Automation in Material Handling Activities -

The Role of Automated Solutions in Increasing Warehousing Efficiency

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Recent years have seen emerging trends in supply chain management that have determined a change in the role of warehouse and its related activities across the supply chain. Growing attention is placed on automation (‘how?’ and ‘when?’) and its return. Although automation in material handling systems began in the early ‘60s and ‘70, nowadays it is no more a matter of fashion or innovation: deciding whether to automate or not usually requires a deep investigation both on the factors to be considered before automating and on the activities to automate among storage, retrieval, order picking or sorting.

This article presents the results of an in-depth survey carried out on automation in materials handling systems in Italian fast moving consumer goods industry.

Background

The new emerging logistics trends (vendor managed inventory, quick response, cross-docking, etc.) have changed across the supply chain the role of warehouse and its related activities. Warehouse managers report a significant increase in the number of SKUs (stock keeping unit) to manage, along with a reduction in size of orders delivered. On the other hand, there is an increasing interest in scale efficiency due to the rationalization of distribution networks and the centralization of inventories, which require increased productivity and shorter lead times. Empirical studies showed that many companies have replaced numerous smaller distribution centers with fewer larger ones, based on an extensive distribution network.

Recently growing attention is placed on questions such as “why automate?” and “where is the return?”. The answers to these questions are not easy. There are many aspects to be considered, such as workload requirements (broken case or full case picking vs. full pallet retrieval), movement requirements (average rate of storage and retrieval, seasonal flows, etc.), storage requirements (size of the warehouse area, number of stored SKU, etc.) and also external factors (i.e. pay back time, quality of labour forces). Literature has focused most of all on application or optimisation of specific automated solutions, while there are few studies with a systemic approach. A recent study from Georgia Institute of Technology, proposed a model to assess operational efficiency of a warehouse, accounting for some critical resources (labour, space, storage and handling equipment) and different workload requirements. Such model tried to correlate investments in material handling systems with warehouse efficiency.

In order to embrace the Italian market on both the demand and the supply side, Politecnico di Milano activated a research program on automated material handling systems, supported by Siemens, worldwide leader of automated material handling systems. Among the main purposes of research program there is the development of a “normative model” which could help to identify the convenience in the use of automated solutions in relation with warehouse characteristics.

The aim of this paper is to evaluate strategic and operational issues that move to automated or manual warehouses. The research methodology is based fist on an empirical analysis of warehouses built in Italy from 1999 to 2003; then on the assessment of operational and financial convenience in using automated warehouses, in order to confirm results of empirical analysis; then, on an on-field analysis of the main warehouses, carried out through direct interviews to both warehouse managers and supply chain managers.

Empirical Analysis

Methodological framework

The initial research program included manufacturers and distributors operating in Fast Moving Consumer Goods (FMCG) industry. We analysed the most recent warehouses that have been built in Italy since 1999, in order to identify possible drivers which move to an automated material handling solution. We considered only recent warehouses, because a change in business requirements could reduce effectiveness in older warehouses.

We obtained data from material handling providers, and from three main Italian logistics reviews1. We collected data on 94 warehouse facilities, belonging to companies with revenues greater than 10 million euro. In this way we avoided studying situations in which the investment in automated solutions would represent a too significant part of the revenues.

On the basis of the level of automation we distinguished between manual and automated warehouses.

The first type (manual warehouse) is defined as a warehouse where all physical activities (receiving, storing, picking, replenishment and shipping) are not automated and carried out entirely by operators and fork lifts. An automated warehouse is a warehouse where the automation is applied on the storage and retrieval activities (such as Automated Storage and Retrieval Systems, miniloads, carousels, Automated Vertical Storage Systems). In this study we didn't examine information automation such as the use of radio frequency identification systems (RFID), because in our opinion this merely represents an optimisation of a “manual warehouse”, where the information system drives and tracks warehouse’s activities.

Each warehouse has been classified according to different criteria, such as: general information about the warehouse, material handling solution adopted and workload requirements (i.e. number of units load moved per hour and number of storage locations, jointly to products characteristics, role of the warehouse within

distribution network, number of stock keeping unit managed, type of unit load, storage needs).

The choice of the number of units load moved per hour and the number of storage locations as main parameters is due to their capacity to explain warehouse requirements. Moreover, these parameters are well known by logistic managers.

Main results
We tested the correlation between workload requirements and warehouse solution, considering only handling of finished products by full pallets. More remarkable results are obtained considering pallets moved per hour and the number of storage locations. Figure 1 shows prevalent use of manual warehouses where values of both pallets moved per hour and storage locations are low. Figure 2 shows a restricted part of Figure 1, considering values of number of storage locations lower than 10,000 pallets and values of pallets moved per hour lower than 100. Results show the existence of two threshold values, above which there is the majority of AS/RS: 6,000 pallets for storage capacity and 40 pallets moved per hour for handling capacity.

We investigated the few cases of manual warehouses with values of these two parameters greater than their respective thresholds. They are warehouses with a low number of SKU and high demand level for every SKU. In this context the use of drive in racks allows a good utilization of space without a great loss in operational efficiency.

With reference to other parameters used to describe warehouse workload requirements, we observed a trend toward automation in factory warehouses (Table 1), while other factors do not seem to be significant.

So empirical analysis seems to confirm a significant impact of warehouse size on the choice of automated warehouses. In the next section we will investigate results of empirical analysis, with particular attention to threshold value of pallets moved per hour and number of storage locations.

![Figure 1](image1.png)  
Empirical analysis of warehouses in FMCG industry

![Figure 2](image2.png)  
Empirical analysis of warehouses in FMCG when number of storage locations is lower than 10,000 pallets and number of pallets moved per hour is lower than 100

<table>
<thead>
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<th>Table 1 Sample characteristics</th>
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<td>Automated Warehouse (AS/RS)</td>
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<td>Manual Warehouse</td>
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<td>Total</td>
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Operational and Financial Analysis

Methodology
We considered two opposite alternatives: manual warehouses, built by selective pallet racking and reach trucks, and automated storage and retrieval systems (AS/RS). We built two models for designing the warehouse, changing some project parameters. According to the results of empirical analysis, we assume as main project parameters the number of pallets moved per hour and the number of storage locations. We considered making maximum use of space, assuming a lift height of 30 m for AS/RS and 11 m for reach trucks.

Models of design together with unit costs of resources (storage and handling equipment, space and labour) allowed to assess both investment value (including storage and handling equipment, storage area) and operating costs (including labour, maintenance, power) of the two alternatives.

Assessment of investment
We study the value of investment varying values of number of storage locations (from 2000 up to 12,000 pallets) and maintaining a fixed value of pallets moved per hour. The effect of increasing the number of pallets stored is clearly a growth of investment cost. If we study the pattern of investment cost with respect to the number of storage locations (Figure 3) we observe a reduction of the gap between the two alternatives. This pattern is explained by greater impact of fixed costs for AS/RS solutions. If we repeat the analysis assuming other values of pallets moved per hour (40, 60, 80 pallets moved per hour) we find the same pattern.

We found similar results changing values of pallets moved per hour and maintaining a fixed value of storage locations.
Assessment of operating costs
We express operating costs both as variable cost of every storage or retrieval mission and as operating cost for every storage location. The second expression of operating costs is derived as ratio between annual operating costs and number of storage locations (pallets) in warehouse. On the other hand, annual operating costs are calculated multiplying the number of annual storage or retrieval missions with the unit cost of every mission.

First, we study operating costs increasing values of pallets moved per hour (range: 20-120 pallets/hour) and maintaining a fixed value of storage locations. We observe that unit cost of every mission decrease for both alternatives, mainly because there is lower incidence of supervision activity. Furthermore, unit cost of every mission for AS/RS is around half of manual warehouse one. Figure 4 shows pattern of operating costs of every pallet location: the effect of increasing pallets moved per hour is a growth of gap between manual warehouse and AS/RS. Analysis has been repeated considering different values of storage locations (4000, 6000, 8000 and 10,000 pallets): yearly unit operating cost decreases for larger values of pallets stored.

Overall, on the basis of the study of investment value and operating costs, increasing size of warehouse AS/RS could result convenient, because there is a reduction of the gap with manual warehouse with reference to investment. This gap could be filled thanks to lower operating costs. The advantage in terms of operating costs increases in the same way as pallets moved per hour increase. If pallets moved per hour increase there isn’t a significant change of investment cost for either alternatives. So, more values of pallets moved per hour and storage locations are high, more AS/RS could be convenient.

Financial analysis
Aim of financial analysis is to understand the joined impact of studied patterns of investment and operating costs varying pallets per hour and number of storage locations. We calculate the present worth of investment for AS/RS and manual warehouse considering following scenarios:

1. Scenario 1: weight average cost of capital (WACC) equal to 12% and planning horizon equal to 3 years.
2. Scenario 2: WACC equal to 12% and planning horizon equal to 5 years.
3. Scenario 3: WACC equal to 8% and planning horizon equal to 3 years.
4. Scenario 4: WACC equal to 8% and planning horizon equal to 5 years.

If the difference of present worth of investment between AS/RS and manual warehouse is greater than 5 %, we consider one solution cheaper than other, otherwise it is not possible to point out the convenience of one solution on others. Results show:

* in each examined scenario, the convenience area for manual warehouses occurs when values of storage locations are lower than 5000-7000 pallets and the pallets moved per hour are lower than 50-60 (Figure 5). These values are similar to results of empirical analysis;
* AS/RS could be convenient for greater values of pallets stored and pallets moved per hour;
* longer is the planning period, more convenient is the AS/RS. This increment in length of planning horizon is equivalent to an increase of agreed pay back time;
* higher is the WACC, more convenient is the manual warehouse, because future benefits of AS/RS in terms of operating costs will be less important.
**On Field Analysis and Conclusions**

On-field analysis allowed to understand better the influence of external factors on the decision to automate or not to automate the material handling process. We investigated reasons for choice of automated solutions with logistics managers of important firms (retailers, manufactures and logistics service providers): Auchan, Ikea, Barilla, Exel, Gambro, ND Logistics, Reckitt Benckiser, RS components, Sergio Tacchini. All types of analysis (empirical, operational and financial, on field) show that the main reason to use AS/RS is economic convenience. In the second place this convenience area is in reference to values of storage locations greater than 5000-7000 pallets and values of pallets moved per hour greater than 50. Other factors to be considered are liquid assets of the firm and variability of products during the time in terms of weight and volume. In fact variability of product characteristics result as very critical factor, above all for retailers and logistics service provider. Within the described context, on field analysis show a great impact of outsourcing process: if warehouses services are on a short-term contract basis (2-3 years) the main focus of logistic provider is flexibility. So, only in presence of long-term relationship (more than 5 years) logistics service provider could turn to automated solutions such as AS/RS. On field interviews also reveal greater percentage of AS/RS solutions in factory warehouses, probably because factory usually evaluates investments on long-term perspective and...
storage activity is rightly seen as prosecution of production activities.
In the end, first results of research program should confirm automated materials handling systems as a way to increase efficiency of distribution network under certain internal and external conditions.

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References