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Key factors for truly sustainable supply chain management

An investigation of the coal industry in Indonesia

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Abstract

Purpose – The purpose of this paper is to explore key factors or criteria of sustainable supply chain management (SSCM) influencing Indonesian coal companies, using "adoption, implementation, and performance" (A-I-P) of SSCM, thru three means: first, to investigate which criteria have higher weight to achieve SSCM in Indonesia; second, to see whether there are any differences between the Indonesia case and existing literature of SSCM; third, to highlight any causal relationships between the Indonesia case and the SSCM theory.
Design/methodology/approach – DEMATEL-based analytic network process (DANP) questionnaire survey with a theoretical SSCM model is applied to conduct an empirical test for the coal production and supply chain companies in Indonesia.
Findings – The "performance" dimension out of the A-I-P of the SSCM is the most important one, while the "adoption" dimension is the least. Out of the 12 criteria under the three dimensions, the "operational, economic, environmental, and social" factors under the category of the performance dimension and the "ISO 14001 certification" criteria belonging to the dimension of "implementation" are the top five key factors in the SSCM.
Research limitations/implications – There are some limitations in this study. First and foremost is the relatively small sample size with a limited geographic area, although they are unavoidable owing to one country case study.
Practical implications – The test results are helpful to draw guidance for sustainable supply chain managers in implementing efficient SSCM in the wave of tough competition and changing marketplace.
Originality/value – This study contributes first to developing a theoretical framework for SSCM under the A-I-P model and second, to applying DANP to an empirical case of SSCM of the coal industry in Indonesia. As a result, the authors draw helpful guidelines and policy implications for SSCM of the coal industry, referring to the A-I-P dimension as drivers and enablers for the SSCM performances of the industry.

Keywords Asia, DEMATEL, Critical success factors, Sustainable supply chain management, Analytic network process (ANP)

Paper type Research paper

Introduction

Supply chain management is an integrated approach to solving business problems and achieving interorganisational cooperation. It involves collaboration and partnership with network partners, who can be suppliers, third-party service providers, mediators, or customers. Recently, there has been an increase in the number of customer concerns about conditions under which products are produced and whether the products should be treated sustainably.

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Consequently, supply chain managers are concerned with not only the basic criteria for evaluating components and materials (e.g. cost, quality, and delivery) but also the solutions for reducing environmental and social impacts (Lam, 2015). A sustainable supply chain encourages practices such as the ecofriendly handling of returns, recycling, remanufacturing, and adequate waste disposal. These elements are considered crucial for performance (Zhu and Sarkis, 2004). However, concerns such as price competition and responsiveness are formidable in the adoption of sustainable practices. Pagell and Shevchenko (2014) argued that relevant studies have not sufficiently contributed towards creating a truly sustainable supply chain. They indicated three common concerns in studies that have focussed on harm reduction rather than harm elimination; presented a limited stakeholder view, the primacy of profits; and focussed mainly on the familiar and tended not to have a negative impact on economic performance. To address how to be sustainable, they encourage multidisciplinary research that could capture new and more stakeholder perspectives for radical innovation and examine potential trade-offs to yield net positive impact. They also suggest more research to be done to study "less developed parts of the world because these under-studied organisations could be sources of inspiration for how to do things differently".

Regarding various nations, Asia has been viewed as a model for new sustainable economic growth by an increasing number of economic analysts (Tse and Esposito, 2013). Asian countries heavily emphasise sustainability despite the difference in views concerning corporate social responsibility (CSR) and sustainability between Europe and Asia (Carter and Mol, 2006). In the context of Southeast Asia, particularly Malaysia, Zailani *et al.* (2012) studied the key drivers of sustainable supply chain management (SSCM) and Eltayeb and Zailani (2009) researched the level of adoption of a green supply chain among ISO 14001 certified manufacturing firms within Malaysia. While in Thailand, Sangaroon (2010) investigated the key circumstances under which the concept of SSCM can be utilised in the hotel industry. In Vietnam, Tencati *et al.* (2010) investigated the impact of more sustainable sourcing policies by many multinational companies whose suppliers are located in Vietnam.

According to reports by various media, the increasing production costs in China are driving manufacturers from China's factories to cheaper manufacturing havens in Southeast Asia, the rapidly expanding emerging market. For example, Samsung Electronics Co. is building the world's largest automobile plant in Vietnam, largely because of lower costs compared with those in China. Based on Harris (2013), many companies build facilities or offices in Southeast Asia like Thailand or Malaysia or Indonesia, believing those countries are going to thrive in the next decade as ASEAN's economic importance rises. It is predicted that after 2016, Southeast Asia may replace China as the world's new factory (Caijing, 2013). Thus, it is crucial for foreign investors to study the regulatory environment as well as sustainability aspect in Southeast Asian countries. There are also many multinational companies that have placed their factories in Indonesia such as Nike, Bayer, Loreal, and General Motors, but research on SSCM in Indonesia is still rare. Therefore, our motivation is also to study further investigation and fill the research gaps.

Indonesia is increasingly concerned with green supply chain management in tandem with greenhouse gas emission issues because it plays a vital role in the world coal markets especially as a major supplier. In 2011, Indonesia overtook Australia as the world's largest coal exporter. Indonesia consumes only approximately 17 per cent of the country's coal output for power generation and industry while the remainder is exported (Soelistijo, 2013). Because of abundant domestic supply, Indonesia's Government encourages the use of coal in the power sector for reducing the use of expensive diesel and fuel oil (EIA, 2013). Thus, 86 per cent of power in Indonesia comes from conventional thermal sources, with coal accounting for slightly more than half of it. In addition, many industrial sectors in Indonesia, such as cement, ceramics, pulp and paper, iron, steel, textiles, and food manufacturing, are using coal privately for their source of power. Therefore, coal mining companies and coal

supply chain managers have begun to realise the significance of SSCM in addressing sustainability-related problems with several short-term, mid-term and long-term targets. For example, the targets involve constructing, reconstructing, and equipping the infrastructures, to redesign supply chains, redefine business models, develop radically and incrementally innovative clean technologies, develop efficient intermodal transport of coal, identify challenges, design innovative strategies, and adapt to new legislation, regulations, laws, and policies. All these targets contribute to creating a platform for stakeholders to develop their sustainable strategy and improve profitability while remaining competitive in the marketplace.

Moreover, recently, social security and environmental issues in Indonesia have become part of the national agenda to achieve sustainable goals and positively contribute to the bottom line of organisations. This background of the coal industry and its supply chain in Indonesia has motivated us to explore key factors or criteria of SSCM influencing Indonesian coal companies, using the adoption, implementation, and performance (A-I-P) of SSCM. Identification of such key factors is achieved by three means: first, to investigate which criteria have higher weight to achieve SSCM in Indonesia; second, to determine whether there are any differences between the Indonesia case and the literature on SSCM; and, third, to highlight any causal relationships between the Indonesia case and SSCM theory. This achievement would contribute to adding value to knowledge and drawing implications for managers in the industry. Thus, we apply a novel multicriteria decision-making method, the DEMATEL-based analytic network process (DANP), which is not only more suitable than the analytical network process (ANP) that Seuring (2013) used for SSCM assessment, but also has not been attempted in the studies on SSCM topics. A questionnaire survey with a theoretical SSCM model having three dimensions and 12 criteria is administered to actors in coal production and supply chain companies including big coal consumers in Indonesia. The findings in this paper are expected to help supply chain managers and stakeholders involved in the coal supply chain systems in Indonesia, whether local, foreign, or both, as a reference for their companies in implementing an efficient SSCM in the wave of tough competition and the changing marketplace.

The remainder of this paper is structured as follows: second section addresses the literature review of SSCM fundamentals. Third section explains the methodology of the DANP adopted in this paper and the development of the dimensions. Fourth section presents the data process and analytical results based on the questionnaire survey. Fifth section addresses discussions on managerial implications of SSCM of the Indonesian coal industry. Finally, sixth section presents the conclusion, future research, and research limitations.

Literature review

Recently, the topic of SSCM has received growing attention. Although the literature is still developing, most papers addressing sustainable dimensions began appearing in 2002 (Seuring and Muller, 2008). SSCM has its roots in supply chain management, which is based on the adoption and extension of its concepts and incorporation with promising organisational theories (Sarkis *et al.*, 2011). SSCM studies have broadly covered nine overlapping boundaries and five major interrelated flows (Sarkis, 2012). By incorporating the aspect of sustainability, SSCM is referred to as an integration of social, environmental, and economic issues (Carter and Rogers, 2008). Shrivastava (1995, p. 955) defined ecological sustainability as "the potential for reducing long-term risks associated with resource depletion, fluctuations in energy costs, product liabilities, and pollution and waste management". This definition focusses more on the ecological point of view without considering the social aspects explicitly. By contrast, Sikdar (2003, p. 1928) adopted a macro-viewpoint that includes social, environmental, and economic aspects, suggesting that sustainability is "a wise balance among economic development, environmental stewardship,

and social equity". Therefore, SSCM is not simply an academic research topic but has attracted attention from various corporate interests.

SSCM has become an industrial practice, in which several companies have recently announced the adoption of sustainability values as part of their corporate culture; for example, Coca Cola, Apple (Kumar and Teichman, 2012), British Aerospace (Gopalakrishnan, 2012), Toyota, Subaru (Hassini *et al.*, 2012), Herman Miller, Hewlett Packard, Timerland, and Xerox (Lakshmi and Visalakshmi, 2012). The supply chain manager plays an essential role in implementing environmental and social sustainability more thoroughly than any other agent does in the entire organisation (Preuss, 2005), by removing impediments to work conditions in warehouses to improve the performance of sustainability, using more fuel-efficient transport and requiring suppliers to undertake environmental and social programmes (Carter and Rogers, 2008). The above cases show the significance of the A-I-P of sustainability in SSCM. This paper employs this theoretical structure of SSCM to explore key factors in it, taking the sustainability case in the Indonesian coal industry.

Hassini *et al.* (2012, p. 75) investigated the internal and external forces of SSCM adoption based on extensive reviews and analysis of the literature published in 2000-2010, mainly from the perspectives of the social and applied sciences, and enumerated nine factors that impel supply chains to adopt sustainable operations: (1) market forces, (2) policy and regulations, (3) science and technology, (4) product development, (5) process capability, (6) sourcing and operations, (7) transport and logistics, (8) marketing and public relations, and (9) social issues. These nine factors are all reflected in the A-I-P model of SSCM. However, items (3), (4), (5), and (6) can be considered internal factors, whereas item (9) coincides with social performance, which is addressed subsequently regarding the performance of SSCM. Concerns about policy and regulations from government, market forces, and stakeholders, as well as customer expectations about global warming and the depletion of natural resources (e.g. coal), have forced the supply chain within organisations to adopt sustainable operations. In other words, the adoption factor of a sustainable policy or strategy is a critical dimension in SSCM. Thus, the adoption of SSCM factors in the Indonesian coal industry case includes four of the nine factors in Hassini *et al.* (2012): market forces, policy and regulations, internal factors, and marketing and public relations.

Relevant studies have addressed the importance of institutional/stakeholder pressure on the adoption of sustainable operations, although training could be an aid to the sustainable development with the resource engagement of larger organisations to deliver general awareness-raising topics (Sarkis *et al.*, 2010). Kim and Lee (2012) determined relationships between stakeholder pressure and the adoption of environmental logistics practices, which are fully mediated by the corporate ecooriented culture. Hoejmose *et al.* (2012) showed that in the business-to-business sector, trust development among supply chain partners and top management support is a key driver of SSCM engagement. However, the results of Tate *et al.* (2014) did not support the influence of institutional pressure but demonstrated that the adoption of an environmental practice is more likely if the information-seeking cost is low or the cost of maintaining the relationship is justifiable. Hazen *et al.* (2011) reported that the adoption of SSCM practices may not contribute to competitive advantages in the case of green reverse logistics. In addition, brand-new products and those consisting of recycled materials elicit indifferent consumer perceptions, whereas reused and remanufactured products are considered low quality. Their study also indicated that considerations of adoption might vary among supply chains. Therefore, it is worth investigating the importance of the adoption of factors of SSCM and their influence on supply chain performance.

The purpose of the implementation of SSCM in the coal industry is to eliminate or minimise waste, such as energy, emissions, chemical/hazardous, and solid wastes, and to

minimise negative by-products of supplied coal, such as dust caused by coal-grinding, soils in mining, coal loss and noise caused by truck transport, and flooding or landslides caused by mountain deforestation. To mitigate the negative outcomes, a barge transport system plus canal construction under the tailored coal maritime logistics programme was attempted in the Kalimantan region (Lee, 2004; Song and Lee, 2009). However, coal transport from mining areas to storages and loading centres for exports causes environmental problems that are sustainable in the mid- and long-term, such as consumption of nonrenewable resources, generation of air emissions in the production, transport and use, and production of solid waste leading to disposal in landfill. These problems are attributable to the vague responsibility among supply chain stakeholders, who have not taken initiatives to improve the overall solution that can simultaneously meet the needs of the supply chain's operating environment and reduce the environmental impact and supply chain costs. Therefore, sustainable coal products are required for implementing a green supply chain, which requires cooperation with a supplier to achieve SSCM goals. Other environmentally friendly practices are related to the coal industry, which is evident throughout the coal supply chain ranging from green design, green procurement practices, total quality environmental management, environmentally friendly loading/discharging, and transport. Azevedo *et al.* (2012) concluded that the reasons for implementing green supply chain practices are to increase resource utilisation through ecodesign and waste reduction, to improve environmental monitoring, business ethics and transparency according to the ISO 14001 certification, and to reduce lead time, inventory levels, and energy consumption for pollution prevention. Nevertheless, receiving this certification is costly and time consuming for suppliers. Therefore, using current certifications to encourage more supplier cooperation was suggested (Tate *et al.*, 2014). Regarding the second dimension in the A-I-P model (i.e. the "implementation" of SSCM in the coal industry), this paper refers to the following criteria: waste reduction, the ISO 14001 certification, ecodesign, and pollution prevention.

Concerning the third dimension of SSCM (i.e. "performance" in this paper), the sustainable evaluation and verification in supply chains should comprise three dimensions: inclusivity, scope, and disclosure, which help characterise how supply chains can collect, evaluate, and verify information by considering diverse stakeholder perspectives (Gualandris *et al.*, 2015). Driven and influenced by the three antecedents of firm capabilities, stakeholder salience, and supply chain integration, the evaluation and verification system can yield three distinct outcomes: risk avoidance, efficiency, and stakeholder credibility. There are various benefits of implementing SSCM including enhanced reputation, social quality, optimal inventory, lead time, and cost control. These benefits should be considered for the short-, mid-, and long-term competitive advantages for companies and their suppliers, because reputation-related sustainability is a major concern of the coal industry. Measuring sustainable coal supply chain performance involves focussing more on how well the supply chain activities or practices undertaken by the coal company cut across the three facets of sustainability, which are the economic, environmental, and social aspects. The social and environmental supply chain activities that intersect the economic bottom line are deemed sustainable. Gunasekaran and Patel (2004) identified four factors of SSCM performance: those that are operational, economic, environmental, and social. Zailani *et al.* (2012) validated these four factors by using varimax rotation to show the dimensionality and appropriateness of the measurement scale. Therefore, this paper assumes that the performance of SSCM is measured according to the following four criteria: operational, economic, environmental, and social aspects.

The A-I-P model comprehensively covers the main themes of relevant literature, including the external environment, internal environment, implementation, and performance issues (Hoejmose and Adrien-Kirby, 2012). Unsurprisingly, the three dimensions of A-I-P influence each other. For example, Lee and Lam (2012) conducted an

extensive literature review of sustainable reverse logistics and an in-depth case study to devise several propositions. They suggested that "green market development has a positive effect on sustainable operations management", "green market development will lead to sustainable outcomes on customer acquisition having high economic, environmental, and social performance", and "sustainable operations management will lead to sustainable outcomes on customer acquisition having high economic, environmental and social performance". Therefore, the A-I-P of SSCM should be considered in an integrated model for carefully examining their interrelations. However, most SSCM studies have been conducted in industrialised countries. Outcomes that conflict with those of a case study in Malaysia, Zailani *et al.* (2012) – particularly SSCM factors in emerging countries such as Indonesia – are worthy of reexamining. In summary, our literature review of SSCM led us to use three dimensions (i.e. A-I-P) and 12 criteria for SSCM (Table I) for exploring the key factors of the A-I-P model of SSCM, investigating an Indonesian coal industry case. This study focusses on insufficiencies in the literature where mixed methods are less addressed and most of the related studies have been conducted in the USA or other developed countries (Hoejmose and Adrien-Kirby, 2012).

The analytical hierarchy process (AHP) is one of the conventional modelling techniques for performance evaluation (Lam and Zhang, 2014) and SSCM assessment (Seuring, 2013). Both the AHP and ANP can help elicit decision makers' preferences over numerous criteria which can be tangible or intangible, subjective or objective, and quantitative or qualitative. Although the AHP has wide applications (Sipahi and Timor, 2010; Saaty, 2013) and is simpler and less time consuming than its generalisation (i.e. the ANP), this paper applies the ANP by considering the complexities of the interrelations and interdependencies among SSCM dimensions and criteria that the AHP has not reflected. This is partly because, according to Saaty (2001), decision and evaluation problems of intradependence and/or interdependence among criteria or alternatives should be addressed by applying the ANP, and partly because Lee *et al.* (2013, 2016) have reconfirmed that the ANP is more meaningful in evaluating criteria of waterfront development projects that involve complex interrelations among criteria. Lam and Dai (2015) also applied the ANP to analyse the interrelations among various customer and design requirements and to determine the relative importance of multiple criteria that help logistics service providers develop environmental sustainability performance.

However, the ANP requires undertaking troublesome efforts such as completing complex and lengthy questionnaires. Numerous studies have integrated the ANP with DEMATEL by establishing a threshold for filtering less critical dependences. Thus, the number of pairwise comparisons can be significantly reduced to avoid possible invalidity because of respondents' impatience (Ou Yang *et al.*, 2008). Moreover, DEMATEL is widely applied in various research fields such as agriculture (Kim, 2006), marketing and consumer behaviour (Hsu *et al.*, 2007), product innovation (Hajime and Kenichi, 2007), airline safety (Liou *et al.*, 2008), clinical decision support (Jeng and Tzeng, 2012), and identification of cognition maps of financial ratios (Lee and Lin, 2013). In addition, a hybrid method of DEMATEL and the ANP is applied to airline safety measurement (Liou *et al.*, 2007), municipal solid waste management (Tseng, 2009), managing sustainable development in small-medium enterprise (SME) (Tsai *et al.*, 2009), cost of quality model selection (Tsai and Hsu, 2010), supply chain planning (Hung, 2011), and organic light emitting diode (OLED) technology selection (Shen *et al.*, 2011).

The latest development of the hybrid method is moving towards the DANP, which not only takes advantage of the less complex questionnaire of DEMATEL but also transforms the total influence matrix into an unweighted supermatrix of the ANP. Consequently, it allows the questionnaire respondents to forgo completing the ANP questionnaire, thereby reducing the number of time-consuming pairwise comparisons among criteria with respect

Dimension/criteria	Contents
1. Adoption	
1-1 Market forces	Include consumers and retailers
	Suppliers may demand green products
	Financial stakeholders and shareholders
	Competitor's actions
1-2 Policy and regulations	Government regulatory requirements
	Environmental standards among industries
	Specific regulations such as ROHS and WEEE regulate life-cycle related impact
1-3 Internal factors	Include top management vision
	Supplier's sustainable initiatives
	Employees commitment
1-4 Marketing and public relations	Nongovernmental organisations campaign towards environmental products
	The use of logos and cobranding to convince customers
	Nature of business to increase sales
2. Implementation	
2-1 Waste reduction	Reuse/remanufacturing and/or recycling materials
	Savings from packaging
	Attempts to manage by-products
2-2 ISO 14001 certification	Benchmark for environmental management system
	International standards
	Provide information on the organisation's environmental performance
2-3 Ecodesign	Green initiatives and practices
	Development of environmental technologies
	Use of biodegradable materials
2-4 Pollution prevention	Avoid the use of harmful/hazardous materials
	Use of renewable energy
	Reduce carbon footprint
3. Performance	
3-1 Operational	Cost savings
	Flexible to meet individual customer requirements
	Improve delivery speed (reduction in lead time)
3-2 Economic	Quality of logistics and customer service
	Efficiency in production management
	Quick responsiveness
3-3 Environmental	Reduce greenhouse gas emissions
	Avoid depletion of natural resources
	Waste reduction into landfill
3-4 Social	Health and safety in working environment
	Harmonious relationship between company and employees
	Reduce noise emissions

Source: The Authors (2016)

Table I.
Contents of dimensions and criteria for SSCM

to a given criterion. The DANP is widely applied in the fields of knowledge management (Wu, 2008), the balanced scorecard for hot spring hotels (Chen *et al.*, 2011), equity investment (Lee *et al.*, 2011), vendor selection (Yang and Tzeng, 2011), brand marketing (Wang and Tzeng, 2012), e-store business (Chiu *et al.*, 2013), and information security management (Ou Yang *et al.*, 2013). Having considered the advantages and benefits of the DANP, we apply it to test the A-I-P model of SSCM and to prioritise the underlying 12 criteria for trade-offs. It is worth noting that decision makers in SSCM are always making decisions under various constraints including conflicting priorities that need trade-off to yield net positive impact (Roehrich *et al.*, 2014).

Method

Dimensions, criteria, and their relationships in the network

Referring to contents of dimension and criteria for SSCM, this study proposes a theoretical model of SSCM key factors comprising three dimensions: adoption, implementation, and performance, each of which consists of four criteria (Figure 1). The A-I-P dimensions and the four criteria in each dimension are apparently influencing among them.

Questionnaire and DANP

Regarding the direct influence scores among criteria input by respondents (Table II), DEMATEL enables investigating influential relations among assessments of total direct and indirect influences. Dimensions and criteria share the same input data structure except that the former utilises a 3×3 input matrix whereas the latter applies a 12×12 one. Following the DEMATEL calculation process, the sum of influences given and received on criteria help identify driving and affected factors.

Details of DEMATEL and DANP procedures are available in Lee *et al.* (2010, 2011), Chen *et al.* (2011), Yang and Tzeng (2011), Wang and Tzeng (2012), Chiu *et al.* (2013), and Ou Yang *et al.* (2013). This paper applies their standard steps of the DANP as follows:

- Step 1: calculate the direct influence matrix by scores.
- Step 2: normalise the direct influence matrix.
- Step 3: attain a total influence matrix.
- Step 4: analyse the results.
- Step 5: find the normalised total influence matrix.

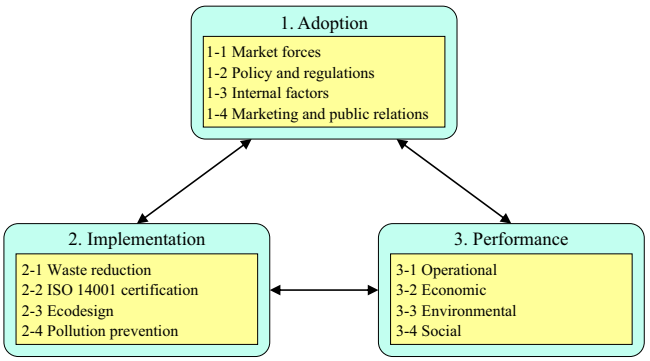


Figure 1. Theoretical model of SSCM: A-I-P dimensions and criteria

→	A	B	C	D
A	–	4[a]	2	0
B	0	–	1	4
C	1	2	–	2
D	3	4	0[b]	–

Notes: 0 – no influence; 1 – low influence; 2 – medium influence; 3 – high influence; 4 – very high influence. [a]Criterion A has very high influence on criterion B, considering its importance; [b]criterion D has no influence on criterion C, considering its importance

Table II. Illustrative input direct influence matrix

- Step 6: find the normalised matrix by dimensions and criteria.
- Step 7: build an unweighted supermatrix.
- Step 8: find the influential weights of the DANP.
- Step 9: draw the influential network relationship map (INRM).
- Step 10: draw the cause-effect diagram.
- Step 11: obtain the global weights of criteria by the limit supermatrix of the DANP.

Data collection and empirical test results

Sample data structure analysis

The population frame of this study consists of coal mining industry and related organisations, comprising of supply heavy instruments (sales and distribution), financial service, and laboratory testing and analysis service issuing certifications for management systems (service provider). Because coal is the most abundant fossil fuel and relatively cheaper than oil and gas, it has been used by many manufacturing firms to generate power and electricity. According to Li and Ragu-Nathan (2006), large companies are more concerned about supply chain practices of coal than small companies. Hence, the majority sampling for this study covers large manufacturing companies in Indonesia because they are expected to adopt sustainability in their supply chains rather than a SME. Questionnaires were distributed by e-mail to large companies involving in coal supply chain in Indonesia and were collected from August 2013 to September 2013. To overcome certain difficulties in obtaining data and to have in-depth information, we had the opportunity to directly access the companies of which headquarters are mostly located in Jakarta area for face-to-face meetings. We finally collected 35 completed questionnaires and all of them were valid for the DANP test. Table III shows the profile of the respondents with their descriptions.

The profile of respondents is consistent with the objectives of this study because the respondents are directly concerned with sustainability. More than 70 per cent of the respondents are in charge of sustainable supply management: 11 (31.4 per cent) are supply

Respondent type	Respondent descriptions	Frequency	Percentage
Respondent job	Supply chain manager	11	31.4
	Supply and purchasing manager	14	40.0
	Director	6	17.1
	Marketing and sales manager	3	8.6
	Other profiles	1	2.9
Firm type	Manufacturing	19	54.3
	Power generation and distribution	2	5.7
	Sales and distribution	5	14.3
	Logistic and service provider	9	25.7
Owner of the firms	Local	29	82.9
	Foreign	1	2.9
	Joint venture between local and foreign	5	14.3
Age of the firms	More than 15 years ($Y \geqslant 15$)	28	80.0
	Less than 15 years ($Y < 15$)	7	20.0
Firm size	Fewer than 100	8	22.9
	Between 100 and 1,000	17	48.6
	More than 1,000	10	28.6

Note: $n = 35$

Table III.
Profile of the respondents

chain managers and 14 (40 per cent) are supply and purchasing managers. Regarding the remainder of the respondents, six (17.1 per cent) are directors, three (8.6 per cent) are marketing and sales managers, and one (2.9 per cent) is other managerial staff.

This paper explores key factors of SSCM across a wide spectrum of sectors in the coal industry; thus, the samples are not restricted to a specific sector or a set of company characteristics: 19 companies (54.3 per cent) are linked to the manufacturing sector, nine (25.7 per cent) to service providers, five (14.3 per cent) to sales and distribution, and two (5.7 per cent) to power generation and distribution. Of 35 companies, 29 (82.9 per cent) are fully Indonesian owned firms whereas five (14.3 per cent) are joint ventures between local and foreign entities, and one (2.9 per cent) is a foreign firm. In total, 28 companies (80 per cent) of the total sample have been operating for more than 15 years and the remainder (20 per cent) for less than 15 years. Of 35 companies, 10 (28.6 per cent) employ more than 1,000 people, 17 companies (48.6 per cent) employ 100-1,000 people, and 8 companies (22.9 per cent) have less than 100 employees. In our sample, 77.1 per cent of the companies are large corporations, of which 48.6 per cent are considered multinational enterprises because they produce or sell goods or services in various countries. However, the remaining 22.9 per cent are considered SMEs.

Of the large companies employing more than 1,000 people, Astra Group and Sinar Mas Group (with coal mining business sectors) were listed on the top 25 most profitable companies in Indonesia in 2013. Both of them were featured in the Fortune 100 ranking in Indonesia. Orang Tua Group has an arm of international sales of coal in conjunction with transport and logistics services, as one of the top three fast-moving consumer goods companies in Indonesia that produce a wide range of products. The group is a large customer of coal-based electricity. Another respondent company, ABC President, is a joint venture between PT ABC Central Food of Indonesia and Uni-President Enterprises Corporation of Taiwan, and has been the major noodle provider in Indonesia. The company consumes coal for their own boiler to generate electricity at their manufacturing plant in Karawang, Jawa Barat.

Test results and discussions

The respondents were asked to determine the direct influence relations among the three dimensions and 12 criteria. The average input direct influence matrices for dimensions and criteria are shown in Tables IV and V, respectively. After obtaining these inputs, DEMATEL further processes the normalised direct influence matrices, the total influence matrices. Furthermore, the total-influence given and received according to each dimension and criterions can be summarised, as shown in Tables VI and VII. Based on the prominences and relations summarised in Tables VI and VII, the INRM can be drawn to visualise the cause-effect relationship (Figure 2).

The DANP steps facilitate obtaining the global relative weight of each criterion (Table VIII), to determine the primary criteria that must be considered for achieving SSCM in Indonesia. Table VIII shows that among 12 criteria, respondents believe that "3-1 Operational" should be the first priority with a weight of 0.0978, followed by "3-3 Environmental" (0.0901). The 3rd to 12th factors in order of importance from greatest to

Dimension	1	2	3	Sum
1. Adoption	0.000	2.371	3.029	5.400
2. Implementation	1.943	0.000	3.029	4.972
3. Performance	2.800	2.800	0.000	5.600
Sum	4.743	5.171	6.058	–

Table IV. Average input direct influence matrix of dimensions

Table V.
Average input direct influence matrix of criteria

G	1-1	1-2	1-3	1-4	2-1	2-2	2-3	2-4	3-1	3-2	3-3	3-4	sum
1-1	0.000	2.429	2.857	3.314	2.171	2.686	2.257	2.486	2.886	3.171	2.200	2.543	29.000
1-2	3.029	0.000	3.000	2.971	3.400	3.343	2.371	2.886	2.971	2.743	2.943	2.714	32.371
1-3	2.371	2.343	0.000	2.486	2.600	2.600	2.371	2.286	3.143	2.800	2.257	2.371	27.629
1-4	3.514	2.686	2.400	0.000	2.514	3.086	2.771	1.686	2.457	3.029	2.086	2.914	29.143
2-1	1.800	2.686	2.257	2.429	0.000	2.857	2.657	3.314	2.943	2.229	3.486	2.400	29.057
2-2	2.771	2.686	2.686	3.257	2.971	0.000	3.086	2.943	3.257	2.029	2.714	2.229	30.629
2-3	1.714	2.429	1.914	2.686	2.771	2.800	0.000	2.543	2.714	2.086	2.943	1.771	26.371
2-4	1.857	2.886	2.143	1.771	3.343	3.314	2.714	0.000	2.286	1.971	3.257	2.400	27.943
3-1	2.971	3.086	3.057	2.943	2.400	2.971	2.686	2.429	0.000	3.229	2.400	3.057	31.229
3-2	3.171	2.457	2.771	3.171	1.686	1.857	2.200	1.971	3.029	0.000	2.000	2.543	26.857
3-3	2.114	2.743	2.114	1.943	3.029	3.029	2.600	3.143	2.457	2.143	0.000	2.743	28.057
3-4	2.514	2.114	2.714	2.800	2.143	2.314	2.229	2.286	3.171	2.400	2.371	0.000	27.057
Sum	27.829	28.543	27.914	29.771	29.029	30.857	27.943	27.971	31.314	27.829	28.657	27.686	–

Table VI.
Sum of influences given and received on dimensions

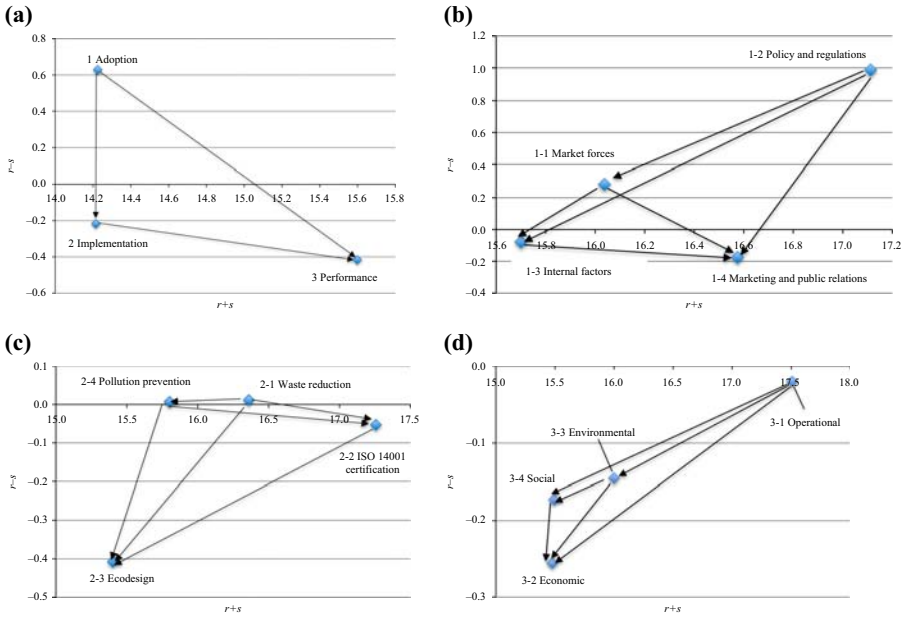
Dimension (i)	r_i	s_i	$r_i + s_i$	$r_i - s_i$
1. Adoption	7.427	6.797	14.224	0.630
2. Implementation	6.999	7.215	14.214	−0.216
3. Performance	7.592	8.006	15.598	−0.414

Table VII.
Sum of influences given and received on criteria

Criteria (i)	r_i	s_i	$r_i + s_i$	$r_i - s_i$
1-1 Market forces	8.161	7.877	16.037	0.284
1-2 Policy and regulations	9.051	8.058	17.109	0.993
1-3 Internal factors	7.812	7.887	15.699	−0.075
1-4 Marketing and public relations	8.200	8.371	16.572	−0.171
2-1 Waste reduction	8.185	8.174	16.359	0.012
2-2 ISO 14001 certification	8.601	8.654	17.255	−0.052
2-3 Ecodesign	7.496	7.903	15.400	−0.407
2-4 Pollution prevention	7.904	7.897	15.801	0.007
3-1 Operational	8.741	8.759	17.500	−0.019
3-2 Economic	7.608	7.863	15.471	−0.255
3-3 Environmental	7.925	8.070	15.995	−0.145
3-4 Social	7.657	7.829	15.486	−0.172

least are "3-2 Economic" (0.0877), "3-4 Social" (0.0873), "2-2 ISO 14001 Certification" (0.0868), "2-1 Waste Reduction" (0.0820), "1-4 Marketing and Public Relations" (0.0805), "2-3 Ecodesign" (0.07932 ≈ 0.0793), "2-4 Pollution Prevention" (0.07926 ≈ 0.0793), "1-2 Policy & Regulations" (0.0776), "1-3 Internal Factors" (0.0759), "1-4 Market Forces" (0.0758). Among the top five criteria, there are four under the dimension of "3 Performance" and only one under the dimension of "2 Implementation". This confirms that SSCM performance is the most crucial dimension with its four key factors (i.e. criteria code 3-1, 3-3, 3-2, and 3-4 in order of importance) for companies to adopt SSCM.

The findings of DEMATEL allow the companies to improve their performance based on the criterion that most influences the others (Tsai *et al.*, 2009). The positive value of relation, $r_i - s_i$, means that the given factor (dimensions or criteria) influences the others. By contrast, the negative value of $r_i - s_i$ means that the given factor (dimensions or criteria)



Notes: (a) INRM of the A-I-P dimensions; (b) INRM of the adoption criteria; (c) INRM of the implementation criteria; (d) INRM of the performance criteria

Figure 2. Influential network relations map (INRM) of the A-I-P model: dimensions and criteria)

Dimension	Criteria	Weight	Rank
1. Adoption	1-1 Market forces	0.0758	12
	1-2 Policy and regulations	0.0776	10
	1-3 Internal factors	0.0759	11
	1-4 Marketing and public relations	0.0805	7
2. Implementation	2-1 Waste reduction	0.0820	6
	2-2 ISO 14001 certification	0.0868	5
	2-3 Ecodesign	0.0793	8
	2-4 Pollution prevention	0.0793	9
3. Performance	3-1 Operational	0.0978	1
	3-2 Economic	0.0877	3
	3-3 Environmental	0.0901	2
	3-4 Social	0.0873	4

Table VIII. Global weights of criteria by the limit supermatrix of DANP

is influenced by the others. According to Table VI and Figure 2(a), the dimension "3 Performance" is of strongest influence given and received (15.598 in total $(r_3 + s_3)$, so-called prominence. In addition, the dimension "3 Performance" has the most negative value of $r_i - s_i$. In other words, "3 Performance" is shown to be the most crucial influenced dimension, whereas "1 Adoption" is influencing both "2 Implementation" and "3 Performance", and "2 Implementation" is also influencing "3 Performance".

In addition, Table VII shows the extent of the influence of each criterion, and whether it directly or indirectly affects other criteria. In the dimension of "1 Adoption" (Figure 2(b)), policy and regulations (1-2) is the first according to the index of strength of influence given and received, followed by market forces (1-1) and marketing and public relations (1-3) in order.

The policy and regulations (1-2) is shown to be the cause factor. The dimension of "2 Implementation" in Figure 2(c) shows that waste reduction (2-1) is the first according to the index of strength of influence given and received, followed by pollution prevention (2-4) and ISO 14001 certification (2-2) in order. The waste reduction (2-1) is the cause factor, while the ecodesign (2-3) is the effect factor. Within the dimension "3 Performance", "3-1 Operational" exerts the strongest influence given and received, followed by "3-3 Environmental", "3-4 Social", and "3-2 Economic" in order (Figure 2(d)). All of the criteria in the dimension "3 Performance" have negative values of $r_i - s_i$ which show that these criteria are influenced by other criteria.

The aforementioned relationship can be further categorised into four types based on the cause-effect diagram as shown in Figure 3. In particular, DEMATEL can detect four typical factors: core factors, driving factors, independent factors, and influenced factors according to the values of relation and prominence:

- Core factors have positive relation ($r_i - s_i$) values and high prominence ($r_i + s_i$) values.
- Driving factors are criteria with positive relation ($r_i - s_i$) values but low prominence ($r_i + s_i$) values.
- Independent factors are criteria with negative relation ($r_i - s_i$) values and low prominence ($r_i + s_i$) values.
- Influenced factors are criteria with negative relation ($r_i - s_i$) values and high prominence ($r_i + s_i$) values.

The core factors and driving factors are considered "cause" factors whereas the independent factors and influenced factors are considered "effect" factors. In Figures 3, "1-1 "Market Forces", "1-2 Policy & regulations", "2-1 Waste reduction", and "2-4 Pollution prevention" belong to cause factors, whereas the others are considered effect factors. It implies that SSCM managers should pay attention to the aforementioned four cause factors to improve the performance of SSCM rather than the effect factors.

Our findings are consistent with Azevedo *et al.* (2012) who concluded that ecodesign, waste reduction, ISO 14001 certification, and pollution prevention are the main variables

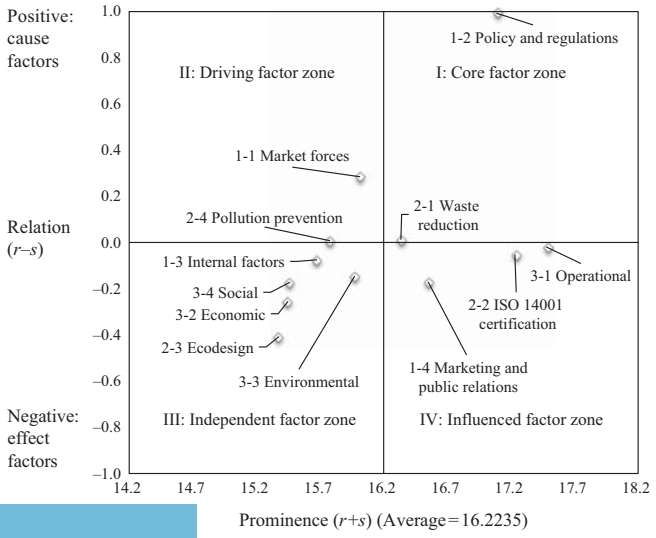


Figure 3.
Cause-effect diagram of the A-I-P criteria

affecting operational, economic, social and environmental performance of green supply chain practices. Similarly, Unilever Indonesia (2011) supports our empirical test results of the Indonesian case; the company has been working on a sustainable plan for improving health and well-being, reducing environmental impacts, and enhancing the quality of life of people (employees). In addition, Sinar Mas Group, as one of the largest conglomerates in Indonesia, which produced 5.3 million tons of coal in 2014, is in line with our findings; the company has directed their employees to implement polices related to environmental, social and economic performance (APP Sustainability Report, 2010). The sustainability report of Sinar Mas Group highlighted the operational performance above those three sustainability pillars: economic, social, and environment as the baseline of their sustainability initiatives. The group has been forced by their stakeholders, governments, and leading NGOs to implement sustainable activities that achieve economic, environmental, and social performance.

Moreover, another Indonesian conglomerate company, Astra (2010), has implemented sustainable development policy through a broad range of community centric health, awareness education, improvement in social economies, and donations, from economic (profit), social (people), and environmental (planet) viewpoints. As the winner of The Most Consistent and Commitment in Indonesia Sustainability Report Award 2010, Astra Group (Astra, 2010) also paid attention to their stakeholders including shareholders, employees, government, the surrounding community and the environment to pursue environmental management measures through various natural resource and energy conservation programmes which pays due regard to environment and social aspects. Operational principle is one of the factors that drives Astra Group achieved outstanding accomplishment (Astra, 2010). Understanding these influential relationships enables managers to make decisions.

Our empirical test results also support the case study in Malaysia (Zailani *et al.*, 2012) which found that implementation practice of sustainable packaging does not have positive effect on operational outcome. In Table VII, all criteria within "3 Performance" are influenced factors; that is, values of $r_i - s_i$ are negative. Conversely, values of $r_i - s_i$ within "2 Implementation" are either negative or approaching zero, meaning that none of the above are influencing factors. Zailani *et al.* (2012) found numerous conflicting outcomes to previous studies. Implementation practice of environmental purchasing was not found to have a positive effect on environmental performance, highlighting possible reasons that the environmental performance may contribute to external parties rather than the firm itself and that environmental performance indicators lack visibility in the emerging country like Malaysia. This observation is contradictory to the findings of Bjorklund (2010), who showed that increased focus on the purchasing function reduces the impact on the natural environment. The results also conflict with the suggestions of Zhu *et al.* (2005), who showed that environmental supply chain management has a positive impact on company's operational performance. Similarly, our results also contradict the findings of Pagell *et al.* (2007), who reported that environmental investments made over a two-year period were positively related to operational performance at the end of that two-year period. Therefore, it is worth reexamining the influence and causal relation of those factors in the emerging country like Indonesia. Indonesia and Malaysia are two neighbouring countries having common similarities in various aspects such as history, culture, language, and religion. Our test result shows that the results of studies on SSCM in Malaysia are applicable to Indonesian situations.

Montalvo (2008) found that the factor of adoption, similar to market forces, is considered a driver for companies to improve their performance through product innovation or implementation of green supply chain. Therefore, it can be said that there are a couple of ways for companies to develop a sustainable supply chain. For example, close collaboration between a company and environmental NGOs helps the company to implement

environmentally friendly programmes by using new technologies or new green products, reducing costs and resulting in higher operational performance (Stafford *et al.*, 2000). These previous findings are largely consistent with our findings in Indonesia, because the performance criterion has the lowest degree of influence received from all others; in other words, performance of SSCM is greatly influenced by factors of the adoption and implementation of green supply chains in the context of the A-I-P model in this paper, according to $r_i + s_i$ and $r_i - s_i$ values.

Implications and recommendation

Through the analysis in this paper, we assess the degree of influence across dimensions and criteria and also the relative importance among criteria as shown in Table I and Figure 1, regarding the Indonesian coal industry. The factors of adoption and implementation of green supply chain influence SSCM performance. This is consistent with Zhu *et al.* (2005), who showed that performance of SSCM can be improved by pressure or factors of adoption and implementation of green supply chain practices. In other words, improvement of any dimension can enhance the achievement of performance goals. Based on this study, improvement of overall perspectives, especially factors of adoption and implementation, will eventually enhance performance results.

This paper determined five criteria as the key factors of SSCM, "3-1 Operational", "3-3 Environmental", "3-2 Economic", "3-4 Social", and "2-2 ISO 14001 Certification", referring to the DANP rankings to show the importance of SSCM. This information would be helpful for companies aiming to develop SSCM in Indonesia, as a reference for their strategic planning. Referring to the top five criteria, the following recommendations are proposed to stakeholders in the coal industry to improve their business performance as well as enhance their reputation:

(1) Operational performance: in addition to assessing the dimensions of cost, flexibility, and delivery, managers should consider the supply chain's ability in day-to-day technical representation, adherence to developed schedule, ability to avoid complaints, and achievement of defect free deliveries. They should also pay attention to developing environmental innovation and programmes, which would result in higher operational efficiency. In Indonesia, most multinational companies such Sinar Mas Group, Astra Group, and Unilever have considered operational performance one of the key drivers for the sustainability of a supply chain.

(2) Environmental performance: sustainable supply chain practices tend to have positive influences on environmental performance. This environmental management results in enhanced utilisation of natural resources and improved efficiency while reducing operating costs. Environmental performance has been deemed one of the most crucial factors in SSCM. For example, the office retailer, Staples and other companies including Office Depot and Walmart once ended their relationship with Sinar Mas Group in 2008 because of their lack of progress in improving environmental performance (Burke, 2008). To address this problem, Sinar Mas Group has significantly increased spending to advance sustainability and environmental protection.

(3) Economic performance: economic performance is typically one of the most vital drivers for firms who wish to adopt SSCM especially for developing countries like Indonesia. The improvement of this type of performance by addressing environmental issues may add value to core business programmes and provide new opportunities for competition in the future. There are several ways to evaluate the sustainable economic performance such as innovations created through supplier

partnerships, total sales, the number of shareholders, promotion of new investments, establishment of new employment opportunities, and profit. In Indonesia, Astra Group focusses on the balance of financial (profit) or economic performance as well as social and environmental performance.

(4) Social performance: people's skills and their engagement in society contribute towards achieving social performance. If employees are happy with their job, they are highly motivated with their work; thus, their efficiency and performance improve. To achieve this goal, companies are encouraged to provide health and safety protection schemes for the employees, promote diversity, provide connection within and outside the community and ensure the quality of life. For a corporation to be recognised as a sustainable business in Indonesia, it needs both to conduct CSR as part of corporate sustainability management.

(5) ISO 14001 Certification: adopting an environmental management standard system evidences whether a company has implemented environmental practices. Respondents from developing Asian countries are more likely to depend on internationally recognised certification such as ISO 14001 to validate their sustainability credentials. India was ranked highest, followed by Indonesia with the highest number of professionals stating that ISO 14001 was of "essential" or "high" importance, whereas Malaysia was ranked third (Eco-Business, 2012). Indonesia has been an active market for certification against ISO standards, especially ISO 9001 (Quality Management Systems) and ISO 14001. Indah Kiat, a subsidiary company of Sinar Mas Group, was also awarded the first ISO 14001 in Indonesia, in 1996.

These five criteria are the key factors for achieving successful SSCM. Nevertheless, only one of these criteria is associated with the second dimension-implementation of green supply chain. The goal of this perspective is mainly to assess the performance of an enterprise itself, especially operational and environmental performance. In other words, managers who plan to conduct SSCM for their firm in Indonesia should consider their performance the priority. However, the overall results of DEMATEL in this paper suggest that the factors of adoption and implementation should be considered drivers and enablers for SSCM performance. Although "1-2 Policy and Regulations" and "1-1 Market Forces" are the two least crucial criteria, they are the driving factors for implementation of SSCM and its performance. The approach of the DANP to SSCM enables managers to determine how well their company has performed using SSCM.

Conclusions

This paper explores key factors that influence the adoption, implementation, and performance of SSCM, applying a DEMATEL technique in conjunction with the ANP (DANP) towards truly SSCM and investigates the coal industry in Indonesia as a research setting for the sake of capturing new and more stakeholder perspectives from the emerging countries. The DANP is a novel multicriteria decision-making method that has not been adopted in studies on SSCM assessment. A theoretical framework for SSCM comprising the three A-I-P dimensions of SSCM and 12 criteria drawn from the literature review were tested using the DANP to evaluate influential weights of the dimensions and criteria. The relative important weights are essential to explore the trade-offs among multiple economic and noneconomic criteria to yield positive net impact (Pagell and Shevchenko, 2014). The test results show that the "performance" dimension of the A-I-P is the most crucial, whereas "adoption" is the least crucial. Of the 12 criteria, the "operational, economic, environmental, and social" factors under the category of the performance dimension and the ISO 14001 certification criteria belonging to the dimension of

"implementation" are the top five key factors in SSCM. This implies that stakeholders who conduct SSCM for their firm in Indonesia should consider its performance the priority. However, considering the overall test results of DEMATEL, we should also contemplate the adoption and implementation dimension as drivers and enablers for SSCM performance, because they can be utilised in tandem with SSCM performance to identify and prioritise the factors necessary to improve and to develop a strategy map that is not only useful as a reference for the coal industry but also enhances SSCM. The supporting evidence from comparing with existing cases, particularly from the Malaysian case, shows the potential generalisation of applying the proposed A-I-P framework to other cases. The findings may be helpful for managers of SSCM in the coal industry in Indonesia, as a reference for their companies in implementing efficient SSCM in the wave of tough competition and changing marketplace.

There are some limitations in this study. First, the sample size is relatively small with a limited geographic area; however, this is unavoidable in a single-country case study. However, future studies may cover other cities on Java Island. Second, the dimensions and criteria shown in Table I might not represent the entire SSCM in the coal industry. Hence, future research may have to develop a detailed conceptualisation of SSCM, especially in the context of Indonesia and other country case studies. Third, the proposed A-I-P model was constructed primarily based on an extensive literature review. Nevertheless, the implementation dimensions and criteria were limited to studies on environmental implementations. Therefore, advancing the development of social implementation in the SSCM context is worthwhile.

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