2018

May – Aug

CHIANG MAI UNIVERSITY JOURNAL OF ECONOMICS

FACULTY OF ECONOMICS – CMU

22#2

CHIANG MAI UNIVERSITY JOURNAL OF ECONOMICS
Vol.22 No.2
May – August 2018
วารสารเศรษฐศาสตร์ มหาวิทยาลัยเชียงใหม่
ปีที่ 22 ฉบับที่ 2
พฤษภาคม–สิงหาคม 2561

ISSN(Print)-0859-8479

สารบัญ

CHIANG MAI UNIVERSITY JOURNAL OF ECONOMICS
– Volume 22, Issue 2

Research articles บทความวิจัย

Green Efficiency Analysis of Longan Supply Chains: A Two-Stage DEA Approach **1-----**
Chanita Panmanee , Roengchai Tansuchat and Pacharaporn Arkornsakul

Applications Generalized Maximum Entropy Estimators to the Factors Influencing to Determinants of Province Minimum Wage in Thailand: A Case Study **11-----**
การประยุกต์ใช้วิธีการประมาณค่าเอนโทรปีสูงสุดสำหรับแบบจำลองเชิงเส้นกับปัจจัยที่มีอิทธิพลต่อการกำหนดค่าจ้างขั้นต่ำระดับจังหวัดของประเทศไทย: กรณีตัวอย่าง
Pramote Boontunjeen , Kittawit Autchariyapanitkul and Kantaporn Chuangchid
ปราโมทย์ บุญตันจีน กฤตวิทย์ อัจฉริยะพานิชกุล และ กันตพร ช่วงชิด

Regime-switching Cointegration and Error Correction Modelling for the Rubber Prices in Thailand and TOCOM Market **31-----**
ความสัมพันธ์ในระยะสั้นและระยะยาวของราคายางพาราในประเทศไทยและตลาด TOCOM โดยแบบจำลอง Regime-switching Cointegration
Supanika Leurcharusmee and Kannika Duangnate
สุพรรณิกา ลือชารัศมี และกรรณิการ์ ดวงเนตร

Business Cycle with Structural Changes in ASEAN-5 **49-----**
วัฏจักรเศรษฐกิจเชิงการปรับโครงสร้างในกลุ่มประเทศอาเซียน-5
Paravee Maneejuk and Woraphon Yamaka
ภารวี มณีจักร และ วรพล ยะมะกะ

Academic article บทความวิชาการ

A Review Paper on Visible and Invisible Underemployment **83-----**
Akkaya Senkrua

Green Efficiency Analysis of Longan Supply Chains: A Two-Stage DEA Approach

Chanita Panmanee[1], Roengchai Tansuchat[2] and Pacharaporn Arkornsakul[3]
Faculty of Economics, Maejo University, Thailand
Faculty of Economics, Chiang Mai University, Thailand
Faculty of Management Sciences, Chiang Mai Rajabhat University, Thailand
E-mail: golffychicha@gmail.com

Received April 06, 2018
Revised July 05, 2018
Accepted July 09, 2018

Abstract

The environmental and social concerns in managing agribusiness are increasing in Thailand. Green supply chain management (GSCM) is becoming more significant tool to improve performance of the process and products according to the environmentally friendly regulations. However, there is a question associating with how to evaluate the green performance of supply chain. This paper applies two-stage DEA model for measuring the network performance of the growers and processors in longan supply chains. The major result represents that the high level of economic efficiency of longan supply chains does not ensure the high score of green performance efficiency. The finding of this research leads to the policy making of the government agencies in promoting the green supply chain of longan to create value added of products and enhance competitiveness, as well as encourage the environmental awareness of the growers and processors.

Keywords: Longan supply chains, green supply chain management, green efficiency, two-stage DEA
JEL Classification Codes: C14, D22, Q50

[1]Assistant Professor, Faculty of Economics, Maejo University, 63 Sansai-Phrao Road, Nongharn, Sansai District, Chiang Mai, 50290 Thailand. Corresponding author: golffychicha@gmail.com.
[2]Associate Professor, Faculty of Economics, Chiang Mai University, 239 Huay Kaew Road, Suthep, Muang, Chiang Mai, 50200 Thailand.
[3]Lecturer, Faculty of Management Sciences, Chiang Mai Rajabhat University, 202 Chang Puak Road, Tambon Chang Puak , Maung, Chiangmai, 50300 Thailand.

1. Introduction

Longan is the crucial economic fruit in the northern region of Thailand. It has been creating the occupation and income of the people in the local areas. Currently, longan yields are distributed to three main purposes including for consumption in domestic market, for consumption in international market, and for using as the input in other product processing. The transferring of fresh longan products from the growers to the consumers has to pass many involved parties such as local merchants, middlemen, wholesalers, retailers, exporters, processing manufacturers, etc. Consequently, the longan supply chains consist of the different actors depending on the aims of selling. These bring about the different supply chain management for achieving the competitiveness in the markets.

Considering the market trend in the present, the demand of green quality goods and services are rising because of the continuously increasing awareness of environmental friendly issues. Many organizations attempt to improve their products for supporting environmental concerns. What is the meaning of environmental friendly? It associates with safety of food and drink, healthy ecosystems, non-toxic, proper and safe waste management, and the restoration of contaminated areas (Council on Environmental Quality, 1996; Beamon, 1999). Upward trends of green food consumption and competition bring about integration between firms and their relevant agencies in supply chain to lower costs and better serve consumers. Thus, the focal firm has to deal with their suppliers and consumers to meet and even exceed the environmental expectations of them (Walton, et al., 1998). For addressing these situations, relevant parties in longan supply chain have been improved their performance to fulfill the consumer requirements by using green supply chain management (GSCM).

GSCM is used for managing the operations of supply chain and creating the added value of products to response demand of consumers who pay attention to their health and concern for the environment (Sarkis, 2003; Rao and Holt, 2005; Srivastava, 2007). GSCM concept stresses on the environmentally friendly systems in the production, marketing and transportation to reduce impacts on natural resources and environment such as clean energy use, renewable resource use, reduction of chemical use, etc. There were many researchers applied the green concept in their works, such as Zhu and Sarkis (2004), Azevedo et al. (2011) and Chan et al. (2012).

However, nowadays, the green performance efficiency of longan supply chain implementing GSCM concept are separately evaluated in each node. The performance efficiency of the growers, the buyers, and other stakeholders are independent considerations. In fact, the operation of one node in supply chain influences on the other nodes like the network effects. The individual performance analyses are not appropriate for evaluating the supply chain performance. Thus, this research applies the two-stage DEA model for analyzing network efficiency of longan supply chain under GSCM orientation by focusing the growers and buyers relationship known as "grower – buyer supply chain model".

The rests of this paper are structured as follows. Section 2 displays literature reviews. Section 3 presents methodology used in this paper, section 4 represents the empirical results, and section 5 discusses and summarizes the study's findings.

2. Literature Review

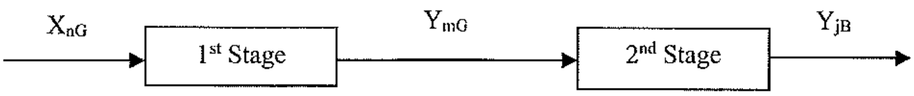
2.1 The Green Supply Chain Management

Green supply chain management (GSCM) is a tool taking into account the environmental impacts for improving images of organizations, increasing their profit, and enhancing their competitiveness (Sarkis, 2003; Rao and Holt, 2005; Srivastava, 2007). The GSCM consists of green design involving in the products design of that have the least impinge on environment over the product life cycle (Sarkis, 1998; Walton et al., 1998; Hervani et al., 2005; Zhu et al., 2007; Eltayeba et al., 2011; Ying and Zhou, 2012); green purchasing involving in environmentally-conscious practices in the procurement of factors or intermediate products including reducing resources, eliminating waste, recycling and reuse, decreasing non-contaminant, and substituting materials without affecting material property (Walton et al.,1998; Min and Galle, 2001; Zsidisin and Siferd, 2001; Hervani et al., 2005; Chen, 2012; Ying and Zhou, 2012) ; green production and processing dealing with the green technology used in production focusing on resource efficiency and waste reduction for environmental benefit, and production capability development such as reduced, reused, reproduced, and recycled components to maximize the value gain (Ying and Zhou, 2012; Dües et al., 2013); green logistics regarding transportation, inventory, and warehouse with minimizing on cost, loss, and greenhouse gas emission (Andic, 2012; Ying and Zhou, 2012); and green recycle (Ying and Zhou, 2012); and green waste management (Andic, 2012). Thus, the GSC concept used in this paper focuses on green production, green waste management, and green logistics.

2.2 Two-Stage DEA Model

Data Envelopment Analysis (DEA) is used for evaluating the efficiency of decision making units (DMUs) by comparing with the reference DMU. In general, the DEA approach is often used to measure the performance of one-stage of DMU, putting one set of inputs and obtaining one set of outputs. However, the structures of some DMUs may be two or more stages. The outputs of the first stage are used as the inputs in the second stage, for example, the seller-buyer supply chain, the distributer-retailer supply chain, the supplier-manufacturer supply chain, etc. (Chen et al., 2009, Chaowarat and Shi, 2013). Thus, the efficiency analysis of these DMUs which have two-stage structure has to use the two-stage DEA model as known as network DEA model.

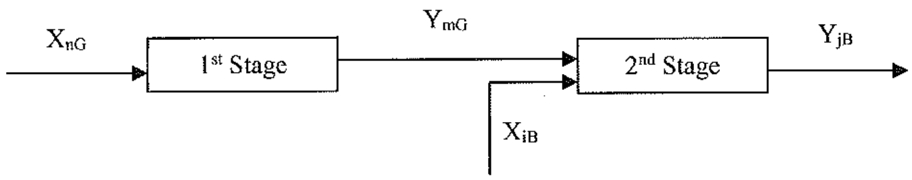
The structures of two-stage DEA are represented in two models (Li et al., 2012) comprising directly two-stage supply chain model and two-stage supply chain model adding inputs in the second stage. In the first model, the outputs from the first stage are generally used as all of inputs of the second stage shown in Figure 1 (Kao and Hwang, 2008 and Liang et al., 2008).



Source: Adapted from Kao and Hwang (2008) and Liang et al. (2008).

Figure 1. Two-stage supply chain

For the second model, the outputs from the first stage are used as the inputs of the second stage, as well as added the other inputs displayed in Figure 2.



Source: Adapted from Liang et al. (2006).

Figure 2. Two-stage supply chain adding inputs in the second stage

Considering the two-stage supply chain model shown in Figure 1, suppose there are n decision making units; DMU_j ($j = 1,2,...,n$). In the first stage, each DMU consumes m inputs; x_{ij} $(i = 1,2,...,m)$ to produce D outputs; z_{dj} $(d = 1,2,...,D)$. These D outputs from the prior stage become the inputs to the second stage as called intermediate measures. The outputs from the later stage are y_{rj} $(r = 1,2,...,s)$.

In case of the non-cooperative model , the efficiency scores in the first stage are calculated by using CCR model (Charnes et al., 1978) as follows:

$$
\begin{aligned}
Max\ \theta_j^1 &= \sum_{d=1}^{D} w_d z_{do} \\
\text{s.t.} \quad & \sum_{d=1}^{D} w_d z_{dj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \quad , j = 1,2,...,n \\
& \sum_{i=1}^{m} v_i x_{io} = 1 \\
& w_d, v_i, q_h, u_r \ge 0
\end{aligned}
\tag{1}
$$

In terms of the second stage, the efficiency scores are evaluated by assuming that the efficiency scores of the first stage are constant (Li et al., 2012) shown as Eq. (2).

$$
Max\ \theta_j^2 = \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{d=1}^{D} w_d z_{do} + \sum_{h=1}^{H} q_h x_{ho}^2}
$$

$$
\begin{aligned}
\text{s.t.} \quad & \frac{\sum_{d=1}^{D} w_d z_{dj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1 \quad , j = 1,2,...,n \\
& \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{d=1}^{D} w_d z_{dj} + \sum_{h=1}^{H} q_h x_{hj}^2} \le 1 \quad , j = 1,2,...,n
\end{aligned}
\tag{2}
$$

$$\frac{\sum_{d=1}^{D} w_d z_{do}}{\sum_{i=1}^{m} v_i x_{io}} = \theta_j^1 \quad , \ \theta_j^1 \in \left[0, \ \max \theta_j^1\right]$$

$$w_d, v_i, q_h, u_r \ \geq \ 0$$

Eq. (2) shows that the efficiency scores of the second stage are based on the first stage efficiency, θ_j^1. The Eq. (2) can be rewrote as:

$$\begin{aligned} Max \ \theta_j^2 &= \sum_{r=1}^{s} u_r y_{ro} \\ \text{s.t.} \ & \sum_{d=1}^{D} w_d z_{dj} - \sum_{i=1}^{m} v_i x_{ij} \ \leq \ 0 \quad , j = 1,2,...,n \\ & \sum_{r=1}^{s} u_r y_{rj} - \sum_{h=1}^{H} q_h x_{hj}^2 - \sum_{d=1}^{D} w_d z_{dj} \ \leq \ 0 \ , j = 1,2,...,n \\ & \sum_{h=1}^{H} q_h x_{ho}^2 + \sum_{d=1}^{D} w_d z_{do} \ = \ 1 \\ & \sum_{d=1}^{D} w_d z_{do} - \theta_j^1 \cdot \sum_{i=1}^{m} v_i x_{io} \ = \ 0 \\ & w_d, v_i, q_h, u_r \ \geq \ 0 \end{aligned} \tag{3}$$

where θ_j^2 represents the efficiency scores in the second stage. Moreover, the overall efficiency are defined from $\theta_j^{non} = \theta_j^1 \cdot \theta_j^2$.

3. Methodology

3.1 Sample selection

The samples in this research are separated in two main groups consisting of the grower group such as longan growers in Chiang Mai, Lamphun and Chiang Rai provinces, and the buyers group including golden dried longan entrepreneurs, dried whole longan fruit entrepreneurs, and other processed longan entrepreneurs. The 200 samples in the first group are selected by quota sampling and multi – stage random sampling methods and using database from the Office of Agricultural Extension and Development of Thailand. In terms of the last group, this research employs the snowball sampling method for linking the relevant samples in the longan supply chains and set the quota of each sub-groups of buyers around 30 samples, namely, 10 golden dried longan entrepreneurs, 10 dried whole longan fruit entrepreneurs, and 10 other processed longan entrepreneurs.

3.2 Research Methods

To address the purpose of green efficiency analysis of longan supply chain performance, two-stage DEA model is applied for evaluating the network efficiency between the growers and three types of buyers. Thus, there are three categories of longan supply chains such as golden dried longan supply chain, dried whole longan fruit supply chain, and other processed longan supply chain. In this paper, traditional supply chain with lean management, and green supply chain with GSCM are calculated for comparing the different efficiency score among them. The inputs and outputs for these models are expressed in Table 1 and the model used, grower-buyer model of longan supply chain, is shown in Figure 3.

Table 1. Inputs and outputs for grower-buyer model of longan supply chain

Dimension	Traditional supply chain (Economic Orientation)		Green supply chain (Environmental Orientation)	
Inputs of growers (Inputs of 1st stage)	GTI1:	Production cost of growers	GGI1:	Green production cost of growers
	GTI2:	Post-harvest cost of growers	GGI2:	Green post-harvest cost of growers
	GTI3:	Logistics cost of growers	GGI3:	Green logistics cost of growers
Outputs of growers (Intermediate measures)	GTO1:	Pollution/waste reduction	GGO1:	Pollution/waste reduction
	GTO2:	Product safety	GGO2:	Product safety
	GTO3:	Selling price	GGO3:	Selling price
	GTO4:	Cost saving	GGO4:	Cost saving
Inputs of buyers (Other Inputs of 2nd stage)	BTI1:	Design cost of buyers	BGI1:	Green design cost of buyers
	BTI2:	Logistics cost of buyers	BGI2:	Green logistics cost of buyers
	BTI3:	Consumption cost of buyers	BGI3:	Green consumption cost of buyers
Outputs of buyers (Outputs of 2nd stage)	BTO1:	Added value of products	BGO1:	Added value of products
	BTO2:	Cost saving	BGO2:	Cost saving
	BTO3:	Satisfaction of products	BGO3:	Satisfaction of products

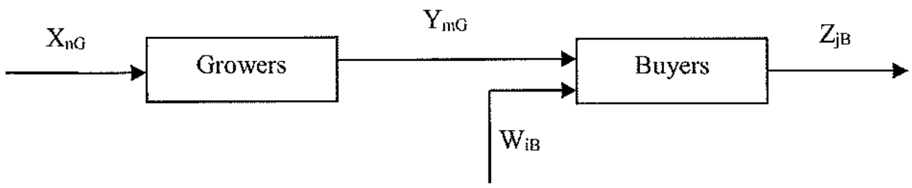


Figure 3. Grower-buyer model of longan supply chain

4. Result

In this paper, the datasets for the growers' inputs X, the intermediate products Y, the buyer's inputs W and the final outputs Z are generated using 10 fresh longan retailers, 10 golden dried longan entrepreneurs, and 10 longan with peels entrepreneurs who use longan yields of the growers as the raw material for processing to further products. Consequently, there are three longan supply chains for analyzing. The results obtained from the model are presented in Table 2 – 4.

In the model (1)-(10) of each supply chain, if the efficiency score of two-stage supply chain is equal to 1 ($\theta_{sc} = 1$), then both θ_g and θ_b are equal to 1 ($\theta_g = 1$ and $\theta_b = 1$). It shows that the DMUs can reach the maximum output using no more than the observed amount of any input. Conversely, if the efficiency score θ_{sc} is lower than 1 ($\theta_{sc} < 1$), then at least one of θ_g or θ_b is lower than 1 ($\theta_g < 1$ or $\theta_b < 1$). Thus, the DMUs can increase their output using the same amount of input. In other words, the DMUs remain inefficient. In Table 2, both the growers and the buyers for the eighth DMU (SC1_8) have the efficiency score of 1. This result indicates that both the growers and the buyers are efficient in both lean and green supply chain management.

Table 2. The green efficiency of golden dried longan supply chain by using two-stage DEA

DMUs	Traditional supply chain (Economic Orientation)			Green supply chain (Environmental Orientation)		
	θ_g^{T1}	θ_b^{T1}	θ_{sc}^{T1}	θ_g^{G1}	θ_b^{G1}	θ_{sc}^{G1}
SC1_1	0.78	0.75	0.59	0.90	0.81	0.73
SC1_2	**1.00**	**1.00**	**1.00**	0.92	**1.00**	0.92
SC1_3	0.81	0.83	0.67	0.89	0.91	0.81
SC1_4	0.92	**1.00**	0.92	**1.00**	**1.00**	**1.00**
SC1_5	0.67	0.85	0.57	0.75	0.88	0.66
SC1_6	0.84	0.95	0.80	0.91	0.80	0.73
SC1_7	**1.00**	0.98	0.98	0.88	0.92	0.81
SC1_8	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
SC1_9	0.88	0.85	0.75	0.94	0.90	0.85
SC1_10	0.97	**1.00**	0.97	0.82	**1.00**	0.82

Considering the green efficiency of dried whole longan fruit supply chain by using two-stage DEA represented in Table 3, the seventh DMU (SC2_7) have the efficiency score of 1 in the aspects of both growers and buyers. The findings also indicate that both the grower and the buyer are efficient in both lean and green supply chain management. In the same time, the fourth DMU (SC3_4) have the efficiency score of 1 in the aspects of both growers and buyer

Table 3. The green efficiency of dried whole longan fruit supply chain by using two-stage DEA

DMUs	Traditional supply chain (Economic Orientation)			Green supply chain (Environmental Orientation)		
	θ_g^{T2}	θ_b^{T2}	θ_{sc}^{T2}	θ_g^{G2}	θ_b^{G2}	θ_{sc}^{G2}
SC2_1	0.88	0.81	0.71	0.85	0.92	0.78
SC2_2	0.69	0.92	0.63	0.92	**1.00**	0.92
SC2_3	0.81	0.75	0.61	0.90	0.88	0.79
SC2_4	0.92	0.86	0.79	**1.00**	0.89	0.89
SC2_5	**1.00**	0.99	0.99	0.88	0.91	0.80
SC2_6	0.84	0.74	0.62	0.64	0.80	0.51
SC2_7	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
SC2_8	0.70	0.94	0.66	0.85	0.99	0.84
SC2_9	0.65	0.80	0.52	0.79	0.87	0.69
SC2_10	0.92	**1.00**	0.92	0.98	**1.00**	0.98

In views of comparing the efficiency scores between traditional supply chain with lean management, and green supply chain with GSCM, the results in Table 2-4 indicate that, the high economic efficiency scores of longan supply chains obtained from traditional model does not ensure the high green efficiency performance.

Moreover, the overall efficiency scores for three categories of supply chains are multiplied by using the efficiency scores of the supply chain's growers and buyers. Thus, if a supply chain is effective, both its growers and its buyers will be efficient. In this study, after separately measuring by member type, the findings reveal that the growers are the source of most of the inefficiency. Many of the growers have efficiency score of less than 1. There are 7 of 30 growers and 5 of 30 growers are inefficient under traditional supply chain and green supply chain perspectives, respectively. The results show that most of the buyers are efficient and thus well managed.

Table 4. The green efficiency of other processed longan supply chain by using two-stage DEA

DMUs	Traditional supply chain (Economic Orientation)			Green supply chain (Environmental Orientation)		
	θ_g^{T3}	θ_b^{T3}	θ_{sc}^{T3}	θ_g^{G3}	θ_b^{G3}	θ_{sc}^{G3}
SC3_1	0.69	0.81	0.56	0.89	0.79	0.70
SC3_2	0.88	0.89	0.78	0.81	0.92	0.75
SC3_3	0.92	0.72	0.66	0.99	0.87	0.86
SC3_4	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
SC3_5	0.79	0.84	0.66	0.75	0.92	0.69
SC3_6	0.82	0.92	0.75	0.82	0.88	0.72
SC3_7	0.95	0.73	0.69	0.99	0.89	0.88
SC3_8	**1.00**	**1.00**	**1.00**	0.92	**1.00**	0.92
SC3_9	0.87	0.91	0.79	0.89	0.50	0.45
SC3_10	0.82	**1.00**	0.82	0.90	**1.00**	0.90

5. Discussion and Conclusion

The environmental and social concerns in managing agribusiness are increasing in Thailand. Green supply chain management (GSCM) is becoming more significant tool to improve performance of the process and products according to the environmentally friendly regulations. However, there is the question associating with how to evaluate the green performance of supply chain. This paper applies two-stage DEA model for measuring the network performance of the growers and processors in longan supply chains. The major result represents that the high economic efficiency level of longan supply chains does not ensure the high level of green performance efficiency.

These results suggest that other factors, such as sizes of cultivating area and change of agricultural systems, may have influence on the growers' cultivating patterns and effect on performance efficiency. The small farms are easy to prevent chemical contamination. On the other hand, in the large cropping areas, the chemical control is difficult and the system changing has to invest highly. Consequently, the likelihood of using chemicals is larger on larger farm size. This relationship between farm size and chemical use has the same direction as the studies of Verschelde et al. (2011), and Rahman and Chima (2018). Thus, the change of cultivation patterns of smallholder growers from traditional systems concerning with economic performance to green systems focusing environment are more feasible than the large grower pattern change. These findings represent the contrast between economics and environmental concerned growers via the large and small grower perspectives. Moreover, the results reveal the negative relation of farm size on the performance efficiency. The smaller farms have higher efficiency than the larger farms. This result is similar to the research findings of Barrett et al. (2010), Ali and Deininger (2013), FAO (2014), and Larson et al. (2014). In the buyer aspect, efficient procedure can influence adding value of products, cost saving, and satisfaction of products because of the easy factory procedure controlling.

The findings of this research bring about the guidelines for improving the green longan supply chain to achieve the maximum efficiency including 1) creating an understanding and acceptance of the growers and stakeholders in environmentally friendly production and marketing management, 2) transferring the green knowledge, technologies, and innovations to the growers and stakeholders, 3) encouraging and followupping on the environmental friendliness in order to achieve the desired results, and 4) monitoring and evaluating the development of the green longan supply chain.

In addition, the results lead to the policy making of the government agencies in promoting green supply chain of longan to create value added products and enhance competitiveness, as well as encourage the environmental awareness of the growers and processors via the research and development, clean technology promotion, and knowledge management.

Reference

Ali, D.A., and Deininger, K. (2013). *Is there a farm-size productivity relationship in African agriculture? Evidence from rural Rwanda.* Washington DC: World Bank

Andiç, E., Yurt, O., and Baltacioglu, T. (2012). Green supply chains: Efforts and potential applications for the Turkish market. *Resources, Conservation and Recycling, 58*, 50-68.

Azevedo, S.G., Carvalho, H., and Machado, V.C. (2011). The influence of green practices on supply chain performance: A case study approach. *Transportation Research Part E, 47*, 850-871.

Barrett, C.B., Bellemare, M.F., and Hou, J.Y. (2010). Reconsidering conventional explanations of the inverse productivity-size relationship. *World Development, 38*(1), 88-97.

Beamon, B.M. (1999). Measuring supply chain performance. *International Journal of Operations and Production Management, 19*(3), 275-292.

Chan, R.Y.K., He, H., Chan, H.K., and Wang, W.Y.C. (2012). Environmental orientation and corporate performance: The mediation mechanism of green supply chain management and moderating effect of competitive intensity. *Industrial Marketing Management, 41*, 621-630.

Chaowarat, W., and Shi, J. (2013). Efficiency measurement of supply chain in the export frozen vegetable industry: A network DEA approach. *International Journal of Materials, Mechanics and Manufacturing,* 1(1), 88-91.

Charnes, A., Cooper, W.W., and Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research, 2*, 429-444.

Chen, Y, Liang, L., and Zhu, J. (2009). Equivalence in two-stage DEA approaches. *European Journal of Operational Research*, 193, 600-604.

Chen, C.C., Shih, H.S., Shyur, H.J., and Wu, K.S. (2012). A business strategy selection of green supply chain management via an analytic network process. *Computers and Mathematics with Applications, 64*, 2544-2557.

Council on Environmental Quality. (1996). The 1996 Annual Report of the Council on Environmental Quality. [Online]. Retrieve: https://clintonwhitehouse4.archives.gov/CEQ/ reports/1996/toc.html.

Dües, C.M., Tan, K.H., and Lim, M. (2013). Green as the new lean: How to use lean practices as a catalyst to greening your supply chain. *Journal of Cleaner Production*, 40, 93-100.

Eltayeb, T.K., Zailani, S., and Ramayah, T. (2011). Green supply chain initiatives among certified companies in Malaysia and environmental sustainability: Investigating the outcomes. *Resources, Conservation and Recycling*, 55(5), 495-506.

FAO. (2014). *The State of Food and Agriculture 2014: Innovation in family farming.* Rome: FAO.

Hervani, A., Helms, M., and Sarkis, J. (2005). Performance measurement for green supply chain management. *Benchmarking: An International Journal*, 12(4), 330-353.

Kao, C., and Hwang, S.N. (2008). Efficiency decomposition in two-stage data envelopment analysis: An application in non-life insurance companies in Taiwan. *European Journal of Operational Research*, 185(1), 418-429.

Larson, D.F., Otsuka, K., Matsumoto, T., and Kilic, T. (2014). Should African rural development strategies depend on smallholder farms? An exploration of the inverse-productivity hypothesis. *Agricultural Economics*, 45(3), 355-367.

Li, Y., Chen, Y., Liang, L., and Xie, J. (2012). DEA models for extended two-stage network structures. *Omega*, 40, 611-618.

Liang, L., Cook, W.D., and Zhu, J. (2008). DEA models for two-stage processes: Game approach and efficiency decomposition. *Naval Research Logistics*, 55, 643-53.

Liang, L., Yang, F., Cook, W.D., and Zhu, J. (2006). DEA models for supply chain efficiency evaluation. *Annals of Operations Research*, 145(1), 35-49.

Min, H., and Galle, W.P. (2001). Green purchasing practices of US firms. *International Journal of Operations & Production Management*, 21(9), 1222-1238.

Rahman, S., and Chima, C.D. (2018). Determinants of pesticide use in food crop production in southeastern Nigeria. *Agriculture*, 8(35), 1-14.

Rao, P., and Holt, D. (2005). Do green supply chains lead to competitiveness and economic performance? *International Journal of Operation & Production Management*, 25(9), 898-916.

Sarkis, J. (2003). A strategic decision framework for green supply chain management. *Journal of Cleaner Production*, 11(4), 397-409.

Srivastava, S.K. (2007). Green supply-chain management: A state-of-the-art literature review. *International Journal of Management Reviews*, 9(1), 53-80.

Verschelde, M., D'Haese, M., Rayp, G., and Vandamme, E. (2011). *Challenging small-scale farming, a non-parametric analysis of the (inverse) relationship between farm productivity and farm size in Burundi.* Working Paper. Belgium: Ghent University.

Walton, S.V., Handfield, R.B., and Melnyk, S.A. (1998). The green supply chain: Integrating suppliers into environmental management processes. *Journal of Supply Chain Management*, 34(2), 2-11.

Ying, J., and Zhou, L.J. (2012). Study on green supply chain management based on circular economy. *Physics Procedia*, 25, 1682-1688.

Zhu, Q., and Sarkis, J. (2004). Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. *Journal of Operations Management*, 22(3), 265-289.

Zhu, Q, Sarkis, J., and Lai, K. (2007). Green supply chain management: pressures, practices and performance within the Chinese automobile industry. *Journal of Cleaner Production*, 15(11-12), 1041-1052.

Zsidisin, G.A., and Siferd, S.P. (2001). Environmental purchasing: A framework for theory development. *European Journal of Purchasing & Supply Management*, 7(1), 61-73.