A model for assessing the quality and functionality of logistics buildings

Baglio M.*, Dallari F.*, Garagiola E.*, Perotti S.**

** School of Industrial Engineering, LIUC – Università Cattaneo, Corso Matteotti 22, 21053 – Castellanza (VA) – Italy (mbaglio@liuc.it, fdallari@liuc.it, egaragiola@liuc.it)*

*** Department of Management, Economics and Industrial Engineering, Politecnico di Milano, Via Lambruschini 4/B, 20156 - Milano – Italy (sara.perottti@polimi.it)*

Abstract: Logistics real estate has been experiencing a recent rebirth also driven by industries such as e-commerce and retailing, searching for warehouses and cross-docking facilities compliant with their logistics needs. In order to identify the top class logistics buildings, the need has emerged for measuring both the quality (e.g. architectural and equipment features) and functionality (e.g. compliancy with logistics requirements) of warehouses. Literature reports examples of assessment models related to industrial buildings from a sustainability perspective (e.g. LEED, BREEAM certifications), but the measurement of their functionality and quality has been scarcely addressed so far. The present paper aims to fill this gap by developing an original model to assess logistics buildings, by identifying, structuring and rating the most relevant features of a warehouse. The proposed model assesses the degree of functionality and quality level of two types of logistics buildings: warehouses and cross-dock platforms. A three-phase methodology was adopted. First, a literature review on logistics real estate was performed to list significant warehouse features. Second, both structured interviews with experts and a Delphi method were used to adjust the list, and to evaluate the importance of each feature. As a result, a model was developed, structured into four sections, each divided into sub-sections. Each sub-section presents multiple-choice questions with response items. The significance of each section/item is described by the weights defined by experts, and the overall rating determines the quality level of the logistics building under assessment. Finally, the rating model was validated by pilot tests on a panel of existing warehouses and cross-dock platforms.

Keywords: Logistics real estate, warehousing, rating systems, building performance, sustainability, benchmarking, facility location, performance measurement.

1. Introduction

Logistics real estate has been experiencing a recent rebirth also driven by industries such as e-commerce (Mangiaracina et al., 2016) and retailing, searching for warehouses and cross-docking facilities compliant with their logistics needs. On the one hand, e-commerce has grown at an accelerating pace, accounting for 23,600 million Euros in 2016 in Italy, with a growth rate of +17% with respect to 2015 (Osservatorio eCommerce B2c, 2017). On the other, the logistics real estate industry in Italy has registered a significant growth with respect to the past years (GVA Redilco, 2017). This has led to a 40% reduction of warehouse vacancy rate and an increase of more than 50% in new constructions in terms of floor area compared to 2015.

Nowadays, evaluating a logistics building essentially entails its size (e.g. in terms of floor area) and few other elements without a reference model for qualitative assessment. This represents a significant limitation, since quality is not defined only by the size of a building, but also by other elements that are essential to perform a logistics activity (Mattarocci et al., 2017). For this reason, in order to identify the top-class logistics buildings, the need has emerged for measuring both the quality (e.g. architectural and equipment features) and functionality (i.e. compliancy with logistics requirements) of warehouses.

The literature reports a number of assessment models for industrial buildings, especially from a sustainability perspective, such as LEED and BREEAM certifications (Mattoni et al, 2018). However, the measurement of their functionality and quality has been scarcely addressed so far. Given these premises, the present paper aims to fill this gap by developing an original model to assess and classify logistics buildings, by identifying, structuring and rating the most relevant features of a warehouse. The remainder of this paper is structured as follows. Section 2 describes the existing literature, addressing the relevant features related to logistics real estate. Section 3 reports the objectives and research questions, while section 4 shows the methodology adopted to develop and validate the model and the overall rating system. Section 4 describes the proposed model and section 5 illustrates the main findings of its application. Finally, the last section presents conclusions, the main implications for academics and practitioners, and further future research opportunities.

2. Literature

In real estate industry rating systems are widely used to evaluate the marketability of any kind of building and space, i.e. residence, apartment, office, industrial building, brownfield area and others (Mattarocci et al., 2017; Glumac et al., 2011).

The evaluation is required and carried out by different players in the real estate value chain, such as real estate agents, appraisers, assessors, mortgage lenders, brokers, property developers, investors and fund managers, lenders, market researchers and analysts, tenants, and others (Pagourtzi et al., 2003). Decisions in the real estate setting need a deep understanding and evaluation of the asset, since the product under assessment is a durable long-term asset, characterised by a high differentiation, located in a specific site (Wyman et al., 2011).

The real estate literature reports a number of assessment models, but the main focus essentially lies in sustainability aspects, such as limitation of gas emissions, energy consumption, application of green rules during the activities of design and construction (Ding, 2008; Ugwua et al., 2007). Indeed, large attention has been paid to environmental assessment given the institutional pressure on increasing building sustainability performance (Zimmermann et al., 2005). Even researchers of logistics and supply chain management have started to investigate this topic pinpointing how to reduce gas emissions during logistics activities (Colicchia et al., 2016).

Focussing on the logistics real estate industry, little investigation has been performed so far on the development of logistics building assessment models. The examined literature mainly focus on facility location and site selection problems, and sustainability topics. This latter aspect (i.e. sustainability) has been achieving higher attention within numerous rating systems, and, overall, as above-stated, in the real estate industry (Krause et al., 2012). Several existing models – i.e. the so-called Green Building Rating Systems (GBRS) – assess the degree of sustainability in the construction industry. Among these tools, the most significant are also recognised as international standards, such as LEED, BREEAM, Green Star, Green Globes, SB Tool, and national versions such as PBRS for Emirate of Abu Dhabi, DNGB for Germany, ITACA for Italy, CASBEE for Japan, (Mattoni et al., 2018; Berardi, 2011). However, these models have not been specifically designed for logistics buildings. Some adjustments are made to fit the logistics context and requirements, but the focus is merely on the environmental assessment of the building.

Besides sustainability aspects, other features in the literature have been found as important when evaluating a logistics building: location and relationship with the context, technical/construction characteristics, external and internal spaces, utilities and systems, and management and maintenance costs (Table 1).

Table 1: Elements for logistics real estate evaluation

Features	References
Location and relationship with the context	Mattarocci et al., 2017; Diziain et al., 2014; Pagoutzi et al., 2003
Technical/construction characteristics	Ciaramella, 2010
External and internal spaces	Ciaramella, 2010; Baker et al., 2009
Utilities and "green" systems	Ciaramella, 2010; Pagoutzi et al., 2003 He et al., 2002
Management and maintenance costs	De Marco et al., 2011 Ahmed et al., 2010

A detailed description of each feature is provided as follows.

Location is generally one of the most important features in real estate (Diziain et al., 2014; Pagoutzi et al., 2003). As far as logistics building are concerned, it also involves availability of transport services and infrastructures in the surroundings, such as motorways, railway stations, ports or airports servicing the area. In this case, the value of a logistics building increases when it is located in an area where a company can deliver goods in the most efficient way or as fast as possible, depending on its role: central warehouse or last mile cross-dock platform (Mattarocci et al., 2017).

Technical and construction characteristics refer to the building elements, such as structural mesh, pavement, roof structure. (Ciaramella, 2010).

Internal and external spaces refer to areas (e.g. truck parking lots, offices, recharge areas for material handling equipment, technical rooms, and restrooms) or devices and facilities (e.g. docks, refrigeration rooms, safety systems) (Ciaramella, 2010).

Utilities and systems refer to those appliances such as fire-detecting and fire-fighting systems, lighting systems, electric systems, heating/air-conditioning systems, photovoltaic systems (Ciaramella, 2010; Pagoutzi et al., 2003; He et al., 2002).

Finally, management and maintenance costs mainly includes building and system maintenance features and the adoption of innovative systems such as the Building Management System (BMS) to control and manage efficiently the entire building, using either a sustainability or costs perspectives (De Marco et al., 2010).

Apart from the above-reported features, the purpose of usage (i.e. "functionality"), although important in the assessment of a logistics building (Mattarocci et al., 2017) seems to be neglected. In particular, the functionality of a logistics building refers to the degree of compatibility to a specific purpose of usage of the building under assessment. In literature, logistics buildings have been recognised to play different roles. The most common one is inventory holding, i.e. conventional stock warehouses where goods are stored in racks and customer orders are consolidated before delivery. A second role is cross-docking, i.e. warehouses where goods are moved directly from receiving area to shipping area, rapidly sorted and loaded to their final destinations (Notteboom et al., 2009; Higgins et al., 2012). According to Baker et al. (2009), other roles for logistics facilities may include value added services (e.g. secondary packaging activities, labelling), or production postponement (i.e. goods are finally assembled after the customer order, in order to have in stock generic products), returned good (for reverse logistics) and other activities, such as service and repair.

3. Objective and research questions

The literature review has revealed a lack of evaluation models with a specific focus on quality and functionality when assessing logistics buildings. Quality is to be intended not only as a combination of architectural characteristics and equipment features, but also as a set of characteristics (e.g. site location, external spaces, building technical characteristics, internal areas, utilities and "green systems") affecting the overall building evaluation. Functionality refers to the level of compliancy of a logistics building to host a certain type of logistics activities (e.g. storage, picking and sorting).

Building on the elements emerged, the present research aims to fill the identified research gap by developing an original model for assessing logistics buildings, identifying, structuring and rating the most relevant features of a warehouse. The intended aim is to build a rating system able to define not only the overall quality of the logistics building, but also the purpose of usage, in line with Mattarocci et al. (2017).

According to the intended aim of the research, the following research questions have been identified:

RQ1: Which are the main types of logistics buildings in Italy from a real estate perspective?

RQ2: Which are the features to be considered in the assessment of a logistics building?

RQ3: How do these features contribute to the overall quality and functionality evaluation of the building under assessment?

4. Methodology

The research methodology was structured into different stages.

First, a literature review on logistics real estate was performed to identify the main types of logistics buildings, the significant features to be considered when assessing a warehouse or a cross-dock platform, and the available assessment methods used in the industry. The literature review results allowed to obtain a first set of information related to RQ1 and RQ2.

Second, both structured interviews with experts and a Delphi method were used to define the main types of logistics buildings (i.e. confirmed as stock warehouses versus cross-docking facilities), to adjust the list of features, and to evaluate the importance of each feature. The Delphi method was used to obtain the most reliable consensus of opinion of a group of experts (Glumac et al., 2011; Okoli et al., 2004; Dalkey et al., 1963). Ten experts involved in the research were selected among real estate agents, property developers, investors and fund managers operating in Italy. They were selected since they all are involved in the logistics real estate market and have a deep knowledge of the industry. Also, they can be potential users of the proposed rating model, since their companies manage several warehouses.

Moreover, to provide a specific assessment of utilities and "green" systems, the pool of experts was also extended to practitioners working on specific equipment types of a warehouse, such as fire-fighting systems, lighting systems, loading bays and racks. The method was structured into four phases. The first one involved a brainstorming phase in which the pool of experts validated and/or integrated the list of features emerged from the literature review. Specifically, experts were asked to add, modify and approve the list of features derived from literature. In the second phase questionnaire were sent individually to the experts, who were asked to rank the features by providing a weight for each, and all the opinions were collected. In the third phase, data were analysed and shared with the experts. Finally, a second round was performed in order to reach consensus (Okoli et al., 2004).

A five-star rating model was finally developed to assess the quality of logistics buildings. The selection of this method was motivated by the easy understanding and identification of this metric (Sparling et al., 2011). Five-star rating is widely deployed in different fields of research, such as finance, hotels, health care structures, information quality, e-commerce, safety systems, and sustainability performance in real estate (Sparling et al., 2011; Berardi, 2011). As a result, the model was structured into four sections (i.e. Location and relationship with the context, External spaces, Building technical characteristics, Internal areas, utilities and green systems), each divided into sub-sections. Each sub-section presents multiple-choice questions with response items. The significance of each section/item is described by the weights defined by the experts, and the overall rating determines the quality level of the logistics building under assessment.

Finally, the rating model was validated by pilot tests on existing warehouses. This phase allowed to fine-tune the model, adjusting wording of questionnaire, weights and scores.

5. Model development

The structure of the rating model resulting from the application of the Delphi method is reported in Table 2.

The four sections of the rating model reflect the main features emerged from literature. Each section is divided into sub-sections:

- "Location and relationship with the context" involves two sub-sections: context and proximity to transport infrastructure;
- "External spaces" involves two sub-sections: external yard and loading/unloading bays;
- "Building technical characteristics" involves three sub-sections: warehouse size, structure and flooring;
- "Internal area, utilities and green systems" involves two sub-sections: office and other spaces, and utilities and green systems.

The "management and maintenance costs" feature emerged in the literature has not been included as a model section. Indeed, system management and maintenance costs are also related to the internal equipment/systems used by the tenant to perform its activity, and not necessarily linked to the quality or functionality of the entire building. For instance, higher maintenance costs can be related not only to building age but also to the presence of automated material handling solutions. However, to consider maintenance issues into the model, we included a question related to the presence of a BMS, which is a system that helps control maintenance costs and manage efficiently all the utilities in the building.

Table 2: Structure of the rating model for logistics buildings

Sections	Sub-sections	Examples
Location and relationship with the context	Context Proximity to transport infrastructures	e.g. proximity to logistics parks, courier hubs, large cities, highway exits, ports and airports
External spaces	External yard Loading/ unloading bays	e.g. dimensions of front/back yard, number of car and truck parking lots, direction of traffic, number of loading bays, dock levellers
Building technical characteristics	Warehouse size Structure Flooring	e.g. building layout, height, depth, mesh, roof structure, panels, fire resistance (R)
Internal area, utilities and green systems	Offices and other spaces Utilities and green systems	e.g. office areas, recharge areas for material handling equipment, technical rooms, fire-fighting system, lighting system

During the interviews, experts highlighted that the evaluation at some points depended also on the functionality of the logistics building, i.e. stock warehouses versus cross-docking facilities. Several distinguishing features also emerged that characterise the two types of logistics buildings, as reported in Table 3.

Table 3: Stock and cross-dock characteristics

Characteristics	Stock warehouses	Cross-docking facilities
Floor space [sqm]	> 5000	< 1500
Internal spaces to total floor space ratio	40-50%	25-30%
No. sides with loading/unloading bays	1 (2 in case of distribution centres)	2 opposite sides
Avg. Loading/unloading bay Density [no. bays/sqm]	1/800	1/200
Building depth [m]	> 80	< 50
Building clear height [m]	> 10	< 6
Floor load [kg/smq]	> 5000	< 3000
Fire resistance (R) mins	> 120	< 60

Regarding quality, different section/item weights were used depending on the building functionality (i.e. stock warehouse versus cross-docking facility), according to the expert's opinion emerged from the Delphi method. As an example, the fire-fighting system received a higher weight in case of stock warehouses, as the presence of a sprinkler system is mandatory to store goods, whereas in case of cross-docking facilities it is not required as the goods are only passing through the facility without being stored. In case of "hybrid" warehouse, the quality was computed as the weighted average of the quality results of the two profiles.

Table 4: Weight and scores

Features	Stock warehouses	Cross-docking facilities
1. Location and relationship with context	*29%*	*45%*
1.1 Context	48%	50%
1.2 Proximity to transportation infrastructure	52%	50%

2. External spaces	*16%*	*19%*
2.1 External yard	58%	60%
2.2 Loading/unloading bays	42%	40%
3. Building technical characteristics	*31%*	*25%*
3.1 Warehouse size	34%	45%
3.2 Structure	38%	35%
3.3 Flooring	28%	20%
4. Internal areas, utilities and "green systems"	*24%*	*11%*
4.1 Office and other spaces	37%	50%
4.2 Utilities and "green systems"	63%	50%

The sum of the weights of all section is equal to 100% along as the sum of the weight for each subsection. As an example, for a stock warehouse the overall weight is computed as the sum of 29% (Location and relationship with the context), 16% (External spaces), 31% (Building technical characteristics), and 24% Internal spaces, utilities and "green systems"). Regarding the subsections for instance, considering a stock warehouse, the overall weight of the "Location and relationship with the context" section is computed as the sum of 48% (context) and 52% (proximity to transport infrastructures).

The weight of each subsection is divided for each question in it. The questions weights were validate and discussed during independent interviews with the experts in the field, in order to give higher weights to the most important questions. The question weight turns into the maximum score achievable answering the best option.

The score given to each individual response item was defined using a parametric scale, so that the "best" option received the maximum score and the others were given a percentage of such score, accordingly with a linear pace. The criteria ware validated and discussed with the expert involved in order to verify the accuracy of the model.

Therefore, the final score was computed based on the responses given by the respondent. The model was designed to give to each response a score for both quality and functionality. The sum of each score associated to each response given brought to the final quality and functionality score.

Finally, the ranges referred to the five-star rating assessment were set. In line with the Green Star certification for sustainability (Mattoni et al., 2018), researchers decided to use intervals of different size to confer the number of stars. The five-star rating ranges used are reported in Table 5.

Table 5: Five-star rating ranges and quality rates

N. of stars	Quality rate intervals
1	0-20%
2	21%-45%
3	46%-60%
4	61%-75%
5	76%-100%

Starting from the model results, it was possible to perform a gap analysis, to pinpoint the weakest features in the evaluation. The gap was calculated as the difference between the maximum score related to the single item and the value resulted from the user's answers.

6. Model results

This section presents the results obtained from the model application. Before performing a pilot test, researchers decided to test the model using a sensitivity analysis (Saltelli, 2002). Thanks to the analysis, it was possible to identify the response items that most influenced the output of the model. As an example, the cross-docking facility type is mostly influenced by the distance from the highway, the presence of a high number of loading docks, and the size of the external area. In turn, the stock warehouse type is highly dependent from the building age, the building clear height, the type of fire-fighting system, and the floor load.

Afterward, the researchers performed a pilot test of the model by means of interviews and on-site visits. Interviewees, i.e. tenants and owners of logistics buildings operating in different industry sectors, received a questionnaire form, composed of open-ended and multiple-choice questions. On-site interviews were necessary since they gave the opportunity to pinpoint wording adjustments or corrections and comment the result obtained. Starting from the results at this stage, it was possible to refine the evaluation ranges for the five-star rating model.

In the following, two cases are reported to show the results of the model. In the first case we present the results provided from a stock warehouse, while in the second case a cross-docking facility is analysed.

In the first case, the warehouse was located in Milan area and the interviewee was the tenant (i.e. a logistics service provider). The 44,000 sqm warehouse 13.7 m height, is used to store electronic devices sourced from Far East. The application of the rating model provided the following results: the logistics building was assessed as a stock warehouse with a functionality rate equal to 59%. As far as quality is concerned, the overall rate was equal to

72%, and each section quality levels are reported in Figure 1.

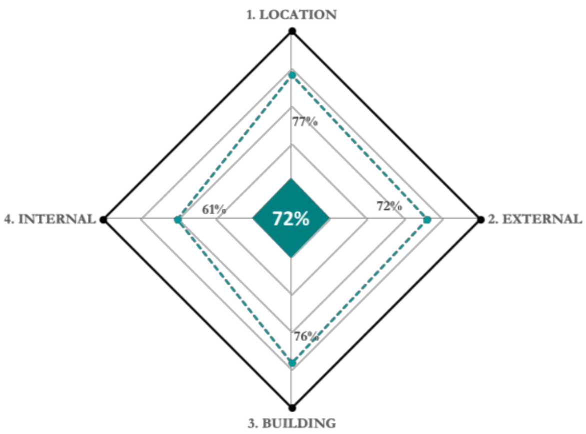

Figure 1: Quality rates for each section – stock warehouse case

In the second case, the logistics building under-assessment was located in the main Italian freight Village close to Bologna, and the interviewee was the tenant (i.e. an express courier). The warehouse was used to distribute small packages. As a result of the model, the logistics building turned out to be a cross-docking facility with a functionality rate equal to 68%. Looking at the quality, the overall rate was equal to 84%. Each section quality levels are reported in Figure 2.

Figure 2: Quality rates for each section – cross-dock platform case

7. Conclusions

The objective of the proposed rating model is twofold. On the one hand, to define the functionality of a logistics building, as a percentage of compatibility with a stock warehouse versus a cross-docking facility. On the other hand, to assess its overall quality level.

The value of this research is to present a structured and complete model for the assessment of a logistics building. The model offers a quantitative and shared method of evaluation, able to estimate both building quality and functionality, thus extending the previous assessment methods available in literature.

The present work has both practical and academic implications. From an academic perspective, the model addresses an identified gap in the existing literature, which merely focuses on facility location and site selection problems, and sustainability topics. Moreover, the model can be used to map warehouses in specific geographical areas, with the aim of creating a database of logistics buildings classified by the level of functionality and quality. From this viewpoint, the availability of data for a large number of warehouses would also make it possible to update the distinguishing features of the logistics building types identified in the model, as well as the related weights and scores.

From a practical viewpoint, it offers significant implications in the real estate industry. Indeed, the proposed tool can be used by real estate agencies, appraisers, brokers, property developers, investors and fund managers to identify the right purpose of usage and, therefore, to better qualify the logistics building under-assessment. It may also be useful to improve the quality of an existing logistics building by identifying its weakest elements to be addressed, in order to evaluate potential technical improvements.

This first version of the model presents some limitations that should be noted. First, response items and weights have been essentially defined by referring to the Italian context. Therefore, the model applicability can require some adjustments to be applied in other countries/contexts. Second, functionality has been analysed by considering two main types of logistics building only (i.e. warehouses and cross-docking facilities). No other differential characteristics, such as product categories, have been considered so far. Third, from a methodological perspective, a higher number of pilot tests should be recommended to improve the fine-tuning of the model.

However, this research offers interesting streams for future investigation. For instance: (1) including the tenants' perspective, e.g. by looking at the characteristics of products to be stored in the logistics building; (2) considering further relevant features to be included, e.g. measurement of CO_2 emissions; and (3) including other logistics functions to the ones already investigated.

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