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Assessing the Effectiveness of Warehouse Layout at a Logistic Company by using Structural Equation Modeling Approach

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ABSTRACT

A basic research that exploratory in nature was conducted at a warehouse of a logistic company in Malaysia. The aim of this paper was to identify how well workplace safety, order picking and space utilization influence the effectiveness of warehouse layout as perceived by the employees. A personally administered questionnaire was executed in distributing the questionnaires to 150 operation staffs at a logistic company using convenience sampling. Forty items were developed in rendering the abstract concept of the variables during an operational definition stage. The exogenous variables explained 29.7% of the variance in explaining the effective warehouse layout and 2 hypotheses were supported. At the end, the descriptive information for the insignificant construct was supplied in order to trigger efforts for future research.

KEYWORDS: Effectiveness, Warehouse Layout, Workplace Safety, Order Picking, Space Utilization.

INTRODUCTION

Layout is an important element in both manufacturing and service operation. The layout is designed by considering the flow of the process of an operation. It would give a tremendous effect on productivity since it ties the movement of people, materials and information. A good layout adhered to efficient materials handling equipment, environment and aesthetics including safety working environment, flows of information and the cost of moving between work areas [7, 13].

Warehouse is spaces that are functionally for: i) receiving goods from a source; ii) storing goods until are needed by the customers (internal or external); and iii) retrieving goods when requested to do so [10]. A warehouse is the commercial building for storage of goods or cargo. It is used by the manufacturers, importers, exporters, agents and others for business transactions. Another definition of warehouse is a location where a firm stores or holds raw materials, semi-finished goods or finished goods for a varying length of time [8]. It is stated that "a warehouse typically consists of several different areas including shipping and receiving areas, bulk storage area and order picking area" [12].

In the logistics industry, warehouse plays important roles in making the storage for all the cargo before it is delivered to the customer or for customer preferences in renting out spaces at the warehouse. Same goes to the air transport industry. The operations in the warehouse are vital because air transport has complex procedures compared to other logistics industry such as land and water logistics. The procedure of delivery for the cargo to customer may consume more time and that is why a warehouse for cargo storage is important. Effective layout in the warehouse can help companies in having better operations management including the storage system, the positioning of equipment and heavy machines in the warehouse have to be in an appropriate place with high utilization of space. Wastage in the warehouse can be described as not fully utilized the space and it would increase the material handling costs. "Material handling costs are all costs related to the transaction including equipment, people, material, supervision, insurance and depreciation" [7].

Another waste in the warehouse is waiting; described as a waste of time. Time management is vital in operations as it involves money. For instance, unnecessary movement of cargo and hunting for tools or stored items that cannot be located are examples of waste. Furthermore, all items in the warehouse should be placed in the right and proper position as it can help the logistic company in having the lean operations and standard of procedures (SOP) in the material handling control system.

It is normal to have a safe and comfortable workplace [9]. Typically in the warehouse management system, there must be forklift and cargo truck carriers. To operate the forklift, organizations must create a standard operating procedure so that employees can follow and obey the work process. On top of that, the people-machine/equipment relationship or ergonomics issue must be well addressed for human well-being. This is because effective warehouse layout might be explained when the warehouse management can provide safe and comfortable workplace for their employees. In the scope of order picking, a proper layout in the warehouse is important because it can reduce time in order picking activities.

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The effective warehouse layout will exist when employees can work comfortably, safe, experience lean operations and also the movement of heavy machines and equipment in the warehouse are operating according to the standard operating procedure. Considering how the layout ties the productivity, exploring ideas and feedback from the employees that directly involve in the warehouse daily operation was a wise decision. Employees' feedback about the current layout is an input for scope of improvement, since they are close to the real process. Therefore, this research was conducted in a logistic company involving the operational employees that have direct access to the warehouse. This paper aims to identify the influence of workplace safety, order picking and space utilization towards effective warehouse layout.

LITERATURE REVIEW

The most appropriate warehouse layout depends on its particular operational conditions and characteristics such as modularity, adaptability, compactness, distribution of movements, accessibility and flexibility [6]. Previous study summarized that effective warehouse layout is when an organization can maintain flexibility and scalability in the layout design [2]. The objectives of successful warehouse layout need to undertake; maximizing the using of space, equipment, the use of labor, and accessibility and protection to all items irrespective the material stored [16]. The effectiveness of a warehouse must be analyzed because the role of the warehouse is vital in any supply chain [20].

Safety issues must be carefully addressed in order to achieve the objectives of the warehouse layout since any accident or injury will lead to loss in term of money, time, effort and/or emotion. The security of workers has been widely studied due to the nature of activities in the warehouse operations that contribute to the high incidence of manual activities like sorting, pushing, picking, lifting, pulling and so on [17]. These activities distress the physical and mental of the workers, therefore the warehouse layout must best costume to the flow of the warehouse activities. Van Reenen et al. (2008) stated that future long-term muscular pain such as musculoskeletal disorders (MSDs) is due to the discomfort experienced by the warehouse operators [17], which are awkward posture and a heavy exertion workload [19]. According to Chung et al. (2001) and Krause et al. (1997), there is significant correlation between poor working posture, over-exertion and MSDs [19]. Back pain and arm problems are examples of MSDs due to repetitive back bending while lifting objects and twisting/pulling/pushing of heavy objects. These postural stresses can give negative influence to worker performance.

Order picking deals with the retrieval of items in a specific location in the warehouse with the aim of minimizing the travel time or distance. Time management is important in any work-process in the warehouse therefore improving time of order picking such as travelling between product locations, picking products and packaging are important [1]. Plentiful research that focus on travel time and/or distance reduction striving to the improvement of the order picking efficiency [16]. It is because faster retrieval activities can improve the efficiency of the whole retrieval process. The warehouse manager is thoughtful in term of the order picking system, since it is worth in cutting down the operational cost as well as improving its efficiency [18]. Order picking in the warehouse including travelling to the storage locations, extracting items and taking them for shipping or delivery to the customer. Its efficiency can be influenced through the layout of the area and the operating policies [12]. Coley et al. (1996) and Grosse et al. (2013) stated that picking activities are paramount in the stocking system because of an important spending of human resources which is between 50% and 75% [17].

It is very important that when an organization plan the design of the warehouse layout, organization needs to think how to make use of the space at the optimum level. Meaning that, "the management's task is to maximize the utilization of the total 'cube' of the warehouse that is utilized at full volume while maintaining low material handling costs" [7]. Space requirements in a warehouse depend on various factors among them are inventory levels, the number and size of the aisles, departmentalization, the type, number and size of storage equipment, depth and height of storage, and the size of the sorting system [6]. By making the best use of space, organization will be able to have a higher total amount of inventory storage. Making the best use of space does not only mean for the specific floor areas only but as a whole, horizontally and vertically. The layout must fully utilize its floor space as well as minimizing the travel time and/or distance in achieving the effective standard [16]. Effective warehouse layout should utilize the space of the warehouse at the optimum level as it can help the organization having the lean process of warehousing such as storing, shipping, order picking and movement of people and equipment in the warehouse [4].

METHODOLOGY

A cross-sectional study was undertaken in order to test 2 hypotheses namely:

H1: Workplace safety would influence effective warehouse layout
H2: Order picking would influence effective warehouse layout
H3: Space utilization would influence effective warehouse layout

The number of population was 552 operations staffs of the logistics company. Structured questionnaire was the mode of data collection used with 40 items were developed as a result of operational definition procedures for all constructs (see Figure 1). All items were adhered to face validity. The numerical of 10-point scale with bipolar adjectives of both ends (strongly disagree-strongly agree) was used. The personally administered questionnaire was executed by using a convenience sampling, where the questionnaires were distributed to the elements of the population that available to provide it [14]. If the population size is 550, the sample size should be 226 [15]. During the fieldwork, 150 completed questionnaires were received. Even though the completed questionnaires received were less than 226, it is accepted for most research that sample size more than 30 and less than 500 are appropriate [14]. In order to analyze the data, the partial least squares (PLS) method was use by adopting SmartPLS 2.0 M3.

Figure 1 demonstrates the research model. There are 4 latent constructs altogether. Effectiveness of warehouse layout is the endogenous latent constructs, whereas workplace safety, order picking and space utilization are the exogenous latent constructs.

Research model

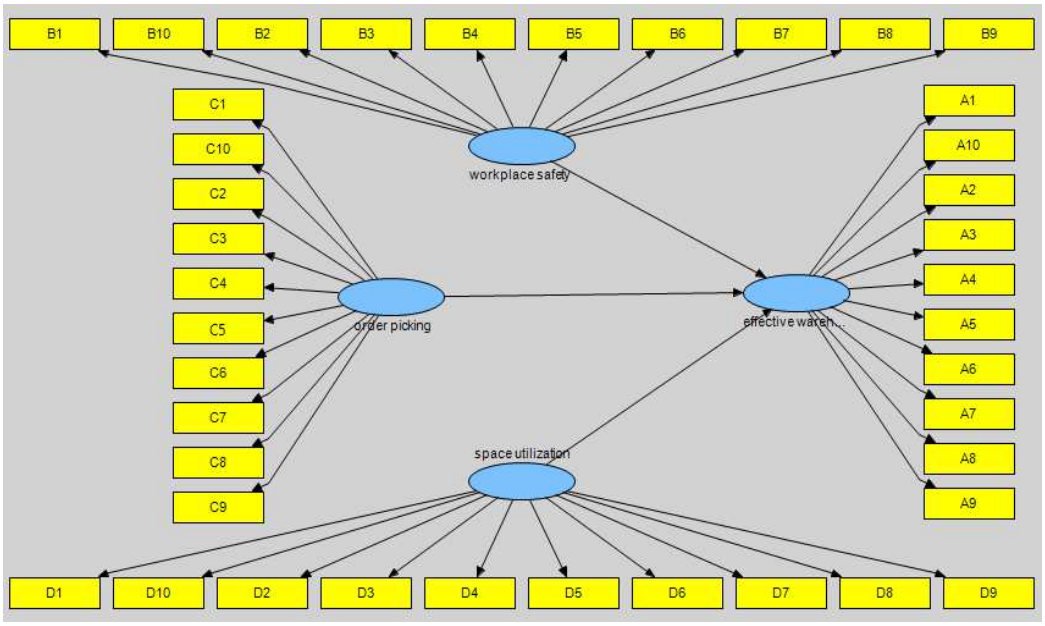

Figure 1: Research model

RESULTS AND DISCUSSION

Profile of Respondents

Table 1 indicates a profile of 150 samples. 90% of the respondents are male. More than 80% of the respondents are at a range of 26 to 45 years old. Most of the respondents are Malay. About 98 respondents work about 5 years and above with the organization.

Table 1: Personal profile of the respondents

		Frequency	Percentage (%)
Gender	Male	135	90.0
	Female	15	10.0
Age	Below 25 years old	13	8.7
	26 to 35 years old	62	41.3
	36 to 45 years old	61	40.7
	46 years old and above	14	9.3
Race	Malay	121	80.7
	Indian	20	13.3
	Chinese	5	3.3
	Others	4	2.7
Length of Service	Less than 1 year	4	2.7
	1 to 2 years	20	13.3
	3 to 4 years	28	18.7
	5 years and above	98	65.3
Position	Senior Manager	3	2.0
	Manager	11	7.3
	Controller	12	8.0
	Executive	37	24.7
	Supervisor	36	24.0
	Senior Officer	31	20.7
	Officer	20	13.3
Education	Master/Professional	5	3.3
	Certificate	45	30.0
	Bachelor/Degree	67	44.7
	Diploma/Certificate	33	22.0
	STPM/SPM		

MEASUREMENT MODEL

Internal Consistency and Convergent Validity

In order to assess the measurement model the convergent validity must be scrutinized. The convergent validity is "the degree to which the multiple items that are used to measure the same concept are in agreement" [3]. The composite reliability is more appropriate in measuring the internal consistency instead of the conservative measure (Cronbach's alpha) [5]. In addition, factor loadings and the average variance extracted (AVE) are the indicators in assessing the convergent validity.

Nunally and Bernstein (1994) stated that "composite reliability values of 0.60 to 0.70 are acceptable in exploratory research, while in more advanced stages of research values between 0.70 and 0.90 can be regarded as satisfactory [5]. The composite reliability of this study is between 0.879 to 0.890 (Table 2).

In the beginning, there are 40 items developed in measuring the latent constructs. However, in order to increase the AVE which is should be higher than 0.50 [5], 14 items were deleted. The remaining items as described in Table 2. The AVE which reflects the overall amount of variance in the indicators accounted for by the latent constructs are between 0.513 to 0.595, which exceeded the recommended value of 0.50 [5].

Table 2: Factor loadings and reliability

Variable	Items	Loadings[a]	CR	AVE	Cronbach Alpha
effective warehouse layout	A1	0.741	0.884	0.525	0.849
	A10	0.859			
	A2	0.650			
	A3	0.757			
	A5	0.586			
	A8	0.764			
	A9	0.684			
workplace safety	B10	0.763	0.879	0.513	0.840
	B3	0.604			
	B4	0.619			
	B5	0.688			
	B7	0.699			
	B8	0.790			
	B9	0.822			
order picking	C1	0.769	0.890	0.537	0.859
	C10	0.726			
	C2	0.783			
	C3	0.702			
	C4	0.718			
	C5	0.710			
	C9	0.719			
space utilization	D1	0.689	0.879	0.595	0.830
	D4	0.775			
	D5	0.850			
	D7	0.824			
	D8	0.706			

CR composite reliability, *AVE* average variance extracted

[a] Standardized loading

Discriminant Validity

Cheung and Lee (2010) stated that discriminant validity is the extent to, which the measures truly distinct from other variables. It is indicated by low correlations between the measure of interest and the measures of other constructs [3]. There are 2 ways of measuring discriminant validity such as examining the cross loadings of the indicators and the Fornell-Larcker criterion [5]. The latter is more conservative approach, where the square root of construct's AVE should be greater than its highest correlation with any other construct.

Table 3 indicates the squared root correlations of each construct are less than the square root of the AVE by the indicators measuring the construct, implying adequate discriminant validity. To sum up, Table 2 and 3 demonstrated adequate convergent and discriminant validity.

Table 3: Inter-construct correlation

	effective warehouse layout	order picking	space utilization	workplace safety
effective warehouse layout	***0.725***			
order picking	0.467	***0.733***		
space utilization	0.407	0.585	***0.771***	
workplace safety	0.461	0.511	0.49	***0.716***

Note diagonal elements are the square root of the AVE of the reflective scales while the off diagonals are the squared correlations between constructs

Structural Model

Figure 2 shows the structural model of the study. The structural model comprises of the hypothesized relationship between exogenous and endogenous variables in the model, it shows how well the theoretical model predicts the hypothesized paths [11]. The bootstrapping procedure (500 samples) was conducted in generating the path coefficient and their t-values.

The analysis revealed that 29.7% of variance in effective warehouse layout as perceived by the employees can be explained by workplace safety, order picking and space utilization (Figure 2). Out of the 3 path coefficient, only 2 were found significant (Table 4). The workplace safety ($\beta = 0.259$, $p < 0.01$) and order picking ($\beta = 0.247$, $p < 0.05$) explained an impact on effective warehouse layout. Therefore, H1 and H2 are supported. However, H4 is not supported ($\beta = 0.148$, $p > 0.10$).

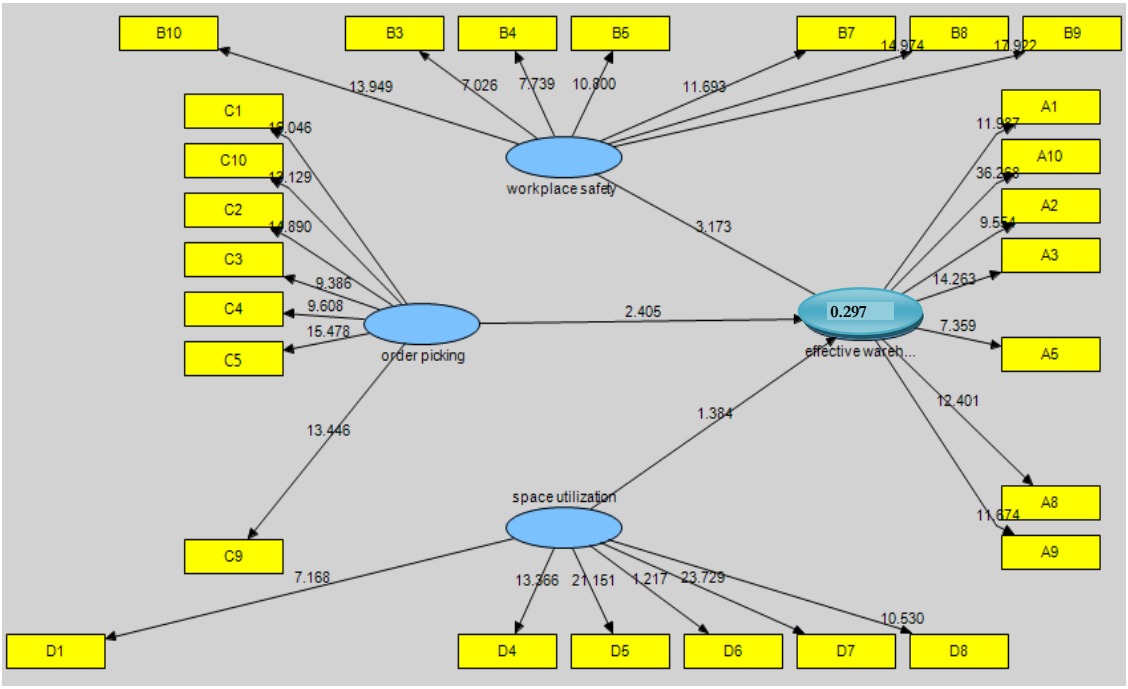

Figure 2: The structural model

Table 4: Summary of structural model

Hypothesis	Description	Path coefficient	Standard Error	t-value	Results
H1	workplace safety -> effective warehouse layout	0.259	0.082	3.173	Supported**
H2	order picking -> effective warehouse layout	0.247	0.103	2.405	Supported*
H3	space utilization -> effective warehouse layout	0.148	0.107	1.384	Not supported

**p<0.01
*p<0.05

Even though individually, the space utilization was not significant when it is combined with workplace safety and order picking they contribute 29.7% towards effective warehouse layout as perceived by the employees. Therefore, the descriptive statistic in Table 5 can provide an insight view for continuous improvement within the company. The mean values in Table 5 indicate averagely the respondents elicited towards "agree" for each item measuring the space utilization. To screen it further, the researchers recode the interval scale to nominal scale as found in frequency column. All items got more the 50% agree responses unless for "SU: Space in the warehouse is fully utilized" which is 50% for both disagree and agree responses. Even though the descriptive table shows a good sign mean value, but the values of standard deviation scored more than 1. This indicates that the patterns of respondents' answers were varied.

Table 5: Descriptive statistic of space utilization

	N	Minimum	Maximum	Frequency		Mean	Std. Deviation
				Disagree	Agree		
D1: Space in the warehouse is fully utilized	150	1	10	75	75	5.49	2.176
D4: Current operating procedure lead to higher utilization of space	150	1	9	58	92	5.93	1.863
D5: Supervisor ensure the operator place the equipment and forklift at appropriate area	150	1	9	72	78	5.71	1.826
D6: Spaces utilization in the warehouse reduces the operational cost	150	2	10	29	121	6.91	1.724
D7: Equipment's in the warehouse have been located at appropriate area	150	1	9	59	91	6.01	1.896
D8: Allocation of the space for the equipment's and goods based on their priority	150	2	9	51	99	6.26	1.657
Valid N (listwise)	150						

CONCLUSION AND RECOMMENDATIONS

This paper aims to identify the influence of workplace safety, order picking and space utilization towards effective warehouse layout. This objective derived to 3 hypotheses, whereas only 2 hypotheses were supported. There are several contributions of the study. It was confirmed the original expectation that workplace safety would affect the effective warehouse layout. A macroscopic approach to improve the working environment should consider safety at the workplace as a priority. The postural issues must be carefully addressed, so that employee can experience a better quality of working life. Battini et al. (2011) stated that merging the ergonomics evaluations in the human operations analysis is vital, since there is a strict interaction between productivity and motion efficiency and operational safety [17].

Order picking should be understood as a time consuming task, therefore a good method analysis would help in improving the time taken of hunting tools, materials or equipments. Therefore an organize workstation with an effective layout would contribute to the efficiency order picking activities. The result stated that 29.7% of the 3 exogenous variables explained the effective warehouse layout. Even though it was proven that space utilization was not significant contributor, it is recommended to reevaluate this construct to another scope of study while increasing the sample size and focuses on industry or applying it to the different types of layout. It is because the nature of the warehouse layout is unique and it is subjected to the nature of the operations in the warehouse and not rigid to a specific arrangement, "there is no best design, methodology or policy for all problems under consideration" [21].

There are a few limitations of the study. Firstly, it was focused on a company using non probability sampling technique. Therefore, the results could not be generalized to the other organizational setting even though the nature of the operational background is similar. Second is the completed questionnaires received was 150, this sample size was considered small as compared to the population size since with 552 of population size it is recommended to distribute the questionnaire to 217 samples. However, the decision was not violating the properties of the scientific research since sample size that more than 30 and less than 500 appropriate for most research [14].

This study provides an insight to a logistic company with regard to the warehouse layout and provides empirical evidence on factors influencing effective warehouse layout in operations management discipline. Even though the generalizability of the study is limited, it would trigger the company's top management to take proactive action in increasing company's productivity and achieving total lean operation of their company by concentrating on the issues of warehouse layout. For future research, it is recommended to the company to execute an observation method in assessing the performance of the warehouse layout.

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