Developing a Decision Support Tool for Increased Warehouse Picking Efficiency

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The warehouse processes which link production to distribution and the customer are usually unresponsive although customer demand often is fluctuating. As one of the most costly components in the whole supply chain, the warehouse carries great potential to cut costs by operating more efficient and adapt to customer requirements. This article presents a decision support tool developed in a study on how to increase the efficiency of the single most resource demanding warehouse activity: order picking. The study showed e.g. that a carefully tailored storage allocation of the stock keeping units (SKUs) is fundamental when improving picking processes. The main implication is that the largest gains in terms of less travel related to picking can be expected for companies experiencing either a strong skewness in demand, seasonal variations in total demand, or a strong seasonality among its products.

Keywords; Order picking, picking efficiency, routing, storage allocation, warehouse operations, warehousing

1. Introduction

Warehousing is central in order to achieve a competitive supply chain, and considered essential for the success, or failure, of businesses today. There is a need for warehouses to operate smoother, faster and more accurate (Baker & Canessa, 2009). In general, warehouses account for a large share of company logistics costs (De Koster, et al., 2007; Establish Davis Logistics Costs and Service, 2013). The manual handling involved in the different warehouse operations is the main cost driver: Receiving store keeping units (SKUs) from production or suppliers, put-away of SKUs, storage, order picking (retrieving the SKUs according to customer orders) while following a certain picking route, and finally shipping of goods to customers, are all performed by human labor in most warehouses, and labor means wages and high costs (Frazelle, 2002; Gu, et al., 2007). The most labor-intensive and costly warehouse operation is order picking, mainly due to the large amount of travelling involved. In the words of Bartholdi and Hackman (2010, p. 143): "travel time is waste. It costs labor hours but does not add value".

Researchers seem to agree that order picking account for at least 50 % of warehouses' total operating costs (e.g. Petersen II, 1997; Petersen & Aase, 2004; Le-Duc & De Koster, 2005; De Koster, et al., 2007; Chan & Chan, 2011). However, warehouses also carry great potential to justify the expenses they bring through reducing the time spent on activities that are not value adding.

This article presents a decision support tool developed for increasing warehouse picking efficiency. The tool aims to provide guidance for how to reduce resources and time spent on picking. Its recommendations are based on a study of the most recent and relevant research available within warehousing. Further, the study identified areas where research is scarce and additional studies needed which also are presented below.

2. Framing the Problem

The different warehouse operations are often interconnected which creates a complex decision area to manage (Gu et al., 2010). Le-Duc and De Koster (2005) established five main factors that affect the performance and efficiency of the order picking in a warehouse:

- Storage allocation; the process of assigning a certain SKU to a certain storage location.
- Order picking; the process of retrieving a number of items from their storage locations to fill a number of independent customer orders.
- Routing; the process of selecting paths to specific destinations, e.g. determining how to move in a warehouse to retrieve all SKUs on a pick list.
- Physical warehouse design; i.e. dimensions, equipment, material flow, aisle configuration etc.
- Demand pattern; the variations in overall and/or SKU specific demand over time.

Figure 1 depicts the interconnection between these factors by having the four triangular shapes of the warehouse factors form a larger triangle together if considered jointly. The omnipresent demand pattern is shown as a cloud in the background, to illustrate its influence on all the other decision areas. The outcome in terms of effect on picking operations, if treating the factors correctly, is shown as an arrow pointing forward to symbolize an increased picking efficiency.

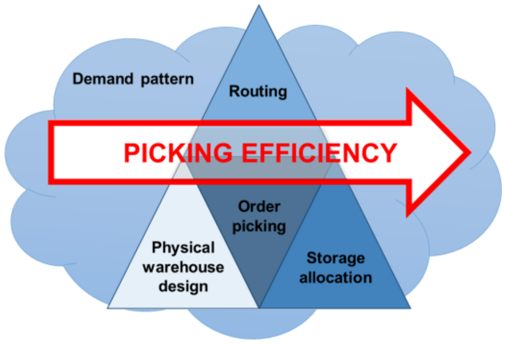

Figure 1 Areas related to increasing picking efficiency (Gildebrand & Josefsson, 2014)

Most of the existing research in order picking is centered on one of these triangles, and the choices and method alternatives that exist when improving that particular factor. Often the type of warehouse and physical constraints limit the outcome; De Koster et al. (2007) argue that there is a lack of general design procedures for order picking. This means that there is a need for a more holistic method, spanning over multiple areas and warehouse types. Moreover, few researchers discuss how to respond to variations in demand at all; a challenging reality for most warehouses.

The main goal when creating the decision support tool was to identify reliable and generalizable ways to continuously improve warehouse picking efficiency why the focus was the three relatively flexible and alterable decisions regarding choice of storage allocation, order picking, and routing methods. Of particular interest was identifying features with significant impact on the choice between method alternatives. The aim was also to present the suggested methods in a structured way; easy to interpret for the uninformed.

3. The Decision Support Tool

The decision support tool was created from leading research, inspired by two comprehensive warehouse design frameworks by Rouwenhorst et al.

(2000), and Hassan (2002). A visualization of the result is presented in Figure 2. Each blue box in the figure represents a step, while the grey boxes contain input/output data and supporting advice. A brief explanation of each step is provided in the following sections in order to clarify the figure.

Step 1: *Warehouse and product characteristics and constraints* maps the prevailing conditions in order to frame the problem at hand. Warehouse dimensions, location of I/O docks, material flow, shelving, product characteristics etc. are concluded and determined as fixed or flexible in order to identify constraints on the storage and picking alternatives.

Step 2: *Order characteristics to consider:* where demand data is analyzed e.g. regarding seasonality, pick pattern (full versus partial pallet picks), order volume, pick density and demand skewness. The output is a mapping of the demand and suggested grouping of SKUs accordingly.

Step 3: *Objectives; priorities and tradeoffs* include somewhat softer aspects where managers are to agree on a suitable ranking of the top priorities for the warehouse at hand. Examples of objectives are minimized travel distance, high warehouse utilization and low risk of congestion.

Step 4: *Storage allocation method* describes the benefits and downsides of the main storage allocation methods: random storage, class-based storage (CBS) and volume-based storage (VBS). The final choice builds on the output from step 1, 2, and 3 and the output is a map displaying the allocated SKUs according to the method chosen, possibly related to a specific season. Depending on choice, this step might include determining storage configuration, creating picking zones and possibly ranking and grouping the SKUs according to a suitable criteria in order to determine their allocation.

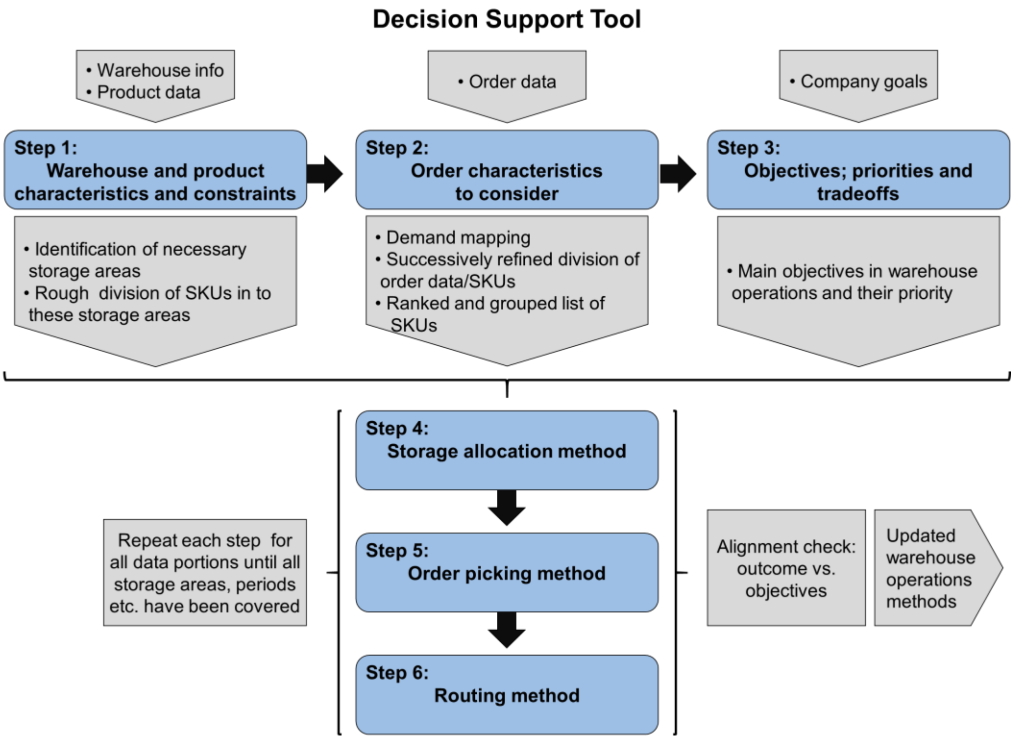

Figure 2 Overview of the decision support tool (Gildebrand & Josefsson, 2014)

Step 5: *Order picking method*, similarly to the previous step presents known benefits and downsides for the main methods. This should be used in order to support a choice, which is the output of step 5.

Step 6: *Routing method* is the final step and decision to make in the tool. There are an abundance of methods available for routing. They differ mainly with regard to route length, but also ease of use and compatibility with pick list size.

One further aspect included in the tool, represented in the grey square boxes in Figure 2, is the need to repeat the last three steps for all storage areas and periods necessary for the warehouse in question. Also, it is important to perform an alignment check to ensure a unified direction of the final choices.

4. Findings

The research review which forms the basis of the information and evaluation of the method alternatives in each step led to several findings. One major finding regarded the importance of the decision areas included in the study. Despite routing and order picking being more directly related to the picking, storage allocation was actually the area that turned out to have the largest impact on the picking performance. The main objective when allocating SKUs to storage locations is to facilitate the order picking and it can potentially reduce the current picking distance by at least 10 % (Renaud & Ruiz, 2008). Without a well-designed storage allocation, the gains from improving order picking and routing procedures will be limited.

Further, the decision support tool almost exclusively recommends the use of CBS in order to increase picking efficiency. This method turned out to be the overall best choice among the methods presented in research, despite performing only second best in the isolated aspect of travel distance (Petersen, et al., 2004). VBS is the undisputed winning method for increasing picking efficiency, but it comes with an increased and insufficiently researched risk for congestion. It is also stated to be complicated both to implement and maintain. In addition, CBS with four classes has the potential to reach up to 94 % of the performance of VBS. The performance when using three classes is about 90 % of VBS, and the corresponding number when using only two classes is 78 % (Petersen, et al., 2004). Thus, when including factors beyond travel distance in the decision making, the recommended storage allocation method will be CBS.

The pick list size influences the choices between many of the method alternatives presented in the tool (Petersen II, 1997; Petersen, 2002; Petersen, et al., 2004). Since this feature can be altered or adjusted it is important to determine a size in accordance with the method choices to avoid sub-optimization. In short, most research point out that a long pick list will blunt the effects of carefully selected warehouse methods. It is most noticeable when using CBS or VBS where popular SKUs are stored in the most convenient locations, as opposed to a complete random storage allocation method. The reason is that a longer pick list is more likely to contain less frequently picked SKUs, and therefore prolong a larger share of the routes than in the case of a short pick list, which is more likely to contain only popular SKUs.

A further finding from the research reviewed is that the level of demand skewness basically determines the value that can be gained from implementing new methods. High skewness refers to when a small share of SKUs account for a large part of the demand, see Figure 3.

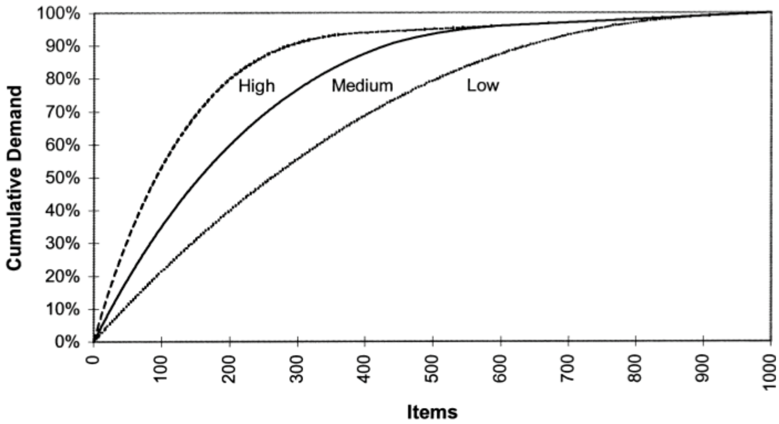

Figure 3 Demand skewness patterns (Petersen II, 2000)

A well-known skewness pattern is the so-called Pareto principle, where 20 % of the SKUs account for 80 % of the demand (Petersen II, 2000).

Roughly, high demand skewness indicates large potential gains, while low skewness indicate that the corresponding potential is low. The identified level of skewness can thus be directly translated into the level of effort to spend on increasing picking efficiency as well as what gains to expect (Petersen, et al., 2004). This does not mean that a warehouse with extremely low skewness should abandon its improvement efforts, but simply identifies the type of warehouses where potential is outstanding.

Another feature with significant impact on the method decisions is seasonality, i.e. the cyclic pattern where the difference in demand between different parts of the year is great. This is partly related to skewness since seasonality in demand over time also might bring changes in the level of skewness. It has been shown that workload equalization between peak and slack periods is crucial to the system efficiency (Jane, 2000). A company with strong variations in demand is therefore recommended to analyze its skewness separately for periods where differences are substantial.

It is necessary to distinguish between two types of seasonality. One refers to when the overall demand is seasonal, and thus have a peak and low over a certain time span. The other kind refers solely to the seasonality among different SKUs. The two types can, but does not necessarily have a parallel development. A total increase in demand can be evenly distributed over all SKUs, or be disproportionate. Similarly, a season-related change in demand for certain SKUs might not show on the total level of demand.

The skewness and the two types of seasonality turned out to be the most important features for the choice of storage allocation method, since their characteristics directly contribute to making storage related decisions such as zone partition and dimensioning, and SKU ranking.

Finally, the motivation behind a chosen method is usually its advantages. However, methods also come with downsides. In order for the tool to be of use, it is fundamental to highlight also the negative aspects of the methods and secure that these downsides are selected in the same conscious way as the benefits. The overall goal when using the tool should be a more efficient picking, but other objectives to include are the weighted importance of e.g. congestion, warehouse utilization and ease of use. Consequently the degree and quality of the tool's recommendation is highly dependent on the outcome of step 3; the company's internal objectives and priorities.

5. Conclusion

The decision support tool and its recommendations carry information that should be of value for all warehouse managers. However, it varies in strength depending on the quantity and quality of research available. Hence it is most useful and relevant for companies with the main goal of improving their picking processes and with one or several of the following characteristics:

- A strong skewness in demand, since the potential gains increase in correlation with skewness in demand.
- Strong and predictable seasonality in total demand, and or among different SKUs. Recurring, well known patterns in demand should be anticipated; either through a change in working procedures or an active choice not to do so.
- A possibility to choose to work with short pick lists. It is well recognized that the possible impact on picking distance increase as the size of the pick list decrease. Put in another way: long pick lists blunt the potential savings from working with the first two bullet points.

6. Suggestions for Future Research

To strengthen the result further, testing the tool in practice and evaluating the outcome after implementation is recommended. The study could also benefit from expanding its scope to include also the factors of replenishment, inventory levels, safety stock, and product value. Considering these factors as well would help improve the extent and quality of the decision support, especially regarding warehouse utilization, zone dimensions, workload, service level, and to free up capital with only a moderate level of effort.

The research field could also be strengthen by including customer importance and requirements. For example, using customer segmentation when classifying the SKUs is a criterion not discussed at all in the reviewed research, although it is a commonly proposed strategy for supply chain management and other business areas (Chopra & Meindl, 2007).

A majority of the research reviewed in the study was performed on isolated areas, e.g. focuses on either picking or storage methods, rather than studying them jointly. It is a likely scenario that combinations of successful implementations from several studies do not bring the same benefits together as they do alone. It could affect performance in a desired direction through synergies, or in a less preferable way through impairment. This makes it difficult to draw general conclusions from the results. Hence, research that identifies general patterns and try to establish specific guidelines for practitioners would be of use.

Last but not least, research on how to handle variations in demand is scarce despite being a common phenomenon. For example, the research on possible gains from implementing a forward area for frequently picked SKUs during high season is not sufficient to provide guidance. Especially concerning in which situations it should be used, its size and its gains in consideration to the additional double handling it brings

To conclude, the authors of this article welcome more generalizable research with clear guidelines and recommendations for how to meet and adapt to fluctuating demand by choosing suitable warehouse operations method.

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