Int. J. Environ. Sci. Technol.
DOI 10.1007/s13762-017-1370-7

ORIGINAL PAPER

Providing an evaluation model of Green Productivity in paper-making industries

F. Taher-Ghahremani[1] · M. Omidvari[1]

Received: 31 August 2016 / Revised: 3 March 2017 / Accepted: 26 May 2017

Abstract Nowadays, the environmental protection is one of the most important duties of every person and organization. One of the industries that pollute the environment is the paper-making industry, which has high importance. The primary objective of this study is to provide a model to evaluate the Green Productivity in the paper-making industry. In this study, Craig–Harris model is used to create a pattern of Green Productivity, after determining the effective indices on Green Productivity, and then the value of Green Productivity index before and after the implementation of ISO 9001 is measured in one of the largest paper-making industries as a case study. Results show that Green Productivity index depends on factors such as manpower, materials, energy and machinery and environmental factors. Results also demonstrate that in a stationary condition, a quality system such as ISO 9001 can be useful in increasing the Green Productivity. According to the results, it is recommended to concern organizational productivity, machinery, manpower, in addition to environmental effects (air, waste, and sewage) to increase Green Productivity in paper-making industry.

Keywords Green Productivity · Paper industry · Environment management · Craig–Harris model

Editorial responsibility: Tan Yigitcanlar.

✉ M. Omidvari
Omidvari88@yahoo.com

[1] Department of Industrial Engineering, Industrial and Mechanical Engineering Faculty, Islamic Azad University, Qazvin Branch, Qazvin, Iran

Introduction

One way to improve the economic and environmental progress in industrial production unit is productivity measurement. Improvement opportunities are defined based on the measurement and analysis of productivity indicators, including indicators of productivity and cycle improvements. Measurement is an integral part and starting point of the scientific process of fertility management. Existence of a reliable system to measure the productivity will cause organization's ability to achieve strategic plans.

Nowadays, environmental issues are concerned by many researchers and managers. The performance of communities about environmental issues has caused various industries to move toward measuring the environmental problems in the organization. Therefore, the issue of concern is that the performance of business should be based on economic parameters, governmental regulations and environmental performance. In response to governmental regulations and increasing public awareness of the effect of industrial activity on the environment, organizations start taking major initiatives to transform their industrial processes. These environmental issues have received increasing attention in recent years. Additionally, productivity with sustainable consideration has also become an important issue (Kuo et al. 2015).

If environmental protection is considered as a strategy for economic development independently, this approach leads to failure. The activities of organizations were focused on short-term profitability in this situation. It is also essential that manufacturing companies apply effective management and control of their pollutants, measure and analyze the pollutants emitted from its production units, based on the results of national standards and guidelines to implement the corrective measures. One of

Published online: 07 June 2017

the most important issues of industrial productivity is energy consumption and renewable energies production. So, the technological improvement in the green path and standardization scenarios will result in lower energy intensities and higher efficiencies (Chaharsooghi et al. 2015; Li and Lin 2015). All production stages have to be considered one by one in the optimization efforts. Besides, companies nowadays have to consider other issues that became important for the sustainability of business and management. One of these issues is environmental factors. Legitimate and social responsibilities put pressure on the achievement of good environmental practices. The best important topics that are considered under environmental issues are energy and pollution (Tuzkaya et al. 2009).

The paper-making industry, one of the industries in the field of environmental pollution, has been concerned by many researchers, in which air pollution, waste and energy consumption are significant environmental aspects in this industry (Korhonen et al. 2015; Montazeri-Gh and Mahmoodi-K 2015).

Woman- Jones pointed out mathematical models to measure productivity. As stated in this regard, functions of Cobb–Douglas can be sufficient to evaluate productivity. Cobb–Douglas could determine the contribution of labor and capital in production rate (Woman- Jones 1991). Timothy et al. (2004) examined the relationship between changes in technology and total productivity. They also proposed four methods of calculating growth, index, production function approach and econometric methods to measure productivity (Timothy et al. 2004). ISO 14031 prescribes the use of performance indicators in environmental management systems to support a continuous improvement strategy (ISO 1999). The selection of meaningful indicators and metrics is critical in environmental performance evaluation and should be specific for each industry and be tailored to the individual organization. Therefore, mass-based Green Productivity indicators, which integrated the environmental and productivity aspects, were prescribed corresponding to the seven established impact categories. The criteria for Green Productivity were based essentially on maximization of resource utilization and minimization of pollution (Pineda-Henson and Culaba 2004).

Hur et al. measured Green Productivity and improved it using life cycle assessment index and the ultimate test materials, energy, water and carbon dioxide (Hur et al. 2004). Moharamnejad and Azarkamand pointed out that the most important Green Productivity indices are water pollution, energy type, paper and energy items consumption (Moharamnejad and Azarkamand 2007). Also, Abbaspour and et al., showed that the guidelines for establishment of green management system in organization are provided based on four major topics, namely (1) education; (2) optimizing of resource consumption; (3) improving the environmental status; and (4) preparation and implementation of the guidelines in green management (Abbaspour et al. 2006). One of the most important concepts in Green Productivity management is environmental knowledge management. Green knowledge management is a very important and powerful resource for organizations to use in the preservation of heritage, accumulation of experience, creation of new ideas and sharing of new knowledge (Huang and Shih 2009). In the new concept of productivity, Green Productivity factors have replaced the traditional factors of productivity. The most of Green Productivity factor include energy, air quality, water consumption and quality, land used and work place environmental demand(Al-Hemoud and Behbehani 2016; Lin et al. 2010; Tuzkaya et al. 2009).

Chang et al. (2011) measured productivity growth in a hospital and argued that one of the factors influencing the increase in productivity is the change in the quality and efficiency of human resources, such that training and motivation of staff can be useful in this regard (Chang et al. 2011). Dohmen (2011) examined individual features and other factors such as nature and enterprise productivity (Dohmen 2011). YuYing et al. in (2013) measured the Green Productivity in the 70 countries in two groups of developing and developed countries and examined the distinction between desirable characteristics of adverse environmental output. The result obtained showed that developing countries had achieved higher growth in the Green Productivity (YuYing et al. 2013). Bartelsman et al. (2013) examined the role of resources allocation in the organizational productivity and discussed ways to improve productivity regarding production and human force. They point out that the choice of resources (environment, human, material, equipment and technology) can be effective in increasing productivity (Bartelsman et al. 2013). Bah and Fang (2015) examined the influence of environmental factors such as business environment and regulations on the organization's productivity and discussed the effect of them on productivity based on the indicators of productivity (Bah and Fang 2015). Jackson and Victor (2011) in an article titled "productivity and work in the green economy, to reduce carbon emissions and maintain high employment" recommended reducing the working hours of the personnel and structural changes in sectors with low productivity (Jackson and Victor (2011; Kuo et al. 2015). Hottenrott et al. (2016) examined the environmental impact of new technology on the organization's productivity and founded communication between green technology (carbon dioxide reduction and increasing energy productivity) and organizational change. The result of this study is the simultaneous application of green technologies and organizational innovation (Hottenrott et al. 2016).

In the present study, the aim is to define and analyze Green Productivity indicators in organizational productivity to provide a model to evaluate Green Productivity in paper-making industries. Therefore, the primary purpose of this study is to provide a model to evaluate Green Productivity in paper-making industries. The central question in this study is: what are Green Productivity indicators in the paper-making industry and what is its importance?

Materials and methods

The research method is descriptive survey (due to case study) and is placed in the category of applied research. The procedure is shown in Fig. 1.

In the first stage, selection of experts was made to define Green Productivity indicators. In this regard, an expert is a person who has at least 5 years of experiences in the paper industry specializing in environmental sciences and familiar with the concepts of productivity. In this regard, ten experts were selected through the census. In the next stage, Craig–Harris model was used to measure total and partial productivity indicators. Green Productivity indices were measured before and after the implementation of the Kaizen, and finally the results were evaluated. It is noteworthy that to calculate all indicators from the information contained in the books and documents were used in the organization.

Productivity measures based on Craig–Harris productivity model

Craig and Harris presented their model in 1973. They emphasized on productivity in the whole company but also consider partial productivity. The primary objective of assessment productivity model is to compare the current situation with the past. In this model, all the inputs and outputs of the company are concerned, and the physical quantities of inputs and outputs are valued based on the price of the base period.

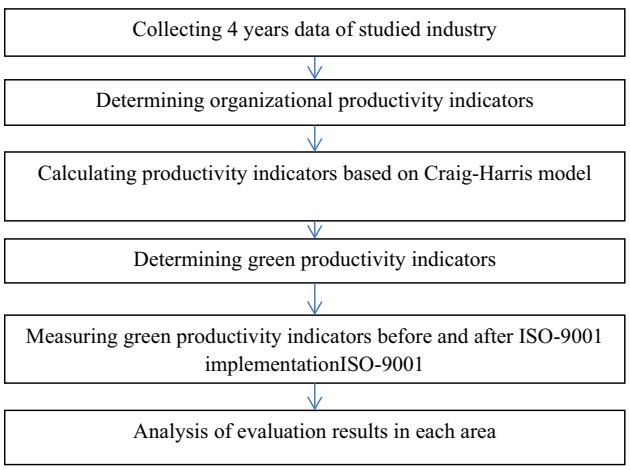

Fig. 1 Procedure of research

This model uses total productivity index, the index of labor productivity, the index of competitiveness of human resource, labor productivity index, material productivity index and machinery productivity index to calculate the productivity. (National Productivity Board 1995).

Productivity indices

A significant number of indicators related to the productivity of resources, following five important indicators of economic performance and financial industries have been identified to measure productivity in production and industrial units, by doing the necessary research studies.

1. The total productivity index
   Total productivity index indicates that for each Rial how much output is obtained for the company and the ratio of output to input price base period total cost base period is calculated.

$$\text{Total productivity of company} = \frac{\text{Total input to basic price}}{\text{Total data to basic price}}.$$

2. The human resources productivity index
   This index represents the amount of output produced per person division in the company. This indicator might be Rial unit employed, or person-months, or 1 day, or 1 h. The productivity can be defined by total input to basic price divided by the average number of employees per year.

$$\text{Productivity of human resource} = \frac{\text{Total input to basic price}}{\text{Average number of employees}}.$$

3. Materials productivity index
   This indicator expresses the amount of output produced per unit of consumed material and can be achieved by the total value of output in the base year for the cost of materials and components used for the base year.

$$\text{Material productivity} = \frac{\text{Total input to basic price}}{\text{Price of consumed material to basic price}}.$$

4. The energy productivity index
   This index shows the correct usage of energy and is

obtained by total output for the base year energy cost for the base year. This unit is Rial on calories. In some countries, this index is calculated by dividing the added value by the value of the energy consumed. In this case, the ratio will be the same.

$$\text{Energy productivity} = \frac{\text{Total input to basic price}}{\text{Price of consumed energy}}.$$

5. Machinery productivity index
The index shows the optimal use of machinery and is obtained by the total value of output in the base year for the value of machinery in the base year.

$$\text{Machinery productivity} = \frac{\text{Total input to basic price}}{\text{Value of machinery in basic price}}.$$

The method of calculating the total value of output

The value of industrial output over a given period against the value of all goods and services produced by the unit during the same period can be obtained from the following formula:

Net sales = sales returns and discounts − Gross sale

Gross sale = Primary and secondary gross sales + other revenues resulting from manufacturing operations.

The method of calculating the total value of data

The calculations were carried out in five areas including labor, capital, materials, energy and other items. This index is shown in Fig. 2. The total value includes costs associated with workforce data—Depreciation—the cost of utilities.

Green Productivity index (GPI)

Green Productivity shown as a proportion of the productivity index system of environmental impact is defined by the relationship below:

GP index = productivity/environmental impact

$$\text{Environmental impact} = \begin{cases} \text{Life cycle (water consumption)} \\ \text{Life cycle (energy)} \\ \text{Total Materials consumption} \end{cases}$$

Productivity is a ratio of the sale price to the cost of production and productivity, which according to equation, itself is divided by environmental impact to define the green (GPI):

$$\text{Productivity} = \frac{\text{SP}}{\text{PC}}$$

$$\text{GPI} = \frac{(\text{SP}/\text{PC})}{\text{EI}}$$

SP price product sales, PC cost of production and EI the environmental impact during the production of the product that is used to obtain the following equation:

$$\text{EI} = W_1 S_{\text{WG}} + W_2 G_{\text{WG}} + W_3 W_C$$

S_{WG} (kg) solid waste generation, G_{WG} (ppm) gaseous waste generation, W_{C} (kg) water consumption and parameters W_1, W_2 and W_3 are the weight of each.

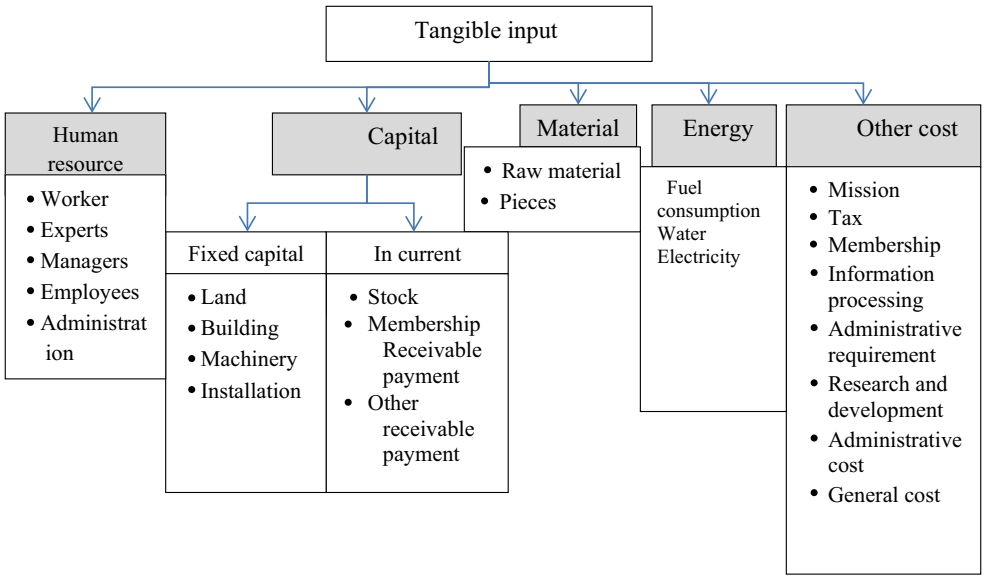

Fig. 2 Indicators related to inputs

To obtain the weights W_1, W_2 and W_3, it is necessary to determine the first six variables of weight coefficients of ESI. Environmental sustainability index indicates the society's capacity for environmental protection during the test in the next several decades. Environmental sustainability index is based on five components. The whole method of weight coefficients is summed to obtain the environmental sustainability index (ESI).

In 2011, the ISO 9001 quality system was implemented in the company under study. In the other study, the impact of the implementation of the ISO 9001 quality system was considered on Green Productivity index. In this part of the study, productivity indicators were measured before and after implementation of ISO 9001. The difference between GPI indicators was compared before and after the implementation of ISO 9001 by using statistical tests T pair. It is noted that the effectiveness of the quality system based on Green Productivity Organization examined over the three years. (Sumaedi and Yarmen 2015).

Results and discussion

Evaluation pattern of Green Productivity index

Results of GPI model and assessment showed that in ESI, the weight coefficients of six environmental sustainability indexes were determined according to experts using the Delphi consensus and available resources. The results are presented in Table 1 (Hur et al. 2004).

According to the coefficients and the total weight of the three most important indices in the ESI, obtaining environmental variables such as weight gain coefficients Green Productivity index of environmental sustainability index weighting coefficients have been achieved in Table 2.

Considering the weight obtained in Table 1, pattern of environmental impact during production is in accordance with the following formula:

$$\mathrm{GPI} = \frac{\mathrm{Sp/Pc}}{0.17S_{\mathrm{WG}} + 0.5G_{\mathrm{WG}} + 0.33W_{\mathrm{C}}}.$$

Case study results

The company under study is now one of the largest paper-making manufacturing units in of Iran and now can produce approximately 30,000 tons of paper and cardboard. Average values of all necessary parameters for calculation of productivity indexes during 2011–2014 of the study are shown in Table 3.

According to data obtained from 2001 to 2004, amount of productivity over 4 years was measured. The results are shown in Table 4.

Green Productivity index of subjects

The results of the Green Productivity calculations are shown in Table 5. Statistical results show a significant difference between the average of Green Productivity before the implementation of ISO 9001 (in 2001) and after the implementation of ISO 9001 (2014). (P value < 0.05).

Table 1 Weighting coefficients of six ESIs (Hur et al. 2004)

Row		Index	Weight
1	Air pollution (0.15)	Air quality	0.05
2		Greenhouse gas emissions	0.05
3		Reduce air pollution process	0.05
4	Solid waste (0.05)	Reduce consumption and solid waste process	0.05
5	Water waste (0.1)	The quantity of sewage	0.05
6		Wastewater quality	0.05

Table 2 Table computationally to determine the weight of GPI

Indicators GPI	ESI par indicators	Weight ESI	Accumulative weight (X_i)	Weight GPI (X_i/3)
Gas waste production	Air quality	0.05	0.15	0.5
	Greenhouse gas emissions	0.05		
	Reduce air pollution	0.05		
Solid waste production	Reducing solid waste generation	0.05	0.05	0.17
Liquid waste production	Water quantity	0.05	0.1	0.33
	Water quality	0.05		
Indicators GPI	Total		0.3	1

Table 3 Average of 4 years (2001–2014) of productivity parameters in the company

Explanation	Name of variable	Unit	Value in case study
(Selling price)	SP	Rial	265,528,800,000
(Production cost)	PC	Rial	262,975,300,000
(Solid waste generation)	S_{WG}	Kg	1,919,000
(Gaseous waste generation)	G_{WG}	ppm	382.56
(Water consumption)	W_C	M^2	4000

Table 4 Amount of parameters for calculation of productivity indexes 2010–2014

Year/parameter	2011	2012	2013	2014
Total input	121,045,856,165	1168, 953,220, 947	300,549,790,302	265,528,849,561
Value added	29,994,176,878	51,705,396,334	51,369,565,108	61,164,719,569
Total data	112,551,927,987	145,175,007,348	295,314,767,823	264,323,603,526
Number of employees	185	185	196	215
Cost of consumed energy	1,628,069,338	1,547,590,163	1,772,990,897	431,987,549
Value of machinery	37,379,530,504	38,077,203,619	51,918,002,646	54,768,598,346
Consumed material	79,703,243,449	105,201,403,324	233,023,366,131	186,784,996,279

Table 5 Results of the calculation of GPI before and after the implementation of the ISO 9001

Indicator	Before ISO (2010)	2012	2013	2014
Production rate (Kg)	14,513,000	13,530,000	12,892,000	11,624,000
PC	262,975,300,000	261,451,614,000	260,232,665,200	259,927,928000
SP	121,045,856,165	168,953,220,947	230,549,790,302	265,528,800,000
S_{WG}	2,395,000	2,121,000	1,953,440	1,727,000
G_{WG}	382.56	382.56	382.56	382.56
W_C	4000	3000	2000	1000
SP/PC	0.46	0.64	0.88	1.021
EI	0.028	0.025	0.025	0.026
GPI		40.84	35.2	24.61

The results of calculation of productivity indexes in 4 years, 2001–2014, are shown in Table 6. As specified in Table, total productivity has been increased within 7 years from 2011 to 2014. Also, human resources productivity has grown from 2001 to 2014. However, energy and machines productivity have been decreased in 2013 and 2014 after the increase in 2011.

Table 6 Results productivity measures indices

Indicator	Year			
	2011	2012	2013	2014
Total productivity	1.08	1.16	1.17	1.19
Productivity of human resource	1.6	2.7	2.6	2.8
Machinery productivity	0.8	1.4	0.9	1.1
Material productivity	0.38	0.39	0.42	0.43
Energy productivity	18.42	33.41	28.97	25.15

Conclusion

This study is designed to measure the productivity of labor, materials, energy, machinery and finally Green Productivity approach to protection of the environment and tries to provide a model of ecological productivity evaluation, utilizes the parameters of human resources productivity and production and energy, suggested strategies for increasing Green Productivity to promoting economic production. Zaum et al. in (2008) discussed the main points of productivity, but not provided the specific type of productivity scale to boost in Green Productivity in an organization. Zaum et al. (2008). Phusavat and Kess (2007) measured the productivity in a clinic and concluded a relationship between labor productivity and workforce capabilities. They recommended increasing worker productivity workforce training incentive systems and their documentation. It should be noted that the study of Phusavat examined only the impact on labor productivity, but other practical factors have not been considered

(Phusavat and Kess 2007). In Hur et al. (2004) offered a model of Green Productivity measurement. In this model, the most important of environmental indicators were economic indicators and air pollution indicators. The results of Hur study were different with this study. Li and Lin (2015) tried to provide a model for measuring productivity using the DEA's green, in their study pointed out that government policies are the most critical factors affecting Green Productivity. Also in this study, an important indicator of Green Productivity is some emissions that in this respect the results of this study are consistent (Li and Lin 2016). Rusiawan et al. (2015) introduced the concept of Green Productivity in 2015, with the aim of reducing carbon dioxide emissions and move toward environmentally sustainable development in Indonesia. In this study, Rusiawan et al. investigated the effect of CO_2 on total factor productivity growth. They also pointed out the importance of productivity labor and capital. Their results indicate that Green Productivity and national policy affect the productivity promotion and reduce carbon dioxide emissions (Rusiawan et al. 2015). Most of the theories and research examined individual measurements or the economic performance of an organization's environmental policy, while the current study measures the environmental performance and economic together. The results showed that one of the ways to increase the productivity of green is paying attention to the consumption of raw materials and reduce waste production. This index shows the added value created by each unit, studied over the years.

Results of the study also showed the energy productivity index has risen in the company under study until 2012 and then has been decreased and that most important reasons can be management factors that require further evaluation. Also, buying new machines and lack of efficient use of new machinery because of lack of staff knowledge to work with the machines increases in energy consumption that it would be the main reasons for the reduction in energy productivity in recent years is required. Selection of the type of energy and finding ways to optimize or reduce usage, the use of renewable and alternative energy can enhance the amount of energy productivity in the organization. The insufficient use of new machinery, weak installation of new machinery, lack of proper system maintenance and lack of serious training employees to improve their skills are the most important causes that reduce the productivity of the machines in 2012 and experts have noted them, which need for further investigation. The most significant results obtained in this study indicate that the factors influencing the Green Productivity, such as the effect of productivity machines, materials, financial and also environmental factors such as reducing air pollution and reduce waste and sewage in the paper industry, can be the most important factors.

Acknowledgements The authors wish to thank all who supported this work.

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