changing the stacking regime from Units to Tray and Tray to Loose

## 5. Discussion and Managerial Implications

Using the specification and the results for the empirical data obtained, important managerial insights can be obtained with regards to the effect of (1) increasing the case pack size; (2) increasing the number of case packs per order line; (3) changing the stacking regime. Table 5 summarizes the main findings from the previous section.

	Increase case pack size	Increase number of case packs	Stacking regime
Unit	28%	12%	
Tray	31%	14%	12% (U->T)
Loose	49%	26%	42% (T->L)

Table 5: Overview of the efficiency gains achieved

Based on this table, the first step, which contributes the most to an efficiency gain, is to set the stacking regime to Tray or Loose for as many SKU's as possible. This strategy needs an additional amount of shelf space needed compared to Unit or Tray which might not be available in stores where usually shelf space in the breadth is scarce and expensive. Next to this logistical constraint, the marketing department might perceive the stacking regimes Tray and/or Loose not suitable for the store format. Tang et al. (2001) analyze the different price formats a retail chain can follow: they consider the whole continuum from Every Day Low Price (discount stores, e.g. Wal-Mart) to HI-LO or Promotional Pricing (e.g. Ahold formats such as Giant). Changing the stacking regime to Tray or Loose might imply that the customers perceive the retail format as a discount store rather than a high-end service oriented store. As such, marketing considerations need to be taken into account too when the presentation of the assortment in the store is changed (Campo et al., 2000).

A second way of gaining efficiency in handling, is to increase all case pack sizes to the largest possible size (e.g. from 6 CU's to 12 CU's or from 12 CU's to 24 CU's). In practice, some retailers have already recognized the possible gains especially with regards to their private label products. However, for the branded products the manufacturer decides upon the case pack size. Studies show that also brand manufacturers (e.g. Procter and Gamble, Nestlé, etc.) are investigating the consequences of different case pack sizes and different packages in the retail supply chain (Saghir and Jönson, 2001).

The third and last option involves the store ordering policy: increase the number of case packs per order line as much as possible. Van Donselaar (1990) and Whybark and Yang (1996) showed that in a 2-echelon distribution system locating most of the inventory close to the customer is the best choice for companies that must fill customer demand from inventory. Putting more inventory on the shelves however implies that there should be enough space to accommodate for this extra inventory. However, shelf space is limited in the breadth, but Broekmeulen et al. (2004) showed that there is a significant amount of unused space available in the back of the shelf (behind the products), which is called Excess Shelf Space. Excess Shelf Space is defined as the retail space that is not required to carry out the current operations with respect to customer service and costs. The available space on the shelf is shown to be strongly influenced by the physical dimensions of the product, the case pack size, and the shelf dimensions. This observation advocates stacking multiple case packs of one product at the same time instead of stacking one case pack at multiple times for these products where enough Excess Shelf Space is available.

Finally, it has to be noted that the effect of the worker cannot be neglected: fillers who work faster have higher efficiency gains than slower workers. For example, focus on the slowest worker (number 3), he is on average already 2.8 seconds per CU slower than the median worker who typically spends only 3 to 5 seconds on handling per CU. This result suggests that worker training is an important aspect in order to get the full benefit from the different actions that can be taken.

According to Saghir and Jönson (2001), every second reduction in the total handling time would represent a reduction of five million EURO in the Swedish grocery industry. Since handling costs in the 2 retail chains studied in this paper are 50 million euro per year, a 10% reduction in handling time would lead to 5 million euro higher profits per year, just for these two companies. This indicates that a lot of costs can be reduced by following the above recommendations with regards to the efficiency in handling.

## 6. Conclusions

It is argued that when store handling costs have an important share of the retail supply chain operations costs, it is important to know the cost drivers. A conceptual model for store handling was derived using the analogy based on order picking models for warehouses. It was shown that the presented model for the stacking time was non-linear in consumer units. By means of a motion and time study, data was collected in four grocery retail stores from two different retail companies. Regression models revealed the impact of the most important drivers for handling efficiency, measured by the Total Stacking Time per Consumer Unit. The main results of the model are: (1) increasing the case pack size results in an average efficiency gain of 24% to 49%; (2) stacking multiple case packs of one product at the same time instead of stacking one case pack at multiple times, results in an average gain between 8% and 31% in total stacking time per CU; (3) the stacking regime has a significant effect on the stacking time (12%-42%). Based on the presented results both retail chains have decided to structurally change their current operations.

Future research involves extending the currently used reorder policies in the retail companies to take into account the handling efficiency with the replenishment. Usually, the underlying logic is based on a  $(R, s, nQ)$ -reorder policy with a dynamic reorder level  $s$ . The reorder level  $s$  is based on a demand forecast for the coming  $L+R$  days ( $L+R$  being the sum of the lead time and the review period). The above analysis shows the need for an adapted inventory replenishment rule taking into account the handling aspects. This implies that for the majority of the items the new replenishment logic should be: whenever a replenishment can no longer be postponed, order as many case packs as can be added to the existing inventory on the shelves. Future research is also needed to analyze the impact on handling of different types of packaging material, different shelf maintenance strategies (such as 'mirroring') as well as different levels of inventory just before stacking the shelves. Moreover, it is expected that larger case packs also reduce the cost of packaging material and the costs of waste. Increased number of case packs per order line reduces the ordering and delivery frequency of a product, which also may lead to lower ordering costs in the store and to lower picking costs in the retailers' warehouse.

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**Appendix 1**

Sub-activity	Starting/ Ending point of sub-activity	
Grab/ open case pack (G) or	<i>Start</i>	The filler stands in front of the rolling container and reaches for a case pack.
	<i>End</i>	The filler prepares to walk away from the rolling container (case pack is or is not opened).
	<i>Start</i>	The filler has arrived at the shelf location and starts opening the case pack.
	<i>End</i>	The filler is ready with opening the case pack and an other sub-activity starts.
Search (S)	<i>Start</i>	The filler starts with checking the product and he/ she looks for the right shelf location.
	<i>End</i>	The filler sees the right shelf location and prepares to approach it (walk).
Walk (W) and	<i>Start</i>	The filler prepares to walk away from the rolling container or walks after searching the right shelf location.
	<i>End</i>	The filler stands still in front of the shelves.
	<i>Start</i>	The filler prepares to walk away from the shelf location or waste disposal place, to the rolling container.
	<i>End</i>	The filler stands in front of the rolling container and reaches for a case pack.
Prepare the shelves/ check 'best before' date (P)	<i>Start</i>	The filler reaches for the old inventory on the shelves and start to check the 'best before' date (if needed).
	<i>End</i>	The filler is ready with preparing the shelves. This means that old inventory is straightened or is removed from the shelves.
Fill new inventory (Fn)	<i>Start</i>	The filler reaches for the new inventory in the case pack.
	<i>End</i>	The filler reaches for the old inventory or grabs the empty box or plastic.
Fill old inventory (Fo)	<i>Start</i>	In case old inventory was removed from the shelves, the filler starts with putting old inventory back on the shelves.
	<i>End</i>	The filler is ready with putting old inventory back on the shelves en grabs the empty box or plastic.
Waste disposal (D)	<i>Start</i>	The filler holds an empty box (or plastic) and starts to flatten it (sometimes the box is preserved for customers).
	<i>End</i>	The moment the filler prepares to leave the waste disposal place (a trolley or a place near the rolling container).
Extra (E)	Any activity not part of the first sub-activities, e.g. help a customer, customer is in the way, get or put away crate, process inventory remainder, organise labels, general cleaning, discuss with a colleague, take away waste, bring empty boxes for customers to check out area, get a new rolling container, take away misplaced products, repare a broken product, remove cord from rolling container, take a product to the kiosk, straighten seperation plate.	
<p><i>Nota bene:</i></p> <p>* Grabbing and opening the case pack are taken together, because the individual activities were difficult to separate.</p> <p>** Walking does not include walking with the rolling container from the storage area to the right aisle or walking with the rolling container between the aisles. But it does include (in exceptional cases) walking with the rolling container when the rolling container is moved to bring certain case packs to the right shelf location (e.g. heavy products).</p> <p>*** It is possible that a filler performs multiple sub-activities at once, e.g. walking while opening the case pack , searching or disposing waste. When this took place, the following reasoning was used: if the walking time was significantly influenced by the attention focused on opening the case pack (or searching or waste disposal), the time for e.g. opening the case pack was measured as sub-activity "G", and the remaining time as sub-activity "W". If the walking time was not significantly influenced by one of these sub-activities, then the total time was measured as walking time (W).</p>		



**Appendix 2**

Category	Number of SKUs	Number of Order Lines	Case Pack Size (CU)			# Case packs per Order Line			Stacking regime (#SKU)			TST (sec/CU)		
			Avg.	Min	Max	Avg.	Min	Max	U	T	L	Avg.	Min	Max
Coffee	118	210	12.31	1	30	1.53	1	9	91	21	6	4.61	0.25	25.17
Chocolate	137	235	16.89	6	33	1.38	1	8	118	19	0	3.04	0.62	15.42
Candy	226	367	15.86	6	36	1.16	1	3	219	7	0	3.06	0.65	9.87
Baby food	83	105	10.69	3	16	1.20	1	5	26	57	0	4.94	1.20	16.25
Canned meat	40	47	12.97	6	24	1.77	1	5	40	0	0	3.68	0.60	7.33
Canned vegetables	89	122	11.86	8	24	1.80	1	6	46	43	0	3.09	1.17	7.92
Wine	93	140	6.84	6	15	1.29	1	5	84	9	0	4.77	1.00	15.67
Coffee milk	38	63	16.73	6	30	1.54	1	5	31	7	0	3.64	1.43	7.00
Sugar	15	23	10.17	5	20	1.83	1	4	11	4	0	1.50	2.10	8.10
Cookies	130	185	15.46	8	36	1.26	1	8	125	2	3	3.57	0.69	9.17
Personal care	214	312	7.69	3	24	1.15	1	3	193	16	5	4.64	0.83	11.50
Canned fruit	20	32	12.37	6	24	1.71	1	4	20	0	0	3.51	1.83	8.50
Sandwich spread	62	81	12.60	6	30	1.64	1	6	39	23	0	3.24	0.72	9.83
Total:	1265	1922							1043	208	14			