Advance Journal of Food Science and Technology 13(1): 29-32, 2017
DOI:10.19026/ajfst.13.3414
ISSN: 2042-4868; e-ISSN: 2042-4876
© 2017 Maxwell Scientific Publication Corp.
Submitted: May 29, 2016 Accepted: July 18, 2016 Published: January 25, 2017

Research Article

Performance Evaluation on Green Cold Chain for Agricultural Products

Na Liu and Min Zhou
College of Management, Shanghai University of Engineering Science, Shanghai 201620, China

Abstract: To more precisely evaluate the performance of green cold chain for agricultural products, this study presents an evaluation system which allows a cold chain logistics enterprise be evaluated in its financial, operational and environmental aspects. As the quality of agricultural products is definitely important, developing green cold chain for agricultural products becomes one main concern in logistics industry. Based on these affecting factors of the evaluation system, suggestions can be raised to the logistics enterprise for improving its performance on green cold chains.

Keywords: Agricultural products, green cold chain, logistics enterprise, performance evaluation

INTRODUCTION

As social progresses and life quality improves, the demands on fresh agricultural products (including fruits, vegetables, meat, poultry, fish, eggs, etc.) are increasing, which brings cold chain logistics enterprises many opportunities and challenges. Cold chain is used to guarantee the freshness and safety of agricultural products (Flick *et al*., 2012). Based on reports from the International Institute of Refrigeration (IIR) (2002), without cold chain, 25-30% of global agricultural production is lost or wasted.

In principal, a cold chain is a temperature-controlled supply chain in which storage and distribution activities are under low temperatures (China Logistics Information Standardization Committee, 2006). A typical cold chain for agricultural products, as Fig. 1 shows, is designed to extend and ensure the shelf life of agricultural products by maintaining a low-temperature environment to protect the agricultural products in all logistics activities including processing, distribution, transportation, warehousing and others (Xu and Zhou, 2014). Losses of agricultural products can thus be reduced in these logistics activities.

Meanwhile, as economy continues, human beings have caused many negative effects on environments, causing many crises such as energy crisis, resource depletion and erratic weather (Rath, 2013). In order to eliminate the conflicts between resources and environments, the greening has emerged throughout the society; more and more governments, organizations, enterprises and individuals are involved in activities in protecting environments.

Cold chains are also responsible for an enormous amount of energy use, resource consumption and greenhouse gas emissions. Under this situation, green cold chain has been proposed for protecting environments and saving energies. Green supply chain and its practices have attracted much attention in the logistics community and logistics enterprises (Sarkis *et al*., 2011). Various means have been successfully developed for helping logistics enterprises apply green supply chains in their business activities.

In this study, we build a system for evaluating green cold chains for agricultural products, which contains an evaluation model covering the important indicators in the financial, operational indicators aspects. Furthermore, the system also takes account of several environmental indicators for checking whether a cold chain has negative impacts on environments. Based on the evaluation results, suggestions can be raised to the enterprise for improving its performance on green cold chains.

MATERIALS AND METHODS

When and where this study was conduct*: January to March, 2016. Shanghai, China.

A green cold chain for agricultural products is more complicated than a usual logistics chain: The purpose of green cold chain for agricultural products is to guarantee the high quality of agricultural products (e.g., they are not perished when delivered to customers) and thus low-temperatures must be maintained during the whole logistics process. Besides, the cold chain must reduce its

Corresponding Author: Na Liu, College of Management, Shanghai University of Engineering Science, Shanghai 201620, China
This work is licensed under a Creative Commons Attribution 4.0 International License(URL: http://creativecommons.org/licenses/by/4.0/).

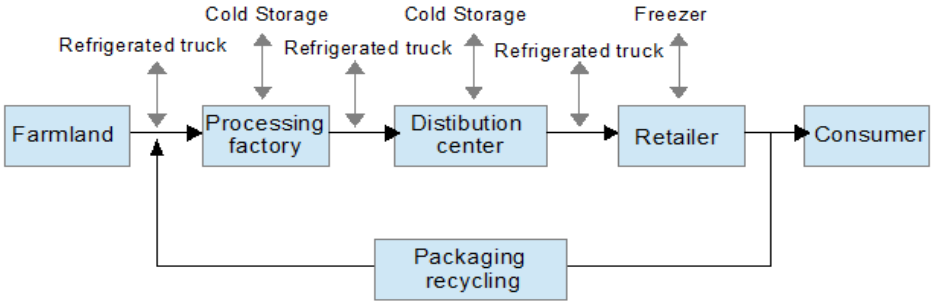

Fig. 1: Framework of cold chains for agricultural products

impacts on the environment. For evaluating the performance of a cold chain enterprise, we design a model containing the indicators in the financial, operational and environmental aspects.

Financial indicators: The final goal of an enterprise is to maximize its profits. Thus it is believed that the financial indicators are quite important for evaluating the performance of a cold chain enterprise. Certainly, a cold chain logistics enterprise for agricultural products also needs to maximize its economic profits through organizing and coordinating its business activities. As explained in the introduction part, a cold chain logistics system for agricultural products incurs higher cost than some general logistics systems, because refrigerated trucks, cold storage and other specific facilities and equipment need to be continuously invested. Thus, financial indicators, such as profit growth rate, return on assets, asset-liability ratio, etc. can be taken to evaluate a cold chain logistics enterprise for agricultural products.

Profit growth rate shows the financial state of a cold chain logistics enterprise: a high growth rate denotes that the logistics enterprise has good business performance and strong market competitiveness. Correspondingly, a low or even negative growth rate indicates that the enterprise is poorly managed.

Return on assets measures the profitability of a cold chain logistics enterprise. It is usually defined as, for an enterprise, its total profit divided by its total asset. It exhibits the capability of the enterprise to leverage its asset to make profit. The higher the indicator is, the stronger profitability the enterprise is.

Asset-liability ratio shows the percentage of an enterprise's asset that is financed by creditor(s), that is, the total liability divided by the total asset. A logistics enterprise with high asset-liability ratio can be danger if its creditor(s) require repayment of debt. The lower the ration is, the better the enterprise is in a long-term solvency.

Asset turnover is defined as the operating income divided by the total asset. This indicator is important for evaluating the efficiency of the asset of an enterprise: The higher the indicator is, the more efficient the asset is used and the higher the income is.

Operational indicators: Operational factors cannot be ignored for maintaining the operation of a cold chain for agricultural products. Fresh agricultural products are sensitive to time and temperature, requiring all participants of a cold chain to coordinate tightly and be organized efficiently. Therefore, the operational indicators for evaluating a green cold chain for agricultural products contain not only those for the usual logistics chains with normal temperature (e.g., the order fill rate, inventory turnover rate, etc.), but also those specifically designed for cold chains, such as cold storage utilization, refrigerated trucks utilization, the agricultural product loss rate and so on.

Order completion rate is a percentage of completed orders to the total orders. A logistics enterprise for agriculture products needs to keep this rate as high as possible to avoid delay in marketing of agricultural products.

Customer satisfaction rate measures how services provided by an enterprise meets the customers' expectation. Only when the customers are satisfied with the services, the logistics enterprise can deliver further services to them. The indicator is usually obtained by gathering feedback (e.g., questionnaires, surveys) from customers.

Refrigerated truck utilization is to evaluate the capability of logistics management of agricultural products. This indicator can be counted by the loaded volumes and weights of refrigerated trucks. The higher the indicator is, the higher operational level a cold chain logistics enterprise is at.

Cold storage utilization can be measured by a volumetric ratio of cold storage, i.e., during a certain period, the used cold storage divided by the whole cold storage. Cold storage is an important infrastructure for operating a green cold chain for agricultural products. A high value indicates that the logistics enterprise can effectively manage its cold storage for agricultural products.

Table 1: Indicators for performance evaluation

Targets	First-level indicators	Second-level indicators
Performance evaluation of green cold chain for agricultural products A	Financial indicators A1	Profit growth rate A11
		Return on assets A12
		Asset-liability ratio A13
		Asset turnover A14
	Operational indicators A2	Order completion rateA21
		Customer satisfaction A22
		Refrigerated truck utilization A23
		Cold storage utilization A24
		Inventory turnover A25
		Agricultural product loss rate A26
	Environmental indicators A3	Environmental accident rate A31
		Investment in environmental protection A32
		Packaging recycling rate A33
		Energy consumption rate A34

Inventory turnover is usually calculated as the cost of goods sold divided by the average inventory. It evaluates the circulation speed of agricultural products in cold storage. That is, inventory turnover can also be calculated as, for an amount of agricultural products, the stored time in cold storage divided by their lifecycle (Hu, 2010). The lower the turnover rate is, the higher operational efficiency the logistics enterprise is of and the longer the circulation of the agricultural products is.

Agricultural product loss rate also manifests the management capabilities of a logistics enterprise. It is calculated as the losses of agricultural products divided by the total agricultural products.

Environmental indicators: A logistics enterprise must take responsible to the environment when making a profit. It needs to save energies and reduce environmental pollutions. Furthermore, the cold chain logistics enterprise for agricultural products also needs to reduce wasted gas and noise that can harm the environment.

The environmental indicators for evaluating the responsibility of a logistics enterprise include environmental accident rate, investment in environmental protection and so on.

Environmental accident rate corresponds to the frequency of an enterprise in making environmental accidents. It is calculated as the number of environmental accidents divided by the operating income. The higher the rate is, the more negative impacts the enterprise has on the environment.

Investment in environmental protection is defined as investment on environment divided by the total income. A high value indicates that the enterprise pays much attention on environmental protection.

Package recycling rate exhibits the recycle capability of a cold chain logistics enterprise for agriculture products. It is calculated as the number of recycled packages divided by the number of total recyclable packages during a certain period (Hu, 2010). The higher the value, the higher the utilization of packages and the less the negative impact on the environment.

Energy consumption rate shows the percentage of energy a logistics enterprise consumes to its total income. The higher the rate is, the more energy per unit of income consumes, the lower the environmental performance is.

The whole index system is given in Table 1, which includes financial, operational and environmental indicators. The abovementioned indicators can help analyze the bottlenecks of a logistics enterprise in conducting green cold chains. Furthermore, the effectiveness of these indicators can be evaluated by the AHP (Analytic Hierarchy Process) and some fuzzy comprehensive evaluation approaches, which will be explored in our future work. After evaluated, a logistics enterprise can also be given more recommendations about how to optimize its cold chains such that its performance can be improved and the resource usage decreased.

RESULTS AND DISCUSSION

On the basis of the financial, operational and environmental indicators for evaluating performance of cold chain logistics enterprises, we provide enterprises suggestions for improving their green cold chains for agricultural products.

Financial aspect:

Making new policies and regulations: The governments need to provide concessional policies to encourage logistics enterprises to implement green cold chain, such as financial subsidies, tax preference and so on, so that the cost of logistics enterprises could be reduced (Xu, 2012). Also, the governments need to make new regulations for green cold chain, for examples, requiring cold chain logistics industry to develop market-accessing criteria and designing industrial standards. With these new policies and regulations, logistics enterprises will improve their competitiveness and profits.

Operational aspect:

Building a complete green cold chain: A complete green cold chain for agricultural products can contain

many green activities including green transportation, green packaging and green processing (Ren, 2013).

Green transportation: During transportation, a cold chain logistics enterprise needs to maintain the quality of agricultural products and reduce their losses through taking multiple product preservation techniques. The enterprises can also plan transportation routes and distribution network for improving the efficiency of transportation. In addition, new vehicles can be used for reducing waste emissions; joint distribution can be taken to reduce pollutions, refrain from traffic congestion and reduce vehicle idling rate, etc.

Green packaging: Packaging agricultural products shall conform to the 4R requirements, i.e., reduction, reuse, reclaim and recycle.

Green processing: Green processing agricultural products is an idea of minimizing cost and reducing pollution through simplifying processing steps, e.g., using biodegradable packaging materials, reducing disposable packages through using simple packaging designs, reusing packaging materials, changing distributed processing activities to a centralized processing activity for enhancing resource utilization and reducing pollutions to environments.

Developing advanced information techniques for cold chains: An information infrastructure for agricultural products can be built, allowing resources to be open to access by cold chain logistics enterprises (Liu, 2014).Furthermore, to develop green cold chain for agricultural products, it is necessary to develop a variety of supporting information techniques, such as radio frequency technology (RFID), Global Positioning System (GPS), Geographic Information Systems (GIS), Electronic Data Interchange (EDI) systems, etc.. Using these new techniques and systems allows a logistics enterprise to monitor a cold chain for agricultural products such that the products can be easy to track, the quality and safety of agricultural products can be easy to keep and the product deterioration can be easy to monitor. It further reduces losses during logistics.

Environmental aspect:

Exhibiting green images: The cold chain logistics enterprises for agricultural products need to exhibit green images showing that they are environment-friendly enterprises (Wang and Zhao, 2014). Logistics enterprises should hold the idea of green, sustainable development, making full use of recycling materials, maximizing resource utilization in cold chain and reducing environmental pollution. This enables logistics enterprises to adapt their cold chain to a global trend of green development and also helps them obtain the trustworthiness from customers.

CONCLUSION

This study presents a performance evaluation system that evaluates the performance of cold chain logistics enterprises for agricultural products in the financial, operational and environmental aspects. Based on these affecting factors of the evaluation system, this study provides the logistics enterprises with suggestions on adapting their cold chains to green ones.

REFERENCES

China Logistics Information Standardization Committee, 2006. National Standard of "Logistics Term" (GB/T 18354-2006). Retrieved from: http://www.moc.gov.cn/zhuantizhuanlan/gonglujiaotong/shoufeigongluzmk/zhengcefagui/201508/t20150 81 4_1863913.html.

Flick, D., H.M. Hoang, G. Alvarez and O. Lagurerre, 2012. Combined deterministic and stochastic approaches for modeling the evolution of food products along the cold chain. Part I: Methodology. Int. J. Refrig., 35(4): 907-914.

Hu, X., 2010. Research on performance measurement of food cold chain logistics enterprise on green supply chain. M.A. Thesis, Chongqing University, China.

International Institute of Refrigeration (IIR), 2002. Report on refrigeration sector achievements and challenges. WSSD Report, IIR, September 2002, Institut International Du Froid, Paris, France.

Liu, Y.H., 2014. Study on development of agricultural produce green logistics in Henan: An SWOT analysis. Logist. Technol., 3: 44-46.

Rath, R.C., 2013. An impact of green marketing on practices of supply chain management in Asia: Emerging economic opportunities and challenges. Int. J. Supply Chain Manage., 2(1): 78-86.

Ren, Y.H., 2013. Development strategy of green logisitics of agricultural products in Henan province. M.A. Thesis, Henan Normal University.

Sarkis, J., Q. Zhu and K.H. Lai, 2011. An organizational theoretic review of green supply chain management literature. Int. J. Prod. Econ., 130(1): 1-15.

Wang, Z.W. and F.N. Zhao, 2014. Research on green logistics for agricultural products cold chain in Hunan province. Logist. Eng. Manage., 36(3): 142-145.

Xu, H.L., 2012. The discussion summary of the foreign agricultural products green logistics development. China Bus. Market, 1: 27-32.

Xu, L.Y. and Y.X. Zhou, 2014. Jiangsu agricultural cold chain logistics mode study. Logist. Sci-Tech., 3: 114-117.