Low-carbon supply chain management and its performance in Japanese manufacturing firms

(Title revised from "Green supply chain management and CO_2 emissions performance in Japanese manufacturing firms")

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Abstract

The focus of corporate environmental management has shifted from individual firms to supply chains, and to so-called green supply chain management (GSCM). This study defines GSCM intending to improve greenhouse gas (GHG) emissions performance as low-carbon supply chain management (LCSCM), and analyzes the influence of Japanese manufacturing firms' LCSCM on their own CO_2 emissions performance and the difference in this influence between industries located on the upper and lower streams of the supply chain. The main findings are as follows. First, when CO_2 emissions performance is evaluated in terms of unit emissions, although firms using LCSCM in general are not more likely to emit lower CO_2 or reduce their emissions further, those in the lower stream industries are more likely to emit lower CO_2 and those in the upper stream industries are more likely to reduce CO_2 emissions further. Second, when CO_2 emissions performance is evaluated in terms of total emissions, although firms using LCSCM in general are not more likely to emit lower CO_2 or reduce their emissions further, those in the lower stream industries are more likely to emit lower CO_2. These results imply the necessity to employ different GHG policies for firms in different industries, with consideration of the unit and total emissions.

Keywords

Low-carbon supply chain management; Lower CO_2 emissions; Further CO2 emissions reduction; Unit emissions; Total emissions

1. Introduction

Global anthropogenic greenhouse gas (GHG) emissions increased from 28.7 $GtCO_2$/year in 1970 to 49.0 $GtCO_2$/year in 2004 (Pachauri and Reisinger, 2007). This suggests that the quantity of anthropogenic GHG emissions increased by 1.7 times in the last 35 years. Anthropogenic GHGs include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF6). CO_2 emissions mainly derived from fossil fuel use, deforestation, decay of biomass, etc., accounted for 76.7% of global anthropogenic GHG emissions in 2004 (Pachauri and Reisinger, 2007). What is already widely known is that the increase in GHG emissions has caused climate change, a serious environmental concern that must be resolved as soon as possible. It is highly likely that the increase in temperature since the middle of the 20th century has been caused mainly by the increase in anthropogenic GHG emissions (Pachauri and Reisinger, 2007). Therefore, the amount of anthropogenic GHG emissions, especially CO_2, must be reduced.

The business sector is responsible for significant quantities of GHG emissions, especially GHG arising from energy consumption that occurs through firms' production activities (Bernstein et al., 2007; Bradford and Fraser, 2008). For example, the business sector (after electricity distribution) accounted for 40.6% of Japan's anthropogenic GHG emissions in 1998.[1] Thus, a fundamental shift of production processes toward sustainability is required (Beamon, 1999). Climate policies to reduce GHG emissions in the business sector include direct regulations (e.g. emission control and energy consumption regulation), indirect regulations (e.g. environmental taxes and emission trading) and promotion of voluntary environmental management by firms (Hatakeda et al., 2012). Because direct regulations negatively influence economic activities, climate policies have generally involved indirect regulations and promotion of voluntary environmental management by firms (Hatakeda et al., 2012). This implies that firms are expected to implement environmental management to reduce GHG emissions voluntarily.

Climate change is global in scope and therefore it is necessary to reduce GHG emissions at the global level. In the business sector, such a global approach has appeared in supply chain management (SCM), which provides the opportunity to capture the synergy of intra- and interfirm integration and management through a network of businesses and relationships (Kokubu and Shinohara, 2011; Lambert and Cooper, 2000). This approach is necessary, as an individual firm's environmental management has a limited effect in reducing GHG emissions and because the GHGs associated with the production of an end-product are not emitted by only the end-product manufacturer, but rather across the entire supply chain. Thus, the focus of a firm's environmental management to reduce GHG emissions has shifted from individual firms toward the entire supply chain. Environmental management trying to minimize the undesirable environmental burdens of supply chain processes within the participating firms, and across the entire supply chain as well, is generally called green supply chain management (GSCM) (Nikbakhsh, 2009). GSCM is concerned with not only traditional SCM performance including timeliness, transaction costs, product quality and effective communication, but also environmental management performance (Faruk et al., 2002). The environmental burdens to be reduced by GSCM include not only those used in the products (product life-cycle influence) but also those in the manufacturing processes (operational life-cycle influence) (Sarkis, 2003).

This paper defines GSCM that is intended to improve GHG emissions performance as low-carbon supply chain management (LCSCM). In the LCSCM framework, firms are responsible for GHGs

[1] Interim Report of the Subcommittee for Goal-achieving Scenario, Global Environment Committee, the Central Environment Council, the Ministry of the Environment of Japan (in Japanese). Available at: http://www.env.go.jp/council/06earth/y062-08/mat02.pdf.

emitted both off- and on-site. The carbon footprint and Scope 3 of the GHG Protocol are methods of LCSCM and the number of firms conducting GHG emissions management using these methods is increasing. For example, Honda Motor Co., Ltd started to disclose Scope 3 emissions in 2012.[2]

In terms of mitigating the climate change, the objective of LCSCM is to reduce GHG emissions across entire supply chains and therefore the relationship between LCSCM and the reduction of GHG emissions of entire supply chains is an important issue to be clarified. However, it is also important to clarify the influence of a firm's LCSCM on its own GHG emissions, especially CO_2 emissions performance. This is not only because the GHG emissions of entire supply chains is an accumulation of those of individual firms, but also because different firms have different strategies and approaches to LCSCM even in the same supply chain. Accordingly, it is expected that the contribution of the LCSCM of individual firms to the reduction in GHG emissions of entire supply chains is also different. Therefore, this study analyzes the influence of Japanese manufacturing firms' LCSCM on their own CO_2 emissions performance and the difference of this influence between industries located in the upper and lower streams of the supply chain. This study employs both CO_2 emissions and CO_2 emission reductions as proxies for CO_2 emissions performance, with consideration given to unit emissions (environmental efficiency) and total emissions. This is because, for example, although many firms regard environmental efficiency as important, CO_2 emissions can increase if the quantity of production increases, even for firms with better CO_2 emissions performance in terms of unit emissions.[3]

The main findings are as follows. First, when CO_2 emissions performance is evaluated in terms of unit emissions, although firms using LCSCM in general are not more likely to emit lower CO_2 or reduce their emissions further, those in the lower stream industries are more likely to emit lower CO_2 and those in the upper stream industries are more likely to reduce CO_2 emissions further. Second, when CO_2 emissions performance is evaluated in terms of total emissions, although firms using LCSCM in general are not more likely to emit lower CO_2 or reduce their emissions further, those in the lower stream industries are more likely to emit lower CO_2. These results imply the necessity of employing different GHG policies for firms in different industries, with consideration of unit and total emissions.

This paper is divided into the following sections. Section 2 reviews the literature on GSCM and LCSCM. Section 3 discusses several hypotheses related to LCSCM. Section 4 details the data and variables and Section 5 provides the estimation results. Section 6 presents some concluding remarks.

2. Literature review

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[2] Honda news release 2012, Available at:
http://world.honda.com/news/2012/c120825Greenhouse-Gas-Emissions.

[3] Nikkei Industrial Newspaper, January 27, 2012.

LCSCM is a relatively new corporate environmental management tool compared with GSCM. Therefore, although there are many studies focusing on GSCM in general, there are only a few studies specifically focusing on LCSCM. As a result, the influence of LCSCM has not been examined. However, because LCSCM is a special type of GSCM designed to reduce GHG emissions, this section reviews the literature on GSCM and discusses the influence of LCSCM on CO_2 emissions reduction.

Most of the previous quantitative studies on GSCM focus mainly on the reasons for its implementation. For example, Zhu and Sarkis (2006), using ANOVA on data about Chinese firms in the automobile, power generating and electronic/electrical industries, found that (possible) GSCM drivers/pressures such as regulations, marketing, suppliers and internal factors are different among these industries. Zhu et al. (2007), using regression analysis on Chinese automobile firm data, found that internal factors positively influence GSCM implementation. Darnall et al. (2008), using Pearson Chi-square tests on data of US manufacturing facilities, found that facilities with an Environmental Management System (EMS) implement GSCM practices more frequently. Testa and Irald (2010), estimating a binary probit model using data about manufacturing facilities in OECD countries such as Canada, France, Germany, Hungary, Japan, Norway and the United States, found that several strategic approaches such as corporate image strategy, product and/or process development strategy and follower strategy, and adoption of EMS positively influence GSCM implementation. Arimura et al. (2011), estimating treatment effects using data about Japanese manufacturing facilities, found that the adoption of ISO 14001 promotes GSCM practices. The determinants of GSCM, however, have also been analyzed by qualitative studies. Walker et al. (2008) reviewed qualitative studies published in the period 1994–2006 and categorized the drivers of GSCM into organizational factors, regulation, customers, competitors and society, and the barriers to it, into costs, lack of legitimacy, regulation, poor supplier commitment and industry-specific barriers.

Thus, these studies clarified that various internal and external factors can influence GSCM. Given these studies, Kajiwara and Kokubu (2012), using ordinary least squares (OLS) on data about Japanese manufacturing firms, found that difficulty in CO_2 measurement, relationship-specific investment, supplier concentration, environmental consciousness of purchasing division, and the stringency of environmental policies influence the implementation of LCSCM. The study by Kajiwara and Kokubu (2012) is valuable because they were the first to analyze LCSCM .

In contrast, a few studies analyzed the influence of a firm's GSCM on its own environmental performance quantitatively. For example, Zhu et al. (2007), using regression analysis on data about Chinese automobile firms, found that GSCM activities positively and negatively influence environmental and economic performance. Vachon and Mao (2008), using OLS on country-level data, found that supply chain strength is positively linked to environmental performance such as that measured by the recycling rate and GHG emissions. Testa and Irald (2010), estimating a binary probit model using data about manufacturing facilities in OECD countries such as Canada, France, Germany, Hungary, Japan, Norway and the United States, found that GSCM improves firms' environmental performance in areas such as changes in the use of natural resources and the generation of solid waste and water effluent.

Thus, although these studies generally found that a firm's GSCM improved its own environmental performance, the influence of GSCM requires further investigation. Accordingly, research analyzing the influence of GSCM needs to be extended. In particular, although Vachon and Mao (2008) found a positive relationship between GSCM and GHG emissions performance using country-level data, whether such a relationship exists at the firm level has not yet been determined. Thus, it is necessary to analyze the influence of a firm's LCSCM on its own CO_2 emissions performance.

However, as this study analyzes the influence of a firm's LCSCM on its own CO_2 emissions performance, it should be noted that LCSCM is different from GSCM in the following ways. First, the areas of the business affected by LCSCM are much broader than those for GSCM, because CO_2 emissions have a strong correlation with energy consumption and thus comprehensive energy management control is necessary. Second, improvement in CO_2 emissions performance is a relatively voluntary-oriented activity, whereas improvement in other environmental performance is a relatively mandatory-oriented activity. Finally, bargaining power in the supply chain tends to influence the behavior of a firm using LCSCM (Kokubu and Shinohara, 2012). Because these differences in characteristics can either positively and/or negatively influence the relationship between LCSCM and CO_2 emissions performance, the influence of LCSCM will be different compared with that of general GSCM.

3. Hypotheses and research design

GSCM designed to improve the environmental performance of supply chain processes within participating firms and the entire supply chain is an increasingly widely accepted activity among firms (Nikbakhsh, 2009; Testa and Irald, 2010). According to Hervani et al. (2005), GSCM is an extension of individual environmental management activities of a firm such as green purchasing, green manufacturing management, green marketing and reverse logistics. Because LCSCM is a special type of GSCM aimed at improving GHG emissions performance, the basic concepts of GSCM could also be applicable to LCSCM. However, a unique element of LCSCM is the extension of the energy management methods of individual components of a supply chain to the entire value chain. In order to integrate these individual activities into GSCM or LCSCM, a proper system of communication with suppliers and of supplier control are necessary (Nawrocka, 2008). As the objective of LCSCM is to reduce GHG emissions, especially CO_2 emissions of entire supply chains, firms using LCSCM endeavor to improve their own CO_2 emissions performance and motivate their suppliers to improve CO_2 emissions performance across the entire supply chain.

Several triggers might cause the shift from individual environmental management to LCSCM. For example, firms that have already implemented their own environmental management can reduce their environmental risk in the supply chain further (Arimura et al., 2011; Nishitani, 2010; Seuring et al., 2008). In addition, firms can fulfill their corporate social responsibility across the entire supply chain (Kovács, 2008). Furthermore, firms can increase sales to environmentally conscious customers in the same supply chain by improving CO_2 emissions performance along the chain. This is because suppliers will be evaluated by the accumulated CO_2 emissions associated with the production of their product, which is obvious from the discussions of the carbon footprint and Scope 3. However, it is important to note that these advantages are not derived directly from LCSCM but indirectly through better CO_2 emissions performance. Thus, it is expected that firms using LCSCM have an incentive to improve CO_2 emissions performance. Therefore, the first hypothesis that this paper tests is as follows.

Hypothesis 1: Firms using LCSCM are more likely to improve their own CO_2 emissions performance.

However, as Figure 1 shows, the volume of CO_2 emissions and of CO_2 emission increases are different among firms in industries generally located in the upper stream of supply chains (textiles, pulp and paper, chemicals, petroleum, rubber, glass, steel, nonferrous metals, and metals) and those in industries generally located in the lower stream (food, pharmaceuticals, general machinery, electrical appliances, transportation machinery, precision instruments and other manufacturing). It is important to note that the emissions from firms in the upper stream industries are relatively larger than those from firms in the lower stream industries, using both unit emissions and total emissions measures. This is because firms in the upper stream industries are more energy intensive than those in the lower stream industries. As a result, it is expected that firms' views on LCSCM are different between the upper and lower streams of supply chains, and therefore the influence of a firm's LCSCM on its own CO_2 emissions performance differs across these groups of firms. Accordingly, the second hypothesis is developed as follows.

Hypothesis 2: The influence of a firm's LCSCM on its own CO_2 emissions performance is different between the upper and lower stream industries.

In testing these hypotheses, CO_2 emissions and increases in CO_2 emissions are used as proxies for CO_2 emissions performance (as explained below). 'CO_2 emissions' measures overall emissions performance, whereas 'CO_2 emission increases' measures emissions improvement. For example, Figure 1 suggests that firms in the upper stream industries emit more CO_2 emissions, but reduce emissions by more. This implies that the firms using LCSCM emit more CO_2 and therefore have an incentive to reduce their emissions. In contrast, firms in the lower stream industries have lower CO_2

emissions; however, they do not achieve such significant reductions in emissions. Thus, the target CO_2 emissions performance might also be different among firms using LCSCM.

Furthermore, although unit emissions (emissions standardized by net sales) have been a more widely accepted measure of CO_2 emissions performance, the performance should be evaluated in terms of both unit emissions and total emissions, where 'unit emissions' measures efficiency and 'total emissions' measures total volume. This is because unit emissions have the shortcoming that improved CO_2 emissions performance does not contribute to the objective of LCSCM when the quantity of production increases. Therefore, it is valuable to evaluate CO_2 emissions performance from several perspectives.

(Figure 1)

4. Data

We conducted a questionnaire survey of 821 manufacturing firms listed on the First Section of the Tokyo Stock Exchange regarding their LCSCM activities jointly conducted by the purchasing (materials/procurement) departments and their suppliers during the period November 11 to December 2, 2011. The number and rate of valid responses were 197 and 23.9%, respectively. These LCSCM data taken from the questionnaire survey were merged with CO_2 emissions data from the Bloomberg database, financial data from Nikkei NEEDS and ISO 14001 data from the Japanese Standards Association, Japan Accreditation Board for Conformity Assessment, and each firm's Web site, and thus consequently the total number of samples with no missing values for the analyses was 97 firms. The descriptive statistics are shown in Table 1.

4-1 CO_2 emissions performance

- CO_2 emissions
- CO_2 emission increases

The proxies for CO_2 emissions performance are CO_2 emissions and CO_2 emission increases. As suggested, the former captures emissions performance, and the latter captures improvement in emissions performance. CO_2 emissions is total CO_2 emissions (millions of tons of CO_2) divided by net sales (millions of yen) when evaluating unit emissions and CO_2 emissions (thousands of tons of CO_2) when evaluating total emissions. CO_2 emission increases are CO_2 emissions divided by net sales in period t minus those in period t–1 when evaluating unit emissions and CO_2 emissions in period t minus those in period t–1 when evaluating total emissions.

3-2 LCSCM

- Official requirements
- Monitoring
- Indirect support
- Direct support

The proxies for LCSCM are official requirements, monitoring, indirect support and direct support, which are specific components of LCSCM designed to improve CO_2 emissions performance, as suggested by Kajiwara and Kokubu (2012).

Official requirements are the extent of buyers' requirements in relation to suppliers' activities regarding CO_2 emissions reduction as measured by the extent of the following efforts: 1) CO_2 reduction; 2) energy saving; 3) CO_2 information disclosure; and 4) CO_2 evaluation.

Monitoring is the degree of buyers' monitoring of main suppliers' activities to reduce CO_2 emissions, which is measured by the average score of the responses to the following questions on a five-point Likert scale ranging from (5) strongly yes to (1) strongly no: 1) does your organization set clear CO_2 emissions reduction goals in its supply chains?; 2) does your organization select suppliers with consideration to their CO_2 emissions reduction?; 3) does your organization select suppliers who are prepared to cooperate in reducing CO_2 emissions in the supply chain?; and 4) does your organization evaluate suppliers' CO_2 emissions reduction using specific criteria?

Indirect support is the degree of buyers' indirect support for suppliers' activities to reduce CO_2 emissions, which is measured as the average score of the responses to the following questions on a five-point Likert scale ranging from (5) strongly yes to (1) strongly no: 1) does your organization hold study groups for CO_2 emissions reduction with its suppliers?; 2) does your organization hold informal gatherings for discussing CO_2 emissions reduction with its suppliers?; 3) does your organization regularly exchange opinions on CO_2 emissions reduction with its suppliers?; 4) does your organization transfer technology for CO_2 emissions reduction to its suppliers?; 5) does your organization provide finance for its suppliers to reduce CO_2 emissions?; and 6) does your organization dispatch CO_2 emissions reduction specialists to its suppliers?

Direct support is the degree of buyers' direct support for suppliers' activities to reduce CO_2 emissions, which is measured as the average score of the responses to the following questions on a five-point Likert scale ranging from (5) strongly yes to (1) strongly no: 1) does your organization set common goals for CO_2 emissions reduction with its suppliers?; 2) does your organization have a mutual understanding relating to CO_2 emissions reduction with its suppliers?; 3) do your organization and suppliers cooperate in designing ways to reduce CO_2 emissions?; and 4) do your organization and suppliers cooperate with secondary suppliers to reduce CO_2 emissions?

3-3 Control variables

- Environmental consciousness of purchasing division
- Difficulty in CO_2 measurement
- Relationship-specific investment
- Supplier concentration
- Stringency of environmental policies
- ISO 14001 dummy
- Firm size
- Return on assets (ROA)
- Debt to equity (DTE)
- Advertising expenditure ratio
- Free float weight

The control variables that may influence CO_2 emissions performance are environmental consciousness of the purchasing division, difficulty in CO_2 measurement, relationship-specific investment, supplier concentration, stringency of environmental policies, ISO 14001 dummy, firm size, return on assets (ROA), debt to equity (DTE) ratio, advertising expenditure ratio and free float weight. Among them, environmental consciousness of the purchasing division, difficulty in CO_2 measurement, relationship-specific investment, supplier concentration, stringency of environmental policies and ISO 14001 dummy are possible determinants of LCSCM suggested by the previous studies. Because these variables capture not only the determinants of LCSCM but also the degree of ease of identifying suppliers' CO_2 emissions performance and stance on environmental management, they could also influence a firm's own CO_2 emissions performance directly. In contrast, firm size, ROA, DTE, advertising expenditure ratio and free float weight are variables often used as control variables in previous studies that analyzed environmental performance.

Environmental consciousness of the purchasing division is the degree of environmental consciousness of the purchasing division of buyers, which is measured as the average score in response to the following questions using a five-point Likert scale ranging from (5) strongly yes to (1) strongly no: 1) is it important for your organization to purchase environmentally conscious products?; 2) is it important for your organization to obtain low-carbon products?; and 3) is it important for your organization to reduce suppliers' CO_2 emissions?

Difficulty in CO_2 measurement is the degree of difficulty in CO_2 measurement in supply chains, which is measured as the average score in response to the following questions using a five-point Likert scale ranging from (5) strongly yes to (1) strongly no: 1) is it difficult for your organization to evaluate the level of CO_2 emissions in materials it purchases?; 2) is it difficult for your organization to compare the level of CO_2 emissions in materials offered by various suppliers when it is making purchasing decisions?; and 3) is it difficult for your organization to influence the cost of reduction of CO_2

emissions in its products?

Relationship-specific investment is the degree of relationship-specific investment in supply chains, which is measured as the average score in response to the following questions using a five-point Likert scale ranging from (5) strongly yes to (1) strongly no: 1) do your main suppliers allocate an exclusive sales representative to manage business with your organization?; 2) do your main suppliers allocate exclusive technology specialists to manage business with your organization?; and 3) do your main suppliers undertake relationship-specific investment related to business with your organization?

Supplier concentration is the degree of concentration of the largest four suppliers, which is measured by the accumulated shares of the largest four suppliers.

Stringency of environmental policies[4] is the degree of stringency of environmental policies that buyers face, which is measured as the average score in response to the following questions using a five-point Likert scale ranging from (5) strongly yes to (1) strongly no: 1) are the environmental regulations for the industry that your organization belongs to stricter than those for other industries?; and 2) are the voluntary restraints on the environment in the industry that your organization belongs to stricter than those for other industries?

ISO 14001 dummy is the degree to which the firm conducts environmental management, which is measured by a dummy variable that takes a value of 1 if it is more than four years since the firm adopted ISO 14001. [5]

Firm size is measured by the logarithm of the book value of total assets. ROA is the degree of profitability, which is measured by net profit divided by total assets. DTE is the degree of debt dependence for finance, which is measured by debt divided by equity. The advertising expenditure ratio is the degree of end-product consumer closeness, measured as the degree of advertising expenditure divided by net sales.[6] Free float weight is the degree of share market dependence, which is measured by the number of stocks available for trading in the market divided by the total number of stocks.

(Table 1)

5. Estimation results

The estimation results for the influence of LCSCM on CO_2 emissions performance in terms of the

[4] Although the influences of industries are usually controlled by industry dummies, this paper controls these influences by stringency of environmental policies because the number of observations is too few to include many industry dummies as independent variables. As Hatakeda et al. (2012) suggested, one of the major industry-specific influences on CO_2 emissions performance is stringency of environmental policies.

[5] The firm must undergo a full recertification audit every three years to renew ISO 14001.

[6] The advertising expenditure ratio captures the direct influence of the location of the supply chain on CO_2 emissions performance.

unit emissions are shown in Tables 2 and 3, and those in terms of total emissions are shown in Tables 4 and 5. The dependent variables are CO_2 emissions in Tables 2 and 4, and CO_2 emission increases in Tables 3 and 5. Estimation is by OLS with White-corrected standard errors. The CO_2 emissions performance in 2012 was determined by LCSCM for 2011 and by control variables for 2009 to avoid the endogeneity problem.[7]

The influence of LCSCM on CO_2 emissions performance is assumed to be homogeneous in all sample firms in the odd-numbered models of Tables 2 to 5 to test Hypothesis 1, and heterogeneous in terms of the upper or lower stream industries in the even-numbered models of these tables to test Hypothesis 2. For our purposes, independent variables related to LCSCM are interacted with the upper or lower stream industry dummies in the even-numbered models.

Table 2 shows the estimation results where the dependent variables are unit emissions of CO_2. In Models (1), (3), (5) and (7), official requirement, monitoring, and indirect and direct support all have an insignificant effect. Thus, if firms are regarded as homogeneous, LCSCM does not influence CO_2 emissions. In Model (2), the interaction term between official requirement and the upper stream industries is significantly positive and that between official requirement and the lower stream industries is significantly negative. In Model (4), neither monitoring variable has a significant effect. In Model (6), the interaction term between indirect support and the lower stream industries is significantly negative. In Model (8), neither direct support variable has a significant effect. Thus, because two of the four LCSCM variables are significantly negative for firms in the lower stream industries, firms using LCSCM in the lower stream industries are more likely to emit lower CO_2. In contrast, because one of the four LCSCM variables is significantly positive for firms in the upper stream industries, firms using LCSCM in the upper stream industries are more likely to emit more CO_2, although evidence from one significant variable is relatively weak. These results suggest that the influence of LCSCM on CO_2 emissions is different between the upper and lower stream industries. Indeed, the influences of official demand, monitoring, indirect support and direct support between the upper and lower stream industries are statistically different at the 1% level, according to the bottom of Table 2. Therefore, LCSCM mainly results in lower CO_2 emissions in the lower stream industries, and Hypothesis 1 is supported in the case of firms in the lower stream industries and Hypothesis 2 is supported.

Table 3 shows the estimation results where the dependent variables are CO_2 emission increases in terms of unit emissions. In Models (1), (3), (5) and (7), official requirement, monitoring, and indirect and direct support all have an insignificant effect. Thus, if firms are regarded as homogeneous, firms using LCSCM are not more likely to reduce CO_2 further. In Model (2), the interaction term of official requirement and the upper stream industries is significantly negative. In Model (4), neither monitoring

[7] Because we included several possible determinants of LCSCM and LCSCM in the regression models simultaneously, we used the data of control variables in 2009 and those of LCSCM in 2011.

variable has a significant effect. In Model (6), the interaction term of indirect support and the upper stream industries is significantly negative. In Model (8), the interaction term of direct support and the upper stream industries is significantly negative. Thus, because three of the four LCSCM variables are significantly negative for firms in the upper stream industries, firms using LCSCM in the upper stream industries are more likely to reduce CO_2 emissions further. In contrast, because none of the four LCSCM variables has a significant effect, firms using LCSCM in the lower stream industries are not more likely to reduce CO_2 emissions further. These results suggest that the influence of LCSCM on CO_2 increases is different between industries. Indeed, the influences of official demand, monitoring, indirect support and direct support between the upper and lower industries are statistically different at the 1% level, according to the bottom of Table 3. Therefore, LCSCM mainly influences a firm's reduction in CO_2 emissions in the upper stream industries, and Hypothesis 1 is supported in the case of firms in the upper stream industries and Hypothesis 2 is supported.

The estimation results in terms of unit emissions in Tables 2 and 3, therefore, suggest that although firms using LCSCM in general are not more likely to emit lower CO_2 or reduce their emissions further, those in the lower stream industries of the supply chain are more likely to emit lower CO_2 and those in the upper stream industries are more likely to reduce CO_2 emissions further. With regard to control variables, supplier concentration, stringency of environmental policies and firm size are significantly positive and advertising expenditure ratio is significantly negative in Table 2. Moreover, environmental consciousness of the purchasing division is significantly positive and stringency of environmental policies and free float weight are significantly negative in Table 3.

Table 4 shows the estimation results where the dependent variables are CO_2 emissions in terms of the total emissions. In Models (1), (3), (5) and (7), official requirement, monitoring, and indirect and direct support all have an insignificant effect. Thus, if firms are regarded as homogeneous, LCSCM does not influence CO_2 emissions. In Model (2), the interaction term between official requirement and the lower stream industries is significantly negative. In Model (4), the interaction term between monitoring and the upper stream industries is significantly positive. In Model (6), neither indirect support variable has a significant effect. In Model (8), the interaction term between direct support and the upper stream industries is significantly positive. Thus, because one of the four LCSCM variables is significantly negative for firms in the lower stream industries, firms using LCSCM in the lower stream industries are more likely to emit lower CO_2, although evidence from one significant variable is relatively weak. In contrast, because two of four LCSCM variables are significantly positive for firms in the upper stream industries, firms using LCSCM in the upper stream industries are more likely to emit more CO_2. These results also suggest that the influence of LCSCM on CO_2 emissions is different between the upper and lower stream industries. Indeed, the influences of official demand, monitoring, indirect supports and direct supports between the upper and lower stream industries are statistically different at the 1% level, according to the bottom of Table 3. Therefore, LCSCM mainly results in lower CO_2 emissions in the lower stream industries. More precisely speaking, firms using LCSCM in the lower stream industries emit lower CO_2 than those in the upper stream industries. That is, Hypothesis 1 is weakly supported in the case of firms in the lower stream industries and Hypothesis 2 is supported.

Table 5 shows the estimation results where the dependent variables are CO_2 emission increases in terms of the unit emissions. In Models (1), (3), (5) and (7), official requirement, monitoring, and indirect and direct support all have an insignificant effect. Thus, if firms are regarded as homogeneous, firms using LCSCM are not more likely to reduce CO_2 further. In Models (2), (4), (6) and (8), official requirement, monitoring, and indirect and direct support all have an insignificant effect. Furthermore, their effects are not statistically different between the upper and lower industries, according to the bottom of Table 5. These results suggest that firms using LCSCM in the upper and lower stream industries are not more likely to reduce CO_2 further. Hence, neither Hypothesis 1 nor 2 is supported.

Therefore, the estimation results in terms of total emissions in Tables 4 and 5 suggest that although firms using LCSCM in general are not more likely to emit lower CO_2 or reduce their emissions further, those in the lower stream industries are more likely to emit lower CO_2. At least, firms using LCSCM in the lower stream industries emit lower CO_2 than those in the upper stream industries. With regard to control variables, stringency of environmental policies and firm size are significantly positive and the ISO 14001 dummy is significantly negative in Table 4, and stringency of environmental policies is significantly negative in Table 5.

(Tables 2 to 5)

6. Concluding remarks

This study analyzed the influence of Japanese manufacturing firms' LCSCM on their own CO_2 emissions performance and the difference of this influence between industries located in the upper and lower streams of the supply chain. The main findings are as follows.

First, when CO_2 emissions performance is evaluated in terms of unit emissions, although firms using LCSCM in general are not more likely to emit lower CO_2 or reduce their emissions further, those in the lower stream industries are more likely to emit lower CO_2 and those in the upper stream industries are more likely to reduce CO_2 emissions further. Accordingly, LCSCM influences a firm's CO_2 emissions and CO_2 reductions differently.

It is interesting to find that LCSCM influences a firm's effort to maintain lower CO_2 emissions in the lower stream industries and a firm's effort to reduce CO_2 emissions further in the upper stream industries. As Figure 1 shows, firms in the upper stream industries emit more CO_2 because they are energy-intensive firms. Thus, the objective of LCSCM for firms in the lower stream industries could be to keep their CO_2 emissions lower, because they do not have scope to reduce them further. In contrast, firms in the upper stream industries have an incentive to reduce CO_2 emissions further, because they still have scope to reduce CO_2 emissions further. As suggested, the quantities of CO_2 emissions and energy consumption have a strong correlation and therefore lower CO_2 emissions leads to an energy cost reduction. Thus, it is reasonable that firms using LCSCM and emitting lower CO_2 have an incentive to maintain their lower emissions, and those emitting more CO_2 have an incentive to reduce their emissions further.

Second, when CO_2 emissions performance is evaluated in terms of total emissions, although firms using LCSCM in general are not more likely to emit lower CO_2 or reduce their emissions further, those in the lower stream industries are more likely to emit lower CO_2. Thus, the influence of LCSCM on CO_2 emissions performance in terms of total emissions is similar to that in terms of unit emissions. However, an important finding is that although LCSCM reduces the CO_2 emissions of firms in the upper stream industries in terms of unit emissions, it does not in terms of total emissions. This implies that it is difficult for them to easily reduce CO_2 emissions or energy consumption in terms of total emissions, because most Japanese manufacturing firms have already introduced energy-efficient production processes following the oil price shocks in the 1970s (Fujita and Tabuchi, 1997). This is because energy consumption can be divided into fixed energy consumption (e.g. the energy requirements of machine components) and variable energy consumption (e.g. the required electrical energy for tool handling, positioning and actual operation), and fixed energy consumption can account for a major share of total energy consumption during production (Herrmann and Thiede, 2009). Namely, although the promotion of operation process efficiency can lead to reductions in CO_2 emissions in terms of unit emissions, replacement of production process equipment is necessary in order to reduce CO_2 emissions in terms of total emissions. That is, if the cost of the new energy-efficient equipment outweighs the cost reduction from the equipment and sales increases from environmentally conscious customers, firms will not replace such equipment in order to reduce CO_2 emissions in terms of total emissions. However, this is inconsistent from other perspectives. For example, from the perspective of political visibility, which is a firm’s exposure to the risk of regulatory action and to the censures and demands of other interest groups, it is expected that firms with larger CO_2 emissions are more visible and therefore they are more likely to reduce CO_2 emissions (Lemke and Page, 1992). To obtain more specific interpretations, interviews with firms that use LCSCM are necessary in the future.

Given the above findings and discussions, the implementation of LCSCM across entire supply chains means that firms that emit lower CO_2 in industries located in the lower stream of a supply chain require that their suppliers that emit more CO_2 in industries located in the upper stream reduce their CO_2 emissions further. Therefore, the ultimate objective of LCSCM would be to help CO_2 emissions reductions in the upstream areas, which have more scope for reduction.

Concerning policy implications, because our estimation results also suggest that firms that face stricter environmental policies are more likely to emit more CO_2, and to reduce CO_2 emissions, it might be reasonable to implement direct regulations for CO_2 emissions reduction. However, direct regulations negatively impact economic activity, as they are not in the mainstream of climate policies as suggested in Section 1. Therefore, policy instruments such as indirect regulation and policies encouraging voluntary corporate environmental management that provide firms with an economic incentive can be more effective. Because LCSCM is a voluntary environmental management activity that has the potential to reduce CO_2 emissions not only in individual firms but also across the entire supply chain, policies encouraging LCSCM such as those providing official environmental disclosure rules are preferable for mitigating climate change. In addition, because the influence of LCSCM on CO_2 emissions performance is different between the upper and lower stream industries and between the unit emissions and total emissions, such policy should be industry specific and give consideration to unit and total emissions.

Thus, this paper clarified the relationship between LCSCM and the CO_2 emissions performance of the LCSCM firms, and provided possible policy implications for reducing CO_2 emissions further through LCSCM. However, the concept of LCSCM is relatively new, and the influence of LCSCM on the reduction of CO_2 emissions in entire supply chains requires further investigation. Future research will address these issues.

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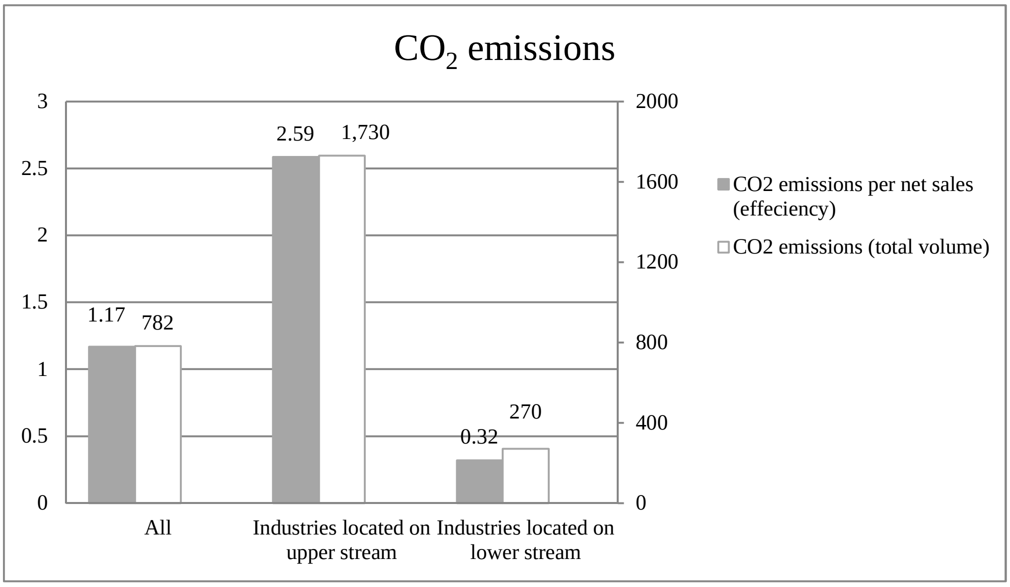
Figure 1 A firm's CO_2 emissions and CO_2 emission increases



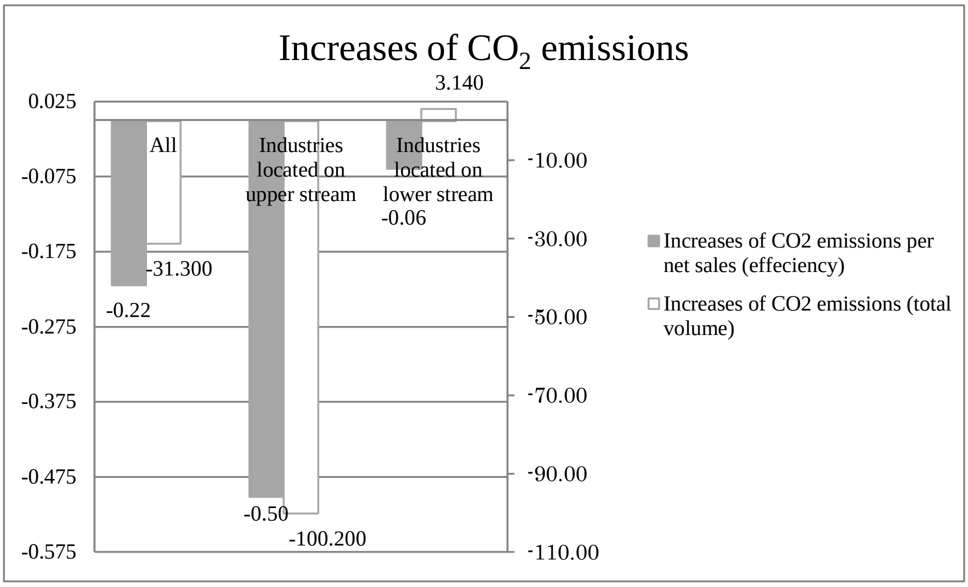


Table 1 Descriptive statistics

	Observations	Mean	S.D.	Min	Max
CO_2 emissions (unit)	88	1.169	2.134	0.039	14.305
CO_2 emission reductions (unit)	76	-0.220	0.390	-1.887	0.442
CO_2 emissions (total)	97	0.782	2.245	0.002	17.266
CO_2 emission reductions (total)	84	-0.031	0.298	-1.756	0.773
Official requirement	97	1.278	1.161	0	4
Monitoring	97	2.187	0.712	1	4
Indirect supports	94	1.628	0.650	1	4
Direct supports	94	1.832	0.776	1	4
Environmental consciousness	97	3.062	0.820	1	5
Difficulty in CO_2 measurement	97	3.677	0.888	1	5
Relationship-specific investment	97	3.412	0.819	1	5
Supplier concentration	97	10.691	2.844	5	18
Stringency of environmental policies	97	3.232	0.726	1	5
ISO 14001 dummy	97	0.959	0.200	0	1
Firm size	97	12.409	1.307	9.684	15.939
ROA	97	0.027	0.045	-0.131	0.171
DTE	97	1.352	1.088	0.067	5.220
Advertising expenditure ratio	97	0.014	0.013	0.003	0.080
Free float weight	97	0.171	0.094	0.037	0.443
Upper stream industries	97	0.351	0.480	0	1
Lower stream industries	97	0.649	0.480	0	1

Table 2 Estimation results of influence of LCSCM on CO_2 emissions (unit emissions)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Official requirement	-0.095	-	-	-	-	-	-	-
	(0.197)							
×Upper stream industries	-	0.785 ***	-	-	-	-	-	-
		(0.296)						
×Lower stream industries	-	-0.425 **	-	-	-	-	-	-
		(0.186)						
Monitoring	-	-	-0.301	-	-	-	-	-
			(0.431)					
×Upper stream industries	-	-	-	0.129	-	-	-	-
				(0.415)				
×Lower stream industries	-	-	-	-0.649	-	-	-	-
				(0.433)				
Indirect supports	-	-	-	-	-0.506	-	-	-
					(0.391)			
×Upper stream industries	-	-	-	-	-	0.153	-	-
						(0.421)		
×Lower stream industries	-	-	-	-	-	-0.828 **	-	-
						(0.385)		
Direct supports	-	-	-	-	-	-	-0.201	-
							(0.407)	
×Upper stream industries	-	-	-	-	-	-	-	0.311
								(0.445)
×Lower stream industries	-	-	-	-	-	-	-	-0.586
								(0.411)
Environmental consciousness	-0.010	-0.102	0.062	0.133	0.100	0.108	0.070	0.167
	(0.319)	(0.274)	(0.411)	(0.361)	(0.341)	(0.298)	(0.395)	(0.361)
Difficulty in CO_2 measurement	-0.190	-0.043	-0.249	-0.092	-0.220	-0.082	-0.182	-0.116
	(0.249)	(0.217)	(0.244)	(0.181)	(0.251)	(0.197)	(0.252)	(0.193)
Relationship-specific investment	-0.168	-0.183	-0.146	-0.026	-0.131	-0.014	-0.159	-0.065
	(0.214)	(0.217)	(0.219)	(0.200)	(0.218)	(0.200)	(0.217)	(0.198)
Supplier concentration	0.130 **	0.115 **	0.130 **	0.076	0.107 *	0.056	0.141 **	0.086
	(0.056)	(0.047)	(0.058)	(0.048)	(0.059)	(0.052)	(0.059)	(0.054)
Stringency of environmental policies	0.906 **	0.770 **	0.963 **	0.726 **	0.891 **	0.644 *	0.946 **	0.639 *
	(0.398)	(0.314)	(0.420)	(0.355)	(0.383)	(0.329)	(0.394)	(0.325)
ISO 14001 dummy	-3.727	-3.893	-3.665	-4.182	-3.700	-4.126	-3.564	-3.900
	(3.345)	(2.750)	(3.208)	(2.942)	(3.151)	(2.974)	(3.154)	(2.919)
Firm size	0.394 *	0.261	0.397 *	0.275	0.463 *	0.376 *	0.485 **	0.362 *
	(0.215)	(0.174)	(0.219)	(0.177)	(0.241)	(0.202)	(0.243)	(0.202)
ROA	2.940	-1.121	2.743	-1.171	2.960	0.099	2.954	0.124
	(4.289)	(3.714)	(3.979)	(3.141)	(4.244)	(3.535)	(4.315)	(3.546)
DTE	-0.023	-0.028	-0.038	-0.023	0.001	-0.030	-0.017	-0.055
	(0.310)	(0.246)	(0.321)	(0.258)	(0.325)	(0.265)	(0.306)	(0.231)
Advertising expenditure ratio	-17.281 *	-12.193	-16.734 *	-11.907	-18.582 *	-17.783 **	-16.778 *	-16.170 *
	(8.783)	(9.500)	(8.652)	(8.759)	(10.014)	(8.414)	(8.724)	(8.579)
Free float weight	2.632	3.682	2.692	3.179	2.833	3.452	3.557	4.608
	(3.085)	(2.521)	(3.129)	(2.699)	(3.095)	(2.696)	(3.666)	(3.176)
Constant	-3.248	-1.204	-3.059	-0.853	-3.506	-1.649	-4.946	-2.340
	(4.066)	(3.222)	(4.053)	(3.283)	(4.079)	(3.380)	(4.276)	(3.616)
Observations	88	88	88	88	85	85	85	85
R^2	0.331	0.494	0.336	0.477	0.348	0.469	0.353	0.484
Difference of influence (p-value)	-	0.000	-	0.000	-	0.000	-	0.000

White-corrected standard errors are in parentheses.

*, **, and *** imply that the coefficient is significantly different from zero at the 10%, 5%, and 1% levels, respectively.

Table 3 Estimation results of influence of LCSCM on CO_2 emission increases (unit emissions)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Official requirement	-0.008	-	-	-	-	-	-	-
	(0.047)							
×Upper stream industries	-	-0.153 ***	-	-	-	-	-	-
		(0.048)						
×Lower stream industries	-	0.051	-	-	-	-	-	-
		(0.033)						
Monitoring	-	-	-0.031	-	-	-	-	-
			(0.082)					
×Upper stream industries	-	-	-	-0.102	-	-	-	-
				(0.083)				
×Lower stream industries	-	-	-	0.035	-	-	-	-
				(0.077)				
Indirect supports	-	-	-	-	-0.051	-	-	-
					(0.074)			
×Upper stream industries	-	-	-	-	-	-0.165 **	-	-
						(0.079)		
×Lower stream industries	-	-	-	-	-	0.030	-	-
						(0.063)		
Direct supports	-	-	-	-	-	-	-0.091	-
							(0.092)	
×Upper stream industries	-	-	-	-	-	-	-	-0.153 *
								(0.084)
×Lower stream industries	-	-	-	-	-	-	-	0.017
								(0.079)
Environmental consciousness	0.120	0.122 *	0.130 *	0.090	0.126 *	0.103 *	0.159 *	0.103
	(0.076)	(0.065)	(0.069)	(0.058)	(0.072)	(0.057)	(0.091)	(0.073)
Difficulty in CO_2 measurement	0.094	0.067	0.090	0.052	0.092	0.054	0.068	0.053
	(0.066)	(0.057)	(0.067)	(0.058)	(0.067)	(0.055)	(0.068)	(0.056)
Relationship-specific investment	0.022	0.022	0.025	-0.007	0.023	-0.010	0.024	-0.002
	(0.051)	(0.048)	(0.054)	(0.052)	(0.054)	(0.051)	(0.050)	(0.046)
Supplier concentration	-0.016	-0.014	-0.016	-0.007	-0.016	-0.005	-0.019	-0.009
	(0.016)	(0.015)	(0.016)	(0.016)	(0.016)	(0.015)	(0.016)	(0.015)
Stringency of environmental policies	-0.207 ***	-0.193 ***	-0.200 ***	-0.165 **	-0.210 ***	-0.167 ***	-0.227 ***	-0.168 ***
	(0.064)	(0.057)	(0.067)	(0.064)	(0.066)	(0.061)	(0.066)	(0.058)
ISO 14001 dummy	-0.136	0.032	-0.152	0.024	-0.149	0.016	-0.143	0.008
	(0.149)	(0.128)	(0.117)	(0.120)	(0.114)	(0.106)	(0.125)	(0.103)
Firm size	-0.049	-0.035	-0.049	-0.030	-0.047	-0.038	-0.064	-0.047
	(0.037)	(0.029)	(0.037)	(0.028)	(0.038)	(0.030)	(0.039)	(0.031)
ROA	0.390	0.887	0.368	0.897	0.393	0.851	0.666	0.996
	(0.682)	(0.619)	(0.674)	(0.708)	(0.656)	(0.680)	(0.639)	(0.673)
DTE	-0.036	-0.028	-0.038	-0.025	-0.038	-0.014	-0.021	-0.002
	(0.060)	(0.045)	(0.058)	(0.045)	(0.063)	(0.049)	(0.062)	(0.048)
Advertising expensiture ratio	1.000	-0.123	0.962	-0.405	0.486	-0.139	0.248	0.052
	(1.777)	(1.885)	(1.762)	(1.863)	(1.887)	(2.155)	(1.759)	(2.105)
Free float weight	-0.513	-0.822 **	-0.487	-0.616	-0.542	-0.736 *	-0.474	-0.801 *
	(0.430)	(0.364)	(0.447)	(0.391)	(0.434)	(0.375)	(0.491)	(0.427)
Constant	0.696	0.416	0.721	0.450	0.763	0.526	1.094	0.674
	(0.677)	(0.501)	(0.681)	(0.485)	(0.699)	(0.481)	(0.731)	(0.567)
Observations	76	76	76	76	73	73	73	73
R^2	0.304	0.446	0.306	0.420	0.311	0.450	0.337	0.475
Difference of influence (p-value)	-	0.000	-	0.000	-	0.000	-	0.000

White-corrected standard errors are in parentheses.

*, **, and *** imply that the coefficient is significantly different from zero at the 10%, 5%, and 1% levels, respectively.

Table 4 Estimation results of influence of LCSCM on CO_2 emission increases (total emissions)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Official requirement	-0.206	-	-	-	-	-	-	-
	(0.198)							
×Upper stream industries	-	0.242	-	-	-	-	-	-
		(0.257)						
×Lower stream industries	-	-0.351 *	-	-	-	-	-	-
		(0.202)						
Monitoring	-	-	0.309	-	-	-	-	-
			(0.268)					
×Upper stream industries	-	-	-	0.562 *	-	-	-	-
				(0.311)				
×Lower stream industries	-	-	-	0.103	-	-	-	-
				(0.253)				
Indirect supports	-	-	-	-	0.005	-	-	-
					(0.356)			
×Upper stream industries	-	-	-	-	-	0.440	-	-
						(0.431)		
×Lower stream industries	-	-	-	-	-	-0.187	-	-
						(0.333)		
Direct supports	-	-	-	-	-	-	0.348	-
							(0.266)	
×Upper stream industries	-	-	-	-	-	-	-	0.643 *
								(0.357)
×Lower stream industries	-	-	-	-	-	-	-	0.123
								(0.233)
Environmental consciousness	0.074	0.030	-0.151	-0.096	0.022	0.038	-0.137	-0.065
	(0.292)	(0.279)	(0.344)	(0.326)	(0.295)	(0.276)	(0.362)	(0.343)
Difficulty in CO_2 measurement	0.261	0.325	0.247	0.340 *	0.242	0.326 *	0.317	0.363 *
	(0.206)	(0.200)	(0.202)	(0.196)	(0.202)	(0.194)	(0.221)	(0.206)
Relationship-specific investment	-0.418	-0.424	-0.439	-0.370	-0.427	-0.351	-0.414	-0.359
	(0.311)	(0.314)	(0.311)	(0.299)	(0.312)	(0.304)	(0.309)	(0.301)
Supplier concentration	0.036	0.027	0.059	0.029	0.049	0.016	0.077	0.045
	(0.048)	(0.047)	(0.058)	(0.054)	(0.055)	(0.053)	(0.063)	(0.059)
Stringency of environmental policies	0.780 ***	0.689 **	0.778 **	0.616 **	0.799 **	0.618 **	0.890 **	0.696 **
	(0.295)	(0.273)	(0.312)	(0.284)	(0.307)	(0.271)	(0.345)	(0.313)
ISO 14001 dummy	-1.551 *	-1.443 *	-1.104	-1.251	-1.191	-1.289 *	-1.097	-1.179
	(0.834)	(0.783)	(0.908)	(0.824)	(0.848)	(0.765)	(0.843)	(0.786)
Firm size	0.789 ***	0.758 ***	0.752 ***	0.705 ***	0.770 ***	0.744 ***	0.803 ***	0.764 ***
	(0.249)	(0.240)	(0.234)	(0.215)	(0.253)	(0.242)	(0.249)	(0.234)
ROA	-3.451	-5.470 *	-1.645	-3.860	-2.433	-4.214 *	-2.970	-4.652 *
	(2.906)	(3.257)	(2.241)	(2.333)	(2.444)	(2.466)	(2.564)	(2.576)
DTE	0.205	0.178	0.188	0.174	0.228	0.180	0.158	0.114
	(0.210)	(0.200)	(0.185)	(0.162)	(0.205)	(0.181)	(0.191)	(0.170)
Advertising expensiture ratio	-7.108	-5.532	-6.604	-3.958	-6.935	-6.575	-4.339	-4.209
	(9.796)	(8.755)	(9.489)	(8.816)	(10.725)	(9.588)	(9.756)	(8.867)
Free float weight	0.274	0.884	0.102	0.564	0.394	0.984	0.375	1.125
	(1.833)	(1.768)	(1.695)	(1.670)	(1.865)	(1.791)	(1.881)	(1.825)
Constant	-10.058 ***	-9.519 ***	-10.402 ***	-9.521 ***	-10.433 ***	-9.727 ***	-11.885 ***	-10.887 ***
	(3.700)	(3.392)	(3.927)	(3.401)	(3.887)	(3.389)	(4.178)	(3.735)
Observations	97	97	97	97	94	94	94	94
R^2	0.369	0.403	0.367	0.410	0.370	0.414	0.396	0.434
Difference of influence (p-value)	-	0.007	-	0.005	-	0.012	-	0.009

White-corrected standard errors are in parentheses.

*, **, and *** imply that the coefficient is significantly different from zero at the 10%, 5%, and 1% levels, respectively.

Table 5 Estimation results of influence of LCSCM on CO_2 emission increases (total emissions)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Official requirement	-0.0002	-	-	-	-	-	-	-
	(0.022)							
×Upper stream industries	-	-0.048	-	-	-	-	-	-
		(0.044)						
×Lower stream industries	-	0.015	-	-	-	-	-	-
		(0.030)						
Monitoring	-	-	0.054	-	-	-	-	-
			(0.046)					
×Upper stream industries	-	-	-	0.047	-	-	-	-
				(0.059)				
×Lower stream industries	-	-	-	0.060	-	-	-	-
				(0.044)				
Indirect supports	-	-	-	-	0.044	-	-	-
					(0.049)			
×Upper stream industries	-	-	-	-	-	0.032	-	-
						(0.071)		
×Lower stream industries	-	-	-	-	-	0.051	-	-
						(0.046)		
Direct supports	-	-	-	-	-	-	0.010	-
							(0.052)	
×Upper stream industries	-	-	-	-	-	-	-	0.001
								(0.060)
×Lower stream industries	-	-	-	-	-	-	-	0.023
								(0.054)
Environmental consciousness	-0.003	-0.002	-0.029	-0.032	-0.022	-0.024	-0.013	-0.020
	(0.057)	(0.055)	(0.052)	(0.058)	(0.055)	(0.058)	(0.059)	(0.066)
Difficulty in CO_2 measurement	0.024	0.016	0.025	0.021	0.023	0.020	0.025	0.022
	(0.061)	(0.067)	(0.059)	(0.067)	(0.060)	(0.067)	(0.062)	(0.067)
Relationship-specific investment	0.040	0.040	0.035	0.032	0.038	0.035	0.040	0.037
	(0.038)	(0.037)	(0.038)	(0.036)	(0.038)	(0.037)	(0.038)	(0.037)
Supplier concentration	-0.011	-0.010	-0.010	-0.009	-0.009	-0.008	-0.010	-0.009
	(0.007)	(0.007)	(0.008)	(0.007)	(0.008)	(0.008)	(0.008)	(0.008)
Stringency of environmental policies	-0.079 *	-0.070 *	-0.088 *	-0.083 **	-0.073	-0.068 *	-0.074	-0.065
	(0.047)	(0.041)	(0.048)	(0.041)	(0.048)	(0.039)	(0.052)	(0.042)
ISO 14001 dummy	0.339	0.347	0.376	0.384	0.359	0.366	0.341	0.351
	(0.280)	(0.254)	(0.258)	(0.259)	(0.265)	(0.264)	(0.273)	(0.273)
Firm size	-0.034	-0.033	-0.034	-0.033	-0.039	-0.039	-0.033	-0.032
	(0.039)	(0.040)	(0.038)	(0.038)	(0.039)	(0.039)	(0.042)	(0.043)
ROA	-0.989	-0.825	-0.897	-0.851	-0.951	-0.905	-1.009	-0.961
	(0.713)	(0.668)	(0.722)	(0.698)	(0.747)	(0.729)	(0.708)	(0.703)
DTE	-0.060	-0.055	-0.060	-0.058	-0.067	-0.064	-0.068	-0.064
	(0.059)	(0.054)	(0.057)	(0.055)	(0.064)	(0.062)	(0.065)	(0.062)
Advertising expensiture ratio	-0.674	-0.928	-0.544	-0.647	-0.264	-0.309	-0.524	-0.533
	(1.492)	(1.664)	(1.446)	(1.511)	(1.652)	(1.703)	(1.637)	(1.717)
Free float weight	-0.410	-0.507	-0.434	-0.447	-0.425	-0.447	-0.423	-0.464
	(0.481)	(0.477)	(0.479)	(0.478)	(0.499)	(0.503)	(0.475)	(0.471)
Constant	0.410	0.373	0.367	0.352	0.415	0.405	0.381	0.348
	(0.669)	(0.667)	(0.665)	(0.649)	(0.682)	(0.678)	(0.782)	(0.764)
Observations	84	84	84	84	81	81	81	81
R^2	0.216	0.239	0.226	0.228	0.227	0.229	0.216	0.219
Difference of influence (p-value)	-	0.309	-	0.763	-	0.723	-	0.646

White-corrected standard errors are in parentheses.

*, **, and *** imply that the coefficient is significantly different from zero at the 10%, 5%, and 1% levels, respectively.