Performance Elementsof Green Eco-Friendly WarehouseTowardsSupply Chains Management Effeciency

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Abstract: Implementation of green eco-friendly factory is not something new as nowadays this is the requirement that most of them mustcomply. More and more tier of suppliers had initiated their daily operation to run while considering on the environmental impact. When we refer to warehouse operation, it will always relate to how important efficiency and responsiveness is. Although warehouse operation is part of the industries hub and had a smaller environmental impact, warehouse operation still takes on a substantial part in reducing adverse impact on the environment. The aim of this paper is to develop a theoretical framework which can help to measure the effectiveness and responsiveness of the warehouse not only on the operation itself, but also relates to how well the operation operate towards green eco-friendly warehouse. This framework can use for warehouse operation to measure gap analysis before fully implement a standard system.

Keywords: Green warehouse, eco-friendly warehouse, accuracy, supply chain.

Abbreviation: Industrial Revolution (IR), Electric Vehicle (EV), Life Cycle Assessment (LCA), Life Cycle Cost (LCC), Green Supply Chain Management (GSCM).

1. Introduction

The awareness of negative effects of environment pollutions is continuously being promoted worldwide. Children in many societies are promoted on environment care at the early stage of education. The massive environment pollution was started in 1850's, specifically during Industry Revolution which numbered as one point zero (1.0). After almost 120 years have passed, the pollution level still at an alerting point (Mackey,2017). Though many efforts are being placed to solve this issue since 1880's, they seem to be not yet sufficient. However, there is a very good sign visible to us on the direction of modern technology development. It is found that ecological awareness level had built up recently with increase of individual and group of people who act and think green. They took a lot of initiative for example spending money to invest on more ecological appliances which could reduce the use of electricity, buying recycle materials where applicable and use more materials that is biodegradable. Most of the tools, machines and devices that are being invented to perform towards the reduction ofenvironmental pollution (Owusu, P. and Asumadu ,2016). This positive sign is due to awareness that are raised in world societies generally and decision makers specifically. Peoplerealize the importance of environment care and are all together putting best efforts towards 100% pollution free environment which this paper referred as Green Eco-Friendly.

The concept of green supply chain management is gaining popularity among manufacturer over the world. Green concept operation is one of the ways that the implementing organization shows their commitment to support sustainability which demonstrate better economic performances and improves their competitiveness in market (Grant and Shaw,2019). Logically we understand why organizations starts to put focus on the green eco-friendly operations. The major reason is the requirement of the organization to comply to certain legislation which the government had enforce. This also link to external requirement by major customers which require them to comply with certain environmental standard and lastly the organization self-awareness on the impact of their operation towards the sustainability of the environment (Andjelkovic & Radosavljević, 2018).

It was found that recent studies concluded major contributors to pollution are vast use of petroleum and used of engine diesel vehicles as well as massive used of fuel in factories operations. Even in introduction of Industry Revolution (IR) 4.0 has emphasized on green eco-friendly production and operation (Kamble, Gunasekaran and Dhone, 2019). The introduction of this IR 4.0 will require more energy consumption and preparation must be planned forward in order to comprehensively avoid any inefficient use of natural resources as well as to reduce pollution by putting this green eco-friendly as one of the considerations. While more focus seems to be given in improving the production process, there is less studies conducted to improve other parts that support the supply chain on products. Warehouse management is one of them (Chen et al.,2017).Going

deep to their operation many elements of the daily operation relates to environment is overlooked. The warehouse is not simply a building or space just to keep ready products before delivery or for materials storage, but also an important area in overall operations that management should put effort to improved. This paper proposed some elements that warehouse can look into in getting the operation closest possible to become green eco-friendly warehouse which could improve the efficiency of supply chain management.

2. Objective of Study

The objectiveof this study is to propose a theoretical framework that can be used to evaluate warehouse towards green eco-friendly operationwhich helps to improve the efficiency of supply chain management. This framework proposed that there is significant relationship between accuracy, resource utilization, financial outcome, responsiveness and flexibility of warehouses with green eco-friendly warehouse which will lead to an effective supply chain management.

3. Literature Review

Warehouses is one of the main components in supply chain. In providing improvements on supply chain, there is variety of value-added activities that can be added to warehouse operation to move the operation towards an efficient warehouse. One of the ways is by measuring the performance of the warehouse towards environmentally friendly operations(Khan, S. and Zhang, 2017). Here we will discuss different measuring components that might be able useful to measure the performance of warehouse towards green eco-friendly warehouse, starts from accuracy, to resource utilization, financial outcome and responsiveness and flexibility of the warehouse.

3.1 Measuring Performance of Eco-Friendly Warehouse from Warehouse Operation Accuracy.

Before we go deep into measuring warehouse accuracy, here is the definition of accuracy. Accuracy can be defined as an ability toobtain data to be correct in specific value or standard in terms of measurement, calculation or specification. One of the ways that we can measure the performance ofthe eco - friendly warehouse is by measuring the accuracy of the warehouse. Inventory is classified as in-house assets of the organization. Even if the firms provide warehouse service to clients, the firm must ensure that the inventory is 100% accurate. These inventories consider as money, which in the forms of finish products or materials. Warehouse accuracy towards the eco - friendly warehousecan be measured by its inventory accuracy. This measurement will consider the percentage of differences between the stock card from system input with the physical inventory count in a particular set of area during a particular period of time(Bogale, 2016).

Zero discrepancyis the target of this measurement, which prove the stock in the system and physical stock is tally and well controlled. This performance measurement can be conducted quarterly or half a year annually to ensure there is no shortage of inventories or excess amount of inventory in the warehouse. In terms of quality, accuracy in warehouse inventories improves inventory tracking, controlling stock levels, avoids stealing of goods from inventories or loss of goods in stocks(Malinowska, Rzeczycki, & Sowa, 2018). Accurate stock level could help in increasing warehouse productivity by shortening the searching of materials in the warehouse and cut short the collection distance by optimizing the arrangement of the inventories according to their monthly needs. This could be linked with eco-friendly activities were less petrol will be used to move forklift which require the movement of targeted goods. Other than that warehouse could benefit from energy saving, where any area with less stock movement doesn't require much usage of lights and part of the lights could be switched off and this could result in saving in electricity usage.

Accuracy in the stock level as well could help in avoiding wastage of material if there is overstock materials in the warehouse. If the warehouse is providing service for storage, they could alert client on the shelf life of each stock and whichever stocks near to expiry, they could alert client in advance where the client could work out something to clear off the stock before it expired and disposed as waste. This could save the environment from being polluted by unwanted materials and reduce materials dump into the landfill. The performance evaluation for eco-warehouse could also add into consideration on checking either the warehouse upgraded their facilities to use barcode and radio frequency tools to optimized the operations and improve the speed of searching, which could help reduce the energy (electricity and fuel) to search for desired materials(Laosirihongthong et al., 2018).

Another way to measure the accuracy performance of the eco - friendly warehouse is by checking the accuracy of order picking and order shipping. In warehouse operation, picking order includes a right process of getting correct instruction inorder, for example, order quantity, unit measure and where the product specific store in the warehouse (Bogale, 2016). We need to understand that some materials are storedcloser to each other. Planning and by knowing in which area the materials stored will shorten the order picking time where

multiple picking of various types of materials might be needed at the same location (Chen et al., 2017). A useful system is required to help the worker to allocate and plan for their movement. Another important performance measurement is on the accuracy of order shipping. To create a good service to customers, these both type of activities is important to create a good service and image to the customers. Failed to achieve 100% accuracy in order picking and order shipping will end up in generating returns from customers and poor image (Bogale, 2016). Return from customer meaning double shipment, which will incur more fuel energy no matter what type of transportation is used: - land, sea, or air (Waller et al., 2016). In measuring the performance of eco-friendly warehouse, accuracy of order picking and order ship to customer must achieve 100% accuracy in order for the warehouse to be considered as fully as green eco-friendly warehouse. Another wastage if these elements of measurement is not 100% achieve, is where shipment to customer might not be able to consolidate (Winkle et al., 2019). If shipment able to be consolidated, it will save the environment by reducing the amount of pallet or case and will reduce forklift handling for instant. This key point is important because by using more forklift is equal to more fossil fuelcombustion. Past study conducted where any unoptimized forklift performance, forexample, using 20% inflated forklift tyre will increase 2% of fuel consumption and misalign forklift will increase 8% increase in fuel consumption (Indrawati, Miranda, & Pratama, 2018). So, in this performance evaluation, it is suggested to check the frequency of forklift maintenance as well.

Next accuracy measurement inevaluating the performance of the eco - friendly warehouse is by knowing the percentage of transaction error and percentage of receiving the correct shipping documents (Laosirihongthong etal., 2018). Any transaction errors or detection on incorrect shipping documents will increase the consumption of electricity and paper. Increase in electricity usage significantly to the error because more time is required for the operator to generate correct transaction or shipping documents and more paper will be used to print out the required information.

3.2 Measuring Performance of Eco-Friendly Warehouse from Resource Utilization.

Resource utilization is the most obvious measurement indicators to measure the performance ofgreen eco-friendly warehouse. The fact is, for any investigators who evaluating the performance of green eco-friendly warehouse, they would notice that the resource utilization reflects directly on the performance of the warehouse. Before we go deeper, the 'investigators' term used here refers to general people with concerns that includes researchers and auditors. Since this study uses Loasirihongthong et al., (2018) journal article as main reference there are three resources utilization measures were discussed which is space utilization, equipment utilization as well as labor and productivity utilization.

It is fairly agreed that hundred percent green eco-friendly environment is not yet feasible due to several applicability factors such as maintainability, implementation cost, time consumption and technological availability. According to Chatur (2019), the hundred percent green power generation is still not feasible in 2050 due to several facilities' implementation issues. However, the efforts towards highest possible green eco-friendly environment would be always worth to reduce pollution effects on our environments.The green eco-friendly implementation availability could be noticeable by investigators through previously listed three resources utilization measures. Space utilization has four factors to be considered. The measures are directly depending on fitting the space use of the four factors that influence the size of a warehouse. It could be concluded that the size of a warehouse depends on product size per unit/category, the storage requirements, storage period and production process (Ma & Abdulai, 2019).
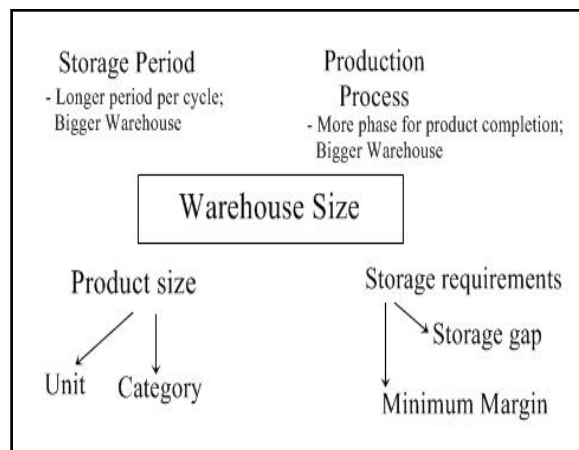

Figure 3.1 summarizes the factors that influence size of a warehouse.

Once the fit of these four factors reaches optimization it should result two visible indicators which are high level production rate and high frequency of available space reuse cycle manage to be scheduled.Goshime, Kitaw and Jilcha, (2018) concluded that, better utilization of space and equipment are factors that maximize the production rate. In order to understand how green eco-friendly is practiced on equipment utilization, the equipment must be categorized based on two co-exist dimensions which are how the equipment is operatedand what are the raw materials used to operate the equipment. Table 3.1summarizes the details of these two co-exist dimensions. According toTodorovic and Simic (2018), the petroleum consumption has not only alerted us on pollution issues, but also bring a dilemma on how long it could sustain. Though the green eco-friendly alternative is available, the high-power consumption equipment has the significant disadvantageof using green eco-friendly organic material compared to petroleum. The implementation and maintenance cost are very high. Therefore, it is a very challenging decision from the management side. The labor and productivity, utilization of green eco-friendly discussion covers all aspects related to products stored in a warehouse. It includes the worker activities, transportation uses, monitoring system and management of the warehouse itself. In can be concluded fromTodorovic and Simic (2018), that the electric vehicles (EV) give high impact to green eco-friendly through pollution-free transportation implementation. Meaning, in evaluating the performance of green eco-friendly warehouse, if EV is used in the warehouse, meaning their operation is nearly comply to ecological operation. The workers' general everyday schedule should be arranged to maximize to categorize the warehouseasgreen eco-friendly. If the worker schedule is well arranged, consumption of electricity will be reduced, fuel consumption will also reduce and less pollution emit to the environment. In addition, working procedures to maintain the green eco-friendlymaxima, such as no unnecessary overtime operation to use the warehouse facilities, to promote recycling to the highest, to ensure all containers use is made of organic materials and thesecriteriamust be enforced. Based on explanation by Adiguzel and Floros (2019), it could be concluded that the phase by phase implementation is the best to fit a proper green eco-friendly transformation for a warehouse on resource utilization. Labor and productivity utilization should be started first and once the measures shows good indicator points, the equipment utilization should then be implemented before finally the space utilization.

Raw material use / Operate using	Petroleum	Organic Materials	No Raw Material
High Voltage Electricity	-Engine uses	-Solar power generated engine uses	-Heating process
	- Usually for domestic purposes	-Usually require high maintenance cost	-Freezing process
			-Require motor uses
Low Voltage Electricity	- Limited/short perod operations using small engine	- Organic fuel for small engine.	- Limited/short period operations on engine use
Battery Powered	Not Applicable	Not Applicable	-Mobile equipment
Living Creatures	Not Applicable	-Human workers -Animals	Not Applicable
Natural Setting	Not Applicable	-Wind -Water flows	Not Applicable

Table 3.1 : Co-Exist Dimension of Equipment

3.3 Measuring Performance of Eco-Friendly Warehouse from Financial Outcome.

Financial benefit of eco-friendly warehouse can be measure through Life Cycle Assessment (LCA) and Life Cycle Cost (LCC). LCA has provided appropriate framework warehouse systems environment performance over its expected lifespan. LCC is complementary of LCA, to measuring the financial return of the project (Fouche & Crawford, 2017). Green warehouse offers several of financial benefits, these include tax abatement, cost savings on utility bills through energy and water efficiency, lower construction costs, higher property value, increased productivity and healthy environment for employees (Ashuri & Durmus-Pedini, 2010). Major financial benefits of green warehouse generally related to lower operational costs due to lower consumption of water and energy, lower maintenance costs, and increased productivity and healthier environment. Cost savings, cash incentives, and increased revenues were noted as economically influential factors in the success of green buildings (Abu-Hijleh & Jaheen, 2019). Green warehouse also presents prospects for incentives to offset any higher initial costs in by result in increased productivity and efficiency in the long-run. The green buildings can cover their expenses because of performance efficiency which translate into saving processes (Abu-Hijleh & Jaheen, 2019). Businesses could be losing out on their energy bills for of inefficient technology, equipment and procedures. At the same time, the eco-friendly design of the warehouse can increase employee productivity and occupant health and well-being, resulting in financial benefits for businesses. Besides saving energy, the warehouse can get financial benefit by reusing materials, which could reduce wastage and increase efficiency(Abu-Hijleh & Jaheen, 2019).

The eco-friendly warehouse could introduce a returnable packaging for their products. Through an efficient and simple system whereby customers can return packaging after receiving products, warehouse can has financial saving from lost on expensively packaging material by reusing it numerous times as opposed to losing the material with every delivery. The warehouse could use eco-friendly material that reusable like wood, cardboard and degradable plastic for packaging and in turn reduces the amount that needs to be purchased or produced.

The long-term financial benefits when adopting green environment, it can improve employee's productivity and motivation. Additionally, investing in programs to engage employees with the eco-friendly push to operational efficiency, which their mental and physical wellbeing will improve the chances of such a push succeeding. Creating the healthiest working environment is important to reaching optimum levels of employee productivity, performance and happiness (Ashuri & Durmus-Pedini, 2010)

Green technology of the warehouse will bring efficiency by reducing number of employees, wastage of resources, product damage and machinery. In the end, green technology could increase financial profitability have also been shown to have a positive effect on the environment makes eco-friendly warehouse a win-win situation for businesses. Adoption of green warehouse will improve productivity and reduce costs of businesses (Abu-Hijleh & Jaheen, 2019). Green building is the solution for many problems from local to global scale, from environment to finance and from community to industry (Ashuri & Durmus-Pedini, 2010). Financial outcome of eco-friendly warehouse will give benefit in the long-run through water and energy efficiency, reduce waste, increased employee productivity and motivation, lower operation cost and reduced employee health cost (Kats et al., 2003)

3.4 Measuring Performance of Eco-Friendly Warehouse from Responsive and Flexibility.

In the study by Rha (2010), he pointed out that environmental management is generally beneficial for environmental performance and some aspects of economic performance of the firm. His also found that implementing Green Supply Chain Management (GSCM) practices enable organizations to strengthen sales, profit, on-time delivery, and the customer service level.There are 3 hypotheses proven in his study for flexibility:

i) GSCM internal practice is positively related to supply chain flexibility.
ii) GSCM external practice is positively related to supply chain flexibility.
iii) GSCM eco design practice is positively related to supply chain flexibility.

Vickery et al. (1999) defined five supply chain flexibilities based on previous operations literature in order to look at supply chain uncertainty problems.

Flexibility Type	Description
Product flexibility	The ability to customize product to meetspecific customer demand
Volume flexibility	The ability to adjust capacity to meet changes in customer quantities
New product flexibility	The ability to launch new or revised products
Distribution flexibility	The ability to provide widespread access to products
Responsiveness flexibility	The ability to respond to target market needs

Table 3.2: Supply Chain Flexibilities
(Vickery et al., 1999)

Green logistics refers to providing environmentally friendly methods of traditional or forward logistics services, directed from the manufacturer to the final consumer. It covers packaging, reduction, recycling, remanufacturing, reusable packaging, air and noise emission reduction, environmental impact of mode selection, measuring the environmental impact and energy reduction. (Patricija Bajec and Danijela Tuljak-Suban, n.d.)

The adoption of internal environmental management is the key to bringing better economic performance. The successful adoption of GSCM practices by a company depends on the intraorganizational environmental management. In this perspective, (Geng, Mansouri, & Aktas, 2017) conclude that high levels of intraorganizational environment practices could improve flexibility and tend to enhance economic performance.

A better transportation approach for manufacturing company is necessary to reach the destination in a timely manner. Joint route planning can be achieved by outsourcing transportation function. The manufacturing firms contract with third parties to provide transportation services to remain focus on production and sustainability goals. A smart transportation management system required to meet delivery requirements. This model includes smart infrastructure, smart vehicle, and smart freight as well (Stindt, 2017).

Transportation flexibility is also important. Rubber Moulds Ltd, for example, use haulage firms to deliver small volume jobs to costly remote locations, leaving their own fleet to deliver full loads to more convenient locations. It follows that manufacturing and service operations both have important roles to play in creating supply chain flexibility. (Stevenson & Spring, 2009)

4. Hypotheses Development & Conceptual Framework

Referring to the literature review, most of the elements in evaluating the performance of warehouse is based on the quality of the warehouse itself. There is not much study conducted to list down some measurements that can be used to evaluate the performance of the warehouse towards green eco-friendly warehouse.The proposed conceptual framework in this study suggesting some measurement that can be measured to evaluate the warehouse towards green eco-friendly warehouse. Below are some possible hypotheses that can be obtained from the proposed framework: -

H1: There is a significant relationship between accuracy of the warehouse performance towards green eco-friendly warehouse towards supply chain efficiency.

H2: There is a significant relationship between resource utilization of the warehouse with green eco-friendly warehouse towards supply chain efficiency.

H3: There is a significant relationship between financial outcome of the warehouse towards the green eco-friendly warehouse towards supply chain efficiency.

H4 There is a significant relationship between the responsiveness and flexibility of the warehouse towards green eco-friendly warehouse towards supply chain efficiency.
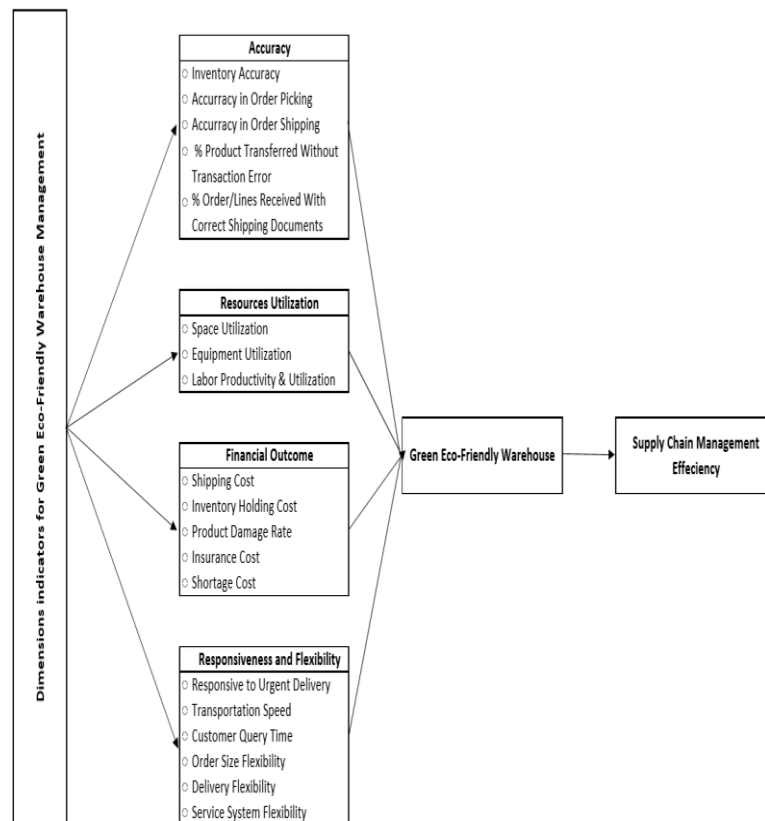
Figure 4.1 Conceptual Framework

5. Research Methodology

This paper is developed by using secondary data mainly from extensive review on literature reviews of articles, books and official release documents. The papers were selected based on some criteria which is warehouse measurement, green warehouse, eco-friendly warehouse and criteria in measuring warehouse performance. Online database such as Science Direct, Scopus, SpringerLink and Wiley Online Library is used to obtain those related articles.

This paper can be develop further using the conceptual framework by running a test on the hypotheses. To test the hypotheses, further study will require quantitative analysis. Researcher can use descriptive analysis to develop by gathering, analyzing and presenting future data collection. It is suggested, for the further study researchers can use correlational where researcher will know the exact relationship between the dependent variable and independent variables. Since this study require less involvement of researcher inference, non-contrived setting can be considered.

6. Limitation

Below are some of the limitation for this study: -
i. This study is a conceptual study, so there is no further test to confirm on the hypotheses.
ii. The theoretical framework is developed from previous study done by (Laosirihongthong et.al, 2018) but some of the measurement is not suitable to measure the performance of warehouse towards eco-friendly operation.

7. Discussion & Conclusion

This study has highlighted that the green eco-friendly warehouse is a way to improve supply chain efficiency sustainable of the ecosystem. This study provided a theoretical framework of measurement that can be used to evaluate the performance of the warehouse in implementing green eco-friendly operation which lead to supply chain management efficiency. In this paper, it emphasized of how selected elements such as operation accuracy, resource utilization, financially, responsive and flexibility in terms of conceptual study is more efficient compared to non-eco-friendly warehouse.For further improvement of this study, other researcher

can conduct a test for confirmation element on the hypothesis. Besides that, to make this study to be more reliable and accurate, the researcher can use primary data to complement the secondary data.It is safe to say the eco-friendly warehouse is the future for theindustries of supply chain. In conclusion, the theoretical framework of this study can be use as a basis for warehouse operation to measure gap analysis before fully implementing their warehouse towards sustainable operation.

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