Strategic factors affecting warehouse maintenance costs

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Abstract

Purpose – The purpose of this paper is to determine the fundamental factors influencing maintenance costs of logistic buildings and to provide benchmark indications for designing maintenance efficient warehouses that contribute to the enhancement of business performance.

Design/methodology/approach – The relations between factors and indicators of building facilities maintenance costs are examined using regression analysis of a dataset collected from about 100 distribution warehouses leased by a leading global freight provider throughout Italy.

Findings – Maintenance cost reduction can only be achieved by making appropriate design decisions on the strategic characteristics of warehouse facilities. In particular, the location and the age of a building are relevant factors of breakdown maintenance, while the monthly volume of freight transiting the warehouse is a significant cost factor of maintenance due to damage.

Research limitations/implications – This paper is limited to logistic service providing organisations, has local impact, and does not consider operational requirements in suggesting design criteria. Further research may gainfully generalise the model by examining other businesses, geographical areas and industrial operations issues. Leasing and frequently relocating facilities have emerged as appropriate distribution management strategies to control location, size and age of a building, and thus to face dynamic business conditions.

Originality/value – This paper provides maintenance cost benchmarks and supports design decision making of distribution warehouse facilities.

Keywords Maintenance costs, Distribution management, Warehouses, Italy

Paper type Research paper

1. Introduction

While significant research is carried out in the field of maintenance of industrial plant equipment, very little is focused on analysing maintenance issues involved in operating the building component of industrial facilities.

This is due to a few reasons. On the one hand, the cost of maintenance of the construction components and building systems of industrial facilities is frequently...
irrelevant compared to the costs associated with labour, maintenance of manufacturing equipment, and utility consumption required for running production and operations. On the other hand, in most industrial organisations, building maintenance expenditure is viewed as an unavoidable burden (Sherwin, 2000; Tsang, 2002) to assure the minimum operating capacity and performance of the workplace and to allow for undiminished income generation. Therefore, maintenance expenses are frequently considered to be fixed costs, without examining their relation to the results from operating activities (Stoy, 2007).

Yet, especially for manufacturers, logistics players, retailers and industries having freight distribution, as an important portion of the business, the cost of plant equipment maintenance is small compared to that associated with warehouse building maintenance. In this context, there is a growing demand for leasing warehouses to serve as freight storage, distribution, consolidation and transition of goods (Ling et al., 2008).

Most industries complain about the increasing cost of maintenance and seek to cut building maintenance spending by leveraging on outsourced facilities management (FM) contracts, reducing repair interventions to a minimum, and delaying preventive maintenance actions, which in turn lead to a cascade of extra costs in the medium- and long-term.

What industrial executives misunderstand is the fact that, to create cost savings, it is important to design and build maintenance cost-efficient workplaces or to select constructed facilities that were designed for this objective. Thus, it is important to investigate the factors of this kind of cost efficiency in warehouse facilities to avoid ineffective and expensive managerial practices aimed at cutting corners rather than reaching substantial maintenance cost reduction through design of the strategic factors influencing the warehouse efficiency.

However, in both the professional and research literature, these issues are only partially taken into consideration for designing cost-effective models of warehouse facilities.

With the purpose of contributing to this knowledge and providing managers with insight on value creation, this paper proposes that the cost of industrial building maintenance should be considered as one of the motivations for selecting the characteristics of warehouses. This is done through statistical analysis of empirical FM data from Italian warehouses of a leading global shipment and logistic service provider that here asks for anonymity.

The paper is structured as follows. The next section provides a short review of relevant research and available models to manage maintenance issues of building performance. Then, we discuss the design of the study, the empirical analysis and the main results. Finally, conclusions and practical implications are drawn together with limitations and future research directions.

2. Warehouse facilities management issues

Maintenance and reliability of manufacturing plant equipment are important factors that can considerably influence an organisation’s ability to compete effectively (Madu, 2000). Yet, despite the emergence of total productive maintenance initiatives to optimise reliability and efficient management of plant assets for continuous improvement of business performance (Ahuja and Khamba, 2008), the issues specifically related to the
maintenance cost of the building components of industrial facilities are struggling to be fully integrated into the business strategy of industrial organisations.

Some theoretical frameworks developed for this purpose are available in the research literature, although very few specifically apply to the strategic design of cost-effective models for warehouse FM. Following is a review of some of the available frameworks and models.

**Performance-based models**

Some authors have attempted to develop models that link maintenance decisions to building performance (Jones and Sharp, 2007). These models suggest that maintenance decisions should be made based on comparisons of building performance indicators against benchmarks (Hassanain et al., 2003). However, the benchmark models are condition based and do not address the underlying issues linking building maintenance expenditure with the business performance of an organisation (Cooke, 2003).

**Impact of maintenance on design decisions**

Another stream of research studies the impact of maintenance-related issues on design decisions and proves that these have considerable impact on the performance of the building and that maintenance-related problems that occur during the lifetime of a building can be minimised by making the corresponding decisions early in the design phase of the project, as long as these choices are made in the context of a life-cycle cost analysis (Arditi and Nawakorawit, 1999a).

In addition, in both the professional and research literature, this cost is not taken into consideration for designing cost-effective models of warehouse facilities, and very few theoretical frameworks are available for taking this into account. With specific application to the scope of this paper, Ling et al. (2008) examined the FM needs that must be designed into warehouse projects: they identified some tenants’ FM requirements of warehouses and investigated the relationship between tenant satisfaction and performance of different facilities to recommend design and FM practices that warehouse owners should adopt to give tenants value for money. However, the work considers warehouse qualitative provisions and does not include an analysis of strategic characteristics of warehouses to meet business performance.

**Cost factors analyses of building performance**

With specific reference to residential buildings, El-Haram and Horner (2002) state that to reduce maintenance costs, it is necessary to minimise the number of maintenance tasks by selecting the most applicable maintenance strategy, designing new facilities for maintenance and reducing or controlling the impact of the factors that influence maintenance costs.

According to Stoy and Kytzia (2008), the cost of maintenance has to be indicated with cost indicators (dependent variables), which are related to relevant cost factors (independent variables). There are numerous factors that influence maintenance cost indicators of residential buildings to varying degrees: building characteristics, tenants, political and other factors (Masshender and Finch, 1998). For example, key cost factors pertaining to building characteristics are the age, function, location and size of the constructed facility (El-Haram and Horner, 2002). The identification of relationships between these maintenance cost indicators and their relevant factors has been studied
and appraised in residential and long-term care and office buildings (Madritsch et al., 2008; Stoy and Kytzia, 2008; Lai and Yik, 2008; Ottoman et al., 1999).

This paper suggests a similar investigation into warehouse buildings where little benchmark work is available, and data about tenancy cost indicators and factors have not been collected and analysed (Stoy, 2007). Moreover, it is not clear how the relations between cost factors and maintenance cost indicators affect business performance.

Seeking to overcome the gaps above, this paper identifies the fundamental strategic factors that influence maintenance costs of warehouse facilities as a supporting tool for enhancing those aspects of business performance inherently linked to location and utilisation of warehouse facilities. Ultimately, it is suggested that maintenance cost efficiency cannot be reached through FM cost saving actions only, but mostly by changing the strategic characteristics of facilities. Through empirical analysis of maintenance cost indicators and associated factors, it is possible to identify the ideal nature of a distribution warehouse to serve as a benchmark for the case company and other similar organisations.

3. Case study empirical analysis

Description of case company

This paper analyses the maintenance costs of the Italian warehouses of a leading Global Logistic Service (GES) provider committed to freight transport, handling, storage, safely and on-time delivery of parcels, documents and freight items throughout the world.

Similarly to competitors, GES leases its warehouse facilities from specialty property owners and shares the maintenance duty. The leasing contract of new or refurbished warehouses averages approximately eight years.

From a general point of view, maintenance is aimed at improving the value of an asset and is defined as “a combination of any actions required to retain an item in, or restore it to, an acceptable condition” (BSI, 1993). In practice, building maintenance can be pursued through the following actions: reactive maintenance, which includes breakdown and corrective repair; preventive maintenance, both cyclic and condition based; and extraordinary maintenance, which comprises refurbishment and improvement (Horner et al., 1997).

In our case, the property owners are charged with extraordinary maintenance or refurbishment of facilities to assure the tenant of acceptable building conditions to execute logistics operations. Usually, GES relocates or the owner refurbishes the building if the obsolescence gap between current performance of the building and minimum acceptable performance to run operations is too great for the tenant to shoulder (Jones and Sharp, 2007).

The case company is responsible for all of the remaining maintenance tasks. It outsources the maintenance service of all warehouses to a sole national external contractor while maintaining a light in-house staff to manage the contracted service, control fulfilment of contract requirements, and avoid the risk of the service agent’s opportunism (Hui and Tsang, 2004).

The outsourced service lasts nine years and includes both reactive and preventive maintenance services. In particular, the contractor responsible for maintenance and repair develops and executes a system of regularly preventive maintenance actions according to the annually arranged schedule and is compensated a lump-sum fee for all warehouses as agreed upon by the service contract. In addition to scheduled maintenance services, the contractor also supplies emergency services for prompt reactive repair or replacement.
of breakdown items (Arditi and Nawakorawit, 1999b). The reactive maintenance process is initiated by a request from the tenant: in the case of breakdown of an item that underwent proven diligent scheduled maintenance, the service contractor executes the work, and GES is only charged the unit price of replaced materials; in the case of damage due to proven inappropriate human usage of the item by the occupier, such as in the case of damaged loading/unloading bays, it is charged with both the cost of materials and labour time spent in maintenance.

A sole list of unit prices for both time and materials was agreed upon in the contract for the entire national territory. Despite uniform fees, the firm recorded unexpected variations of reactive maintenance costs among warehouses.

Our research group was asked to help the company improve building maintenance performance to be more aligned with benchmarks. As part of this mission, we first looked for relevant maintenance cost factors to understand whether cost variability was caused by inappropriate design of fundamental characteristics of the warehouses or by cost benchmark misalignment. In particular, we analysed breakdown maintenance only since GES is charged with preventive maintenance fixed costs.

Survey methodology
First, exploratory analysis of the data (Tukey, 1977) were carried out and recorded by the case company. Then, regression analysis was performed to determine a linear model able to describe the response variables and to determine factors explaining the response variability. Linear regression analysis is a widely used tool for investigating costs, and it reflects the relationship between variables of historical datasets.

Exploratory data analysis
Approximately, 1,500 corrective maintenance actions were analysed and the associated registered tenant costs. To enable examination of relevant relationships, the cost datasets were collected from 98 warehouse facilities located throughout Italy (Figure 1) with a total of 193,998 m² of usable floor area (UFA), from 1 May 2007 to 30 April 2008. Data were extracted from the FM information system used by the company to request and manage the maintenance process and the associated administrative transactions.

Figure 1.
Geographical distribution of warehouses
During the recording period, maintenance prices were constant with no inflation adjustment.

Some of the parameters that characterise the pool of warehouse facilities are reported in Table I. The potential key cost factors are the size referred to as the UFA, age, monthly lease amount (MLA), and monthly freight volume (MFV). The size of warehouses was heterogeneous and ranged from 103 to 5,914 m² of UFA. The age of buildings, which refers to the time elapsed since beginning of occupancy of either new or refurbished warehouses, was not more than 20 years. The median monthly lease was 5.25 €/m², with variations depending on the local real estate market prices. The mean volume of freight transiting a distribution warehouse per month was 21 parcels/m². The facilities bore a median annual reactive maintenance cost of 1.131 €/m² of UFA, which is a summation of both breakdown and damage maintenance costs (DMCs).

Figure 2 shows (boxplot) the distributions of the maintenance cost factors.

The dataset does not include a few additional potential cost factors. For instance, it does not consider the operational headcount because it proves to be linearly equivalent to freight volumes. It also regards meteorological factors as irrelevant; in fact, only four out of 1,500 maintenance actions could be linked to wear of elements due to weather conditions.

The present study is aimed at understanding which of the parameters among those in Table I are relevant actors (independent variables) to maintenance cost indicators

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Lower quartile</th>
<th>Median</th>
<th>Upper</th>
<th>SD</th>
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<td>1,800.0</td>
<td>2,536.0</td>
<td>1,199.9</td>
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<td>8.0</td>
<td>11.0</td>
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<tr>
<td>MLA/ UFA (€/m²)</td>
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<td>5.25</td>
<td>6.00</td>
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</tr>
<tr>
<td>MFV/ UFA (parcels/m²)</td>
<td>12.54</td>
<td>21.00</td>
<td>31.21</td>
<td>16.06</td>
</tr>
</tbody>
</table>

**Table I.**
Factors and indicators of maintenance costs

![Boxplots](image.png)

**Figure 2.**
Boxplots of independent variables
A first statistical analysis on dependent variables showed a non-normality of records (Figure 3). Therefore, a logarithmic transformation was applied to the breakdown maintenance cost (BMC) and DMC data, which lead to a normal distribution (Figure 4). As a result, the transformed DMC and BMC variables (referred to in the following as mlogBMC and mlogDMC, respectively) are used as response variables of the linear regression model.

**Results of regression analysis and discussion**

Tables II and III show the results of the regression analysis performed using the R-software tool (R Development Core Team, 2006) on the complete dataset. The model includes both first-order variables and their second-order interactions. The columns report the estimate of the regression coefficient, the standard error of the coefficient estimate, the value of the $t$-statistic; the $p$-value and the associated level of $t$-test significance, respectively.
As far as the BMC is concerned (Table II), the geographical location of the warehouse facility proves to be a relevant factor, despite uniform national maintenance contract and fees (region $p$-value: 0.0141). The monthly amount paid for leasing the facility is also a relevant parameter (MLA $p$-value: 0.0192). Indeed, because lease pricing is inherent with the local real estate market conditions, this analysis confirms that the MLA is a function of the regional position of the warehouse and that the rental fee is almost as relevant as the region. In particular, the northern part of Italy is associated with reduced maintenance cost compared to the central and southern regions. Clearly, all second-order interactions with the region are also relevant maintenance cost factors (AGE:region; MFV:region; MLA:region).

As a practical implication, this means that the location decision model is an important component not only for running an effective logistical business, but also for reducing the BMC of warehouse building assets.

With regard to DMCs, the monthly volume of freight treated by the single warehouse is significant at the level of $p$ less than 0.01. The age of the building, though still a relevant driver of DMC, is a less significant factor than in the BMC. This corroborates the intuitive expected behaviour: in fact, while breakdown of building elements is highly
4. Conclusions
This work fosters the notion that strategic characteristics of warehouse facilities, such as geographical location and size, are more important factors for reducing maintenance costs and for supporting the logistical business performance rather than design decisions on building details and minor actions aimed at cutting FM costs.

It is stated that the ideal distribution warehouse must be located in an efficient region to assure low BMC. Also, the perfect facility must have a correct level of exploitation to reduce the DMC. In particular, the ratio between the UFA and the volume of transiting freight must be sized appropriately to avoid either under or overutilization of the warehouse.

However, this study poses some limitations. First, it draws implications for the geographical area that has been considered and any extrapolation for general use in similar contexts out of Italy might require local country data and appropriate regional clustering.

Second, because traffic volumes are dynamic and change over time, it may be difficult for a logistics company to size warehouses based on unsteady projected freight volumes.

Therefore, based on both the difficulty of estimating future market demand and the relevance of the age of the building in determining BMCs, it becomes clear that frequently relocating warehouses to meet the changing needs of freight volume and to use young building facilities is a valuable management practice. In this sense, leasing warehouse facilities proves to be a more effective strategy to manage maintenance cost than real property.

Of course, this study fails to consider other operational requirements in the process of shaping the appropriate size and location of warehouse facilities. Further research is currently developing these additional operational issues to look for the most appropriate factors of cost-efficiency in warehouse buildings.

References


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