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Performance of green supply chain management: A systematic review and meta analysis

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ABSTRACT

Environmental sustainability is nowadays driving firms to not only develop internal green activities, but also extend toward green supply chain management (GSCM). The extensive application of external GSCM by firms can be partially justified from perspective of transaction costs. GSCM practices are often considered to be prudent because studies suggested that such practices have a positive impact on firm performance according to the resource-based view. However, crucial questions still surround the practice-performance relationship. First, what is the overall relationship between GSCM practice and firm performance? Second, under what situations is the relationship stronger or weaker? To answer these questions, this paper focuses on quantitatively analyzing extant literature published in the field of GSCM. A random-effects meta-analysis is used to synthesize the empirical results of 54 selected literature with 245 effect sizes. Besides, subgroup analysis and meta-regression are applied to test potential moderators that may influence the strength of practice-performance relationship. We find that, internal and external GSCM practices are positively related, and they are both positively related to firm performance. Particularly, their relationship with environmental ($r = 0.518$) performance is the largest, followed by operational ($r = 0.481$) and economic ($r = 0.464$) performance. In addition, test of moderators discovers that industry type, ISO certification, export orientation and the cultural dimension of uncertainty avoidance all have moderating effect on the practice-performance relationship. Discussions and limitations are further addressed.

1. Introduction

These days as never before, people are much more conscious of the climate change and environmental sustainability (World development report, 2015). The constantly increasing green concerns in consumer markets as well as rapidly growing pressure from governmental regulations are now driving companies to manage their daily activities from an ecological perspective (Mutingi et al., 2014). Besides the cost, lead-time and quality, firms today need to consider the improvement of green performance as a fundamental competitive priority when doing businesses (Bloom and Morton, 1991; Azzone and Bertele, 1994). In earlier years, firms focused on the internal green measurements such as pollution control to alleviate the environmental influence of their production. Recently, external practices (e.g., green purchasing and eco-design) have started to be widely implemented because they come to realize that the environmental crisis in other firms can also bring harm to them via disruptions along the supply chain (Corbett and Klassen, 2000). Therefore, green supply chain management (GSCM) has then emerged as an important topic in both academia and practice, which requires firms to integrate environmental thinking into the whole supply chain.

Throughout the past decade, researchers have conducted a large number of relative investigations, and one of the main streams is to empirically examine the performance of GSCM, which is supposed to provide companies with constructive guidance for the adoption of specific practices (e.g., Zhu and Sarkis, 2004; Chavez et al., 2015; Govindan et al., 2015). However, the findings of prior empirical studies do not always correspond with each other, which may make practitioners confused when they intend to initiate GSCM and also prevent the further advancement of GSCM study. For instance, Rao and Holt (2005) indicated that firms adopting GSCM in Southeast Asia witness evident increases in both competitiveness and economic performance. But contrarily, Zhu et al. (2007) argued that

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little significant improvement in economic performance is found within firms adopting GSCM in China. Hence, there should now be a strong motivation for us to make a more comprehensive quantitative analysis of the prolific GSCM literature, which is able to shed light on those inconsistencies in prior empirical results by looking into potential moderators that might influence them.

Endeavors to consolidate previous empirical results of GSCM studies have also been made throughout these years. But most of them are either qualitative (e.g., Jung, 2011; Chen et al., 2013) or only based on small samples (e.g., Rao and Holt, 2005). Few of them have attempted to integrate the prior researches from a quantitative perspective. On the contrary, meta-analysis is a statistical technique designed to quantitatively synthesize research findings across a large number of studies, which has been used as an effective analysis tool in medical and clinical areas for over two decades (e.g., Lau and Chalmers, 1995; LeLorier et al., 1997; Borenstein et al., 2009; Bowater et al., 2015), and has also recently proved its efficiency in management field (e.g., Geyskens et al., 2009; Melo et al., 2009; Lu et al., 2015). The widespread use of meta-analysis attests to its growing reputation as a tool for consolidating prior knowledge and explaining mixed findings. Therefore, in our study, we abandon the traditional narrative and vote-counting methodologies, and then turn to meta-analysis, which can help us to address the two following research questions.

First, what is the overall relationship between GSCM practice and firm performance? Understanding the link between GSCM and performance has valuable implications. The improvement of performance has always been a central aim for both researchers and managers (Luthra et al., 2013). If the link between GSCM and performance is strong, it may imply a need for researchers to dedicate growing attention to GSCM within their studies, and for firms to give more emphasis on developing environmental initiatives in their supply chains. However, if the link is weak, researchers and managers may regard the implementation of GSCM to be less imperative. The second key question about practice-performance relationship is as follows: under what situations is the link between GSCM and performance is stronger or weaker? Considering the broad diversity of firms seeking to improve performance through GSCM, it should be unlikely that the overall relationship between GSCM and performance remains constant for every single firm. Thus, discovering moderators that affect the strength of practice-performance relationship could also be an important issue, because it has implications for the ways how researchers construct theories about supply chains, as well as the decisions that managers make. For example, if the relationship is found to be stronger for firms with ISO certification, researchers might hope to build a theory to interpret why this difference happens and how to diminish it. In the meantime, managers may be motivated to achieve ISO certification in order to better explore the performance of their GSCM practices.

As mentioned above, we attempt to address these two research questions by using meta-analysis. Hunter and Schmidt (1990) put that this approach can combine the effects of multiple independent studies, which can lead to more robust conclusions than those presented in a single study. They further claimed that meta-analysis could correct for individual artifacts, such as sampling and measurement errors, and provide more accurate estimates of the investigated relationship than those narrative and vote-counting methods. Also, Orlitzky and Benjamin (2001) added that meta-analytical tools (e.g., subgroup analysis and meta-regression) could shed light on generalizability of prior findings and determine whether different moderators impact the associations found. By synthesizing the empirical results of 54 selected literature, this paper intends to narrow the gap between what we already know and what we need to know about the relationship between GSCM and performance.

The remainder of this paper proceeds as follows. The literature review and hypotheses are developed in Section 2. And we subsequently elaborate on the criteria and procedures for shortlisting extant literature in Section 3. Moreover, a systematic review of selected literature is conducted in Section 4. In Section 5, we perform a meta-analysis to investigate the proposed hypotheses and a subgroup analysis to explore the effect of substantive moderators as well as a meta-regression to examine cultural moderators that moderate the practice-performance relationship. Findings are concluded in Section 6. And finally, we close our paper in Section 7 with the discussion of study implications and future agenda for GSCM research.

2. Literature review and hypotheses

Since the late 1980's, when “the concepts of SCM and environmental management as strategic organizational practices to gain competitive advantage” emerged, a large variety of subtopics have been continually included into the study about GSCM (Luthra et al., 2014a; Fahimnia et al., 2015b). Basically, the research streams concentrate on two crucial issues. One relates to the relationship between GSCM practice and firm performance, whilst the other refers to the potential factors that may moderate this relationship (i.e., whether they exert positive, negative or neutral impacts on the relationship). And those two research streams are both incorporated in our theoretical framework, and are then discussed exhaustively as follows.

2.1. GSCM practices

GSCM practices are involved throughout the life cycle of green produces, from the product design to manufacturing, packaging and even after-sale service. Given the extensive scope of green practices, many literature attempt to categorize them comprehensively (e.g., Madu, 2007; Srivastava, 2007; Shang et al., 2010), among which the categorization method proposed by Zhu et al. (2008c) is the most commonly referred. They investigated the GSCM practice constructs and put forward a 21-item measurement scale for evaluating the GSCM implementations, reaching to the conclusion that green practices could be generally divided into five factors: internal environmental management (IEM), green purchasing (GP), customer cooperation (CC), investment recovery (IR) and eco-design (ED). Those five practices have been broadly studied in previous empirical researches about GSCM (e.g., Choi and Hwang, 2015; Gopal and Thakkar, 2016; Mangla et al., 2016). IEM relates to the practices from management within enterprises, such as the implementation of total quality environmental management (Ahmed, 2001) and the mid or top-level managers' ecological commitment (Rice, 2003), while GP, CC, IR and ED are often referred as external initiatives.

More specifically, as an emergent GSCM approach, GP exerts notable influence on the upstream link of a company's supply chain by specifying environmental requirements for its ordered products from suppliers and collaborating with them to realize its environmental targets (Zsidisin and Hendrick, 1998; Zhu et al., 2008b). Unlike GP, a close cooperation with customers affects the downstream segment of a company's supply chain via collaborative activities such as customer education, customer support and joint ventures with the purpose to improve customers' willingness to participate in ecological supply chain operations (Eltayeb et al., 2011). Apart from GP and CC, IR is also regarded as a key GSCM practice, which usually happens at the end of supply chain cycle (Zhu et al., 2008a). And according to Zhu and Sarkis (2004), it aims at encouraging the recycling of end-of-life products into other

usable materials so as to reduce their negative environmental impacts. Similarly, ED is perceived as another powerful technique to the minimize a product's ecological effects, but it works mainly by ensuring a new product to be designed in an environmentally friendly manner through its entire lifecycle from the procurement of raw materials, to the production, usage and disposal stages without compromising on its functionality (Eltayeb et al., 2011). The wide application of external GSCM initiatives by firms can be partially explained from perspective of transaction costs. Williamson (1975) said that transaction costs play an important role in firms' economic activity and 'vertical co-ordination' as they always try to obtain resources at a low cost and in a secure manner. Arminas (2004) additionally claimed that firms' growing dependence on scarce or valuable resources can motivate them to strengthen coordination with other supply chain members, such as gaining access to strategic supplier's technologies or knowledge by establishing supplier partnerships and strategic coalitions. Hence, in the context of green supply chain management, firms may also tend to seek coordination with other supply chain members, such as green purchasing and customer cooperation, in order to achieve certain environmental, economic or operational goals.

More importantly, Lee et al. (2014) pointed out that the five GSCM practices should be considered from an integrated perspective rather than being confined to a single department or function. In particular, the relationship between IEM and external green actions is one of the most frequently discussed. Walton et al. (1998) indicated that external practices need to be based on IEM, because the successful adoption of them demands cooperation and coordination with internal sustainability strategies. Furthermore, Green et al. (2012) suggested that only when environmental sustainability has been accepted as a strategic imperative and supported by the mid and top-level managers within a company could it proceed with such external GSCM practices as GP, CC, IR and ED. Also, when all firms in a supply chain are environmentally oriented, the establishment of external collaborative green practices can be much easier (Giovanni, 2012). One of the empirical examples indicating the positive impact of internal management support on external GSCM practices can be seen from an investigation conducted in Spanish automotive industry (Gonzalez et al., 2008). Thus, hypothesis can be made as follows.

H1. Internal environmental management positively impacts green purchasing (a), customer cooperation (b), investment recovery (c) and eco-design (d).

2.2. Performance of GSCM

Drawing upon the resource-based view, a firm's organizational resources and capabilities may significantly influence its competitive strategies and performance (e.g., Wernerfelt, 1984; Barney, 1991). Hart (1995) further proposed a natural-resource-based view, and argued that a firm can develop its competitiveness by managing its relationship with the natural environment. Given that, with the increasing constraints from the natural environment, a firm's capabilities to address these constraints can become its scarce, valuable and inimitable organizational resources, which may consequently enhance the firm performance (Chan, 2005). Moreover, some researches have extended the resource-based view beyond internal capabilities to incorporate external capabilities (e.g., Das and Teng, 2000). For example, Mathews (2003) suggested that competitiveness can be derived from both internal and external resources. Squire et al. (2009) also indicated that inter-firm collaborative relationships are important for a firm to obtain the resources or capabilities it lacks. Hence, from this perspective, both internal (i.e., IEM) and external GSCM initiatives (i.e., GP, CC, IR and ED) are supposed to exert significant influence on firm performance in our study.

On top of that, it is widely acknowledged that measuring performance consequences is an effective way to evaluate GSCM practices, which provides enterprises with an outline of how their supply chain functions in terms of sustainability (Gunasekaran et al., 2001). Particularly, Buyukozkan and Cifci (2012) pointed out that both environmental and non-environmental-based measures should be considered because GSCM initiatives not only enable the greening of supply chain, but also exert significant influences on its business and operational activities. On account of the measures used in previous literature (e.g., Zhu et al., 2007; Green et al., 2012; Lee et al., 2012), we hereby discuss the outcomes of GSCM practices from three distinct perspectives: environmental, economic and operational. Those differentiated performance measures can help us to have a more comprehensive understanding of the impacts of GSCM practices.

2.2.1. Environmental performance

Basically, GSCM practices are designed and performed to enhance environmental sustainability. Evidence can be witnessed in many literature that the implementation of GSCM practices can positively affect the environmental performance (e.g., Zhu and Sarkis, 2004). In particular, significant relationship between internal environmental management and green performance has been identified in prior studies (e.g., Zhu et al., 2007; Seuring and Müller, 2008). For example, Zhu et al. (2007) conducted an empirical survey in Chinese automotive industry, and found out that internal environmental management, such as support from mid and top level managers, green compliance and auditing programs, has significantly positive impact on environmental performance. Concerning those external practices, Preuss (2001) discovered a possible "green multiplier effect" that is attributed to the extension of green purchasing practices from direct suppliers to second and third suppliers. And this effect can greatly contribute to the greenness of the whole supply chain. Additionally, Diabat and Govindan (2011) found that eco-design, which aims to reduce a product's environmental impact without a sacrifice of other design standards such as functionality, will directly and positively influence the environmental outcome. Thus, hypotheses about environmental outcome of GSCM can be formulated as follows.

H2. Internal environmental management positively affects environmental performance.

H3. Green purchasing (a), customer cooperation (b), investment recovery (c) and eco-design (d) positively impacts the environmental performance.

2.2.2. Economic performance

One of the principal purposes of enacting GSCM practices is to reduce wastes relative to environmental and ecological sustainability. However, some GSCM practices can probably increase cost for adopting firms at the early adoption stage. For example, 3D printing, also known as additive manufacturing or rapid prototyping, is a process of joining materials to build objects from 3D model data (Huang et al., 2013). In contrast to conventional manufacturing, 3D physical objects are manufactured through layer-by-layer formation of matter based on digital blueprint, rather than any tools, molds or dies (Gebler et al., 2014). Given that, it is considered to be with the potential to reduce resource and energy consumption as well as process-related carbon emissions (Campbell et al., 2011). But Lindemann et al. (2012) claimed that firms might suffer from high machine costs at the early adoption stage. Baumers et al. (2016) further argued that machine

productivity is a major driver of per-unit manufacturing cost, which acts as a barrier for firms intending to implement 3D printing.

Even though high cost may possibly be engendered by the adoption of some GSCM practices as argued, their resulting waste elimination is still believed to bring about improved economic performance (Green et al., 2012). The positive associations between GSCM practices and competitiveness as well as economic outcome are supported in many extant literature (e.g., Rao and Holt, 2005; Laosirihongthong et al., 2013). For instance, Ameer and Othman (2012) empirically analyzed 100 top sustainable global companies, and discovered that internal environmental practices with a long run orientation could lead to significant sales growth, return on assets, profit and cash flows. Regarding external environmental practices, Hollos et al. (2012) claimed that sustainable supplier cooperation has a positive influence on economic performance, because inter-organizational alliance among firms in a supply chain can help to build trust and reduce risk. Besides, another possible reason accounting for the positive relationship between GSCM practices and economic performance can be the effect of winning environmental awards by companies on their stock prices (Klassen and McLaughlin, 1996). Specifically, Klassen and McLaughlin (1996) showed that the ecological behavior of firms is valued by stock market, which awards them with higher stock prices. Thereby, the hypotheses relative to the economic outcome of GSCM can be made as follows.

H4. Internal environmental management positively affects economic performance.

H5. Green purchasing (a), customer cooperation (b), investment recovery (c) and eco-design (d) positively impacts the economic performance.

2.2.3. Operational performance

According to Zhu et al. (2008c), operational performance refers to an enterprise's capabilities to produce and transport products to its customers promptly and efficiently. As GSCM practices demand companies to keep close connections with their suppliers and customers, it is easier for them to facilitate management strategies such as total quality management and JIT, which can lead to higher operational performance (Frosch, 1994). In particular, many empirical researches have indicated that the implementation of green practices either internal to a firm or across the supply chain can help to enhance its operational performance from perspectives of inventory level, quality, lead-time and customer satisfaction (e.g., Vachon, 2007; Seuring and Müller, 2008). For example, Sroufe (2003) found that environmental management system, which is an important internal green practice, could exert a positive influence on operational performance measures, including quality and cost. Similarly, Melnyk et al. (2003) also discovered a significant impact of environmental management system on operational performance, such as quality, cost, flexibility as well as delivery efficiency. Thus, following assumptions can be hypothesized.

H6. Internal environmental management positively affects operational performance.

H7. Green purchasing (a), customer cooperation (b), investment recovery (c) and eco-design (d) positively impacts the operational performance.

2.2.4. Linkages among performance

As outlined above, the bivariate relationships between GSCM practices and firm performance (i.e., environmental, economic and operational) have been hypothesized. Then we will further discuss about the interactions among different performance, which are also frequently studied practically and theoretically in previous literature (e.g., Green et al., 2012; Zhu et al., 2013). As regards the linkage between environmental and economic performance, a dominating view is that a firm's progresses in economic performance (e.g., lower cost of capital and increase of profitability) can arise from its improvement in environmental performance, such as more effective utilization of resource (Klassen and McLaughlin, 1996; Uotila et al., 2009). On the one hand, Tang et al. (2012) pointed out that the enhanced reputation and customer satisfaction brought by improved environmental performance of a firm can finally lead to a larger market share and better economic performance. On the other hand, Green et al. (2012) argued that the cost saving nature of environmental performance could also account for the improved economic consequence. Therefore, based on the above discussion, we have the following hypothesis.

H8. Environmental performance can positively impact the economic performance.

Besides, the positive influence of environmental performance on operational performance is also studied. Frosch (1994) showed that the improvement in environmental performance is supposed to reinforce closer inter-organizational linkages, making it easier for companies to communicate operational requirements with their supply chain partners and thus enhancing the operational performance. In addition, Zhu et al. (2007) suggested that amelioration of environmental situation and decrease of environmental accidents can promote higher product quality and delivery efficiency for firms. Hence, the hypothesis can be formulated as follows.

H9. Environmental performance can positively impact the operational performance.

In regard to the association between operational and economic performance, the notion of “eco-efficiency” proposed by Porter and Van der Linde (1995) has been widely researched (e.g., Zhu et al., 2013). Eco-efficiency tells that the enhancement of operational performance can help companies to reduce the waste output as well as the consumption of materials, thus cutting down the cost for waste disposing and material purchasing (Porter and Van der Linde, 1995). Iasevoli and Massi (2012) further claimed that sustainable business management is able to improve a firm's economic competitiveness through higher eco-efficiency. The evidence for the positive influence of operational performance on the economic performance can also been found in an empirical research conducted in China with a sample of 396 Chinese manufacturers (Zhu et al., 2013). As a consequence, we can put forward the hypothesis as follows.

H10. Operational performance can positively impact the economic performance.

2.3. Moderators

Although our hypotheses are posited on the basis of well-founded theories (e.g., theory of transaction costs, and resource-based view) and evidence, inconsistencies of empirical results can still be found in prior researches (e.g., Rao and Holt, 2005; Zhu et al., 2007). One possible theoretical explanation for those inconsistencies lies in contingency theory, which posits that organizational efficiency can be realized only by matching business strategies to contingencies (i.e., any factors that can moderate the impact of business strategies) and scarcely any strategies can apply in disparate business contexts with the same effects (Lawrence and

Lorsch, 1967; Donaldson, 2001, p.7). The theory has been broadly employed in prior researches. Based on contingency concept, Lee and Miller (1996) found that Korean companies are more likely to succeed if they acclimatize their strategies to the need of local marketplace, particularly for those companies adopting newly emergent technologies. In meta-analysis, contingency theory is frequently referenced to address the problem of inconsistent findings. For example, Ketchen et al. (1997) applied meta-analytical methodology to examine the link between organizational configuration and performance, and used contingency theory to explain their discovery that firms whose configurations are well acclimatized to their environment could perform better than those whose configurations are not.

In our meta-analysis, we also attempt to discuss the inconsistencies in prior GSCM literature from the contingency perspective. To be specific, Elsayed and Paton (2005) claimed that the variation of results in previous GSCM studies is primarily attributed to the heterogeneity of practices that different organizations implement in different environments. And more importantly, some researches have already studied the impacts of moderators on relationship between GSCM practices and firm performance (e.g., Golicic and Smith, 2013; Friso and Kai, 2014), which strongly verify the existence of inconsistencies among extant results. Therefore, by augmenting our research hypotheses with contingency perspective, we are able to clarify the mixed findings obtained from prior literature that are conducted in diverse research contexts. Hereby, we should first identify possible moderators and then evaluate their impacts on the practice-performance relationship.

In general, there are two types of moderators frequently employed by researchers of meta-analysis: cultural moderators and substantive moderators (e.g., Tellis, 1988; Kirca et al., 2005; Golicic and Smith, 2013). Accordingly, a detailed discussion for each potential moderator is given as follows.

2.3.1. Cultural moderators

As proposed in the contingency theory, difference of business contexts is a leading source of inconsistencies in empirical results, which can be largely reflected on the dissimilarity of various social and cultural aspects (Harris, 2001). Moreover, as most studies about GSCM are carried out in very different countries (e.g., Zhu and Sarkis, 2004 in China; Eltayeb et al., 2011 in Malaysia; Green et al., 2012 in America), it is of great necessity to test how cultural distinctions moderate the practice-performance relationship. Prior attempts to clarify the impact of cultural context have also been made (e.g., Golicic and Smith, 2013; Fahimnia et al., 2015b), but most of them only discuss about the geographic difference, which is just one single aspect of culture. Therefore, in order to test the overall effect, we follow Hofstede (2001)'s dimensions of culture (i.e., power distance, individualism, masculinity, uncertainty avoidance, long term orientation and indulgence) and take them as potential moderators of our previously proposed relationships.

First, power distance is defined as the extent to which the less powerful members of organizations within a region expect and accept power inequalities. Nakata and Sivakumar (2001) suggested that lower-power-distance cultures could create more flexible organizational structure as well as cozier working conditions for employees, thus consequently enhancing their productivities. So from the perspective of GSCM, higher work efficiencies may imply more satisfactory outcomes. Second, individualism refers to the degree of interdependence that a society maintains among its members. In individualist cultures, people only look after themselves and their direct families, whilst in collectivist cultures, people tend to collaborate closely within organizations. Moreover, Nakata and Sivakumar (2001) indicated that GSCM practices are more efficient in collectivist countries (e.g., Japan) where interdependence, cooperation and unified goal are strongly emphasized. Third, masculinity dimension relates to whether a society is driven by competition, achievement and success (masculine) or motivated by life quality (feminine). Nakata and Sivakumar (2001) suggested that an enterprise could adopt GSCM practices more effectively in masculine culture on account of its dominant values such as focus on success, thereby contributing to a better performance.

Fourth, uncertainty avoidance describes the extent to which the members of a culture feel threatened by unknown situations and have beliefs that try to avoid the uncertainty. In particular, people in countries that rank high on uncertainty avoidance need a lot of structure and predictability in their work life (Hofstede, 2001), which can make their working conditions less comfortable and reduce their productivities consequently (Kirca et al., 2005). Fifth, long-term orientation is perceived as the degree to which a society tries to maintain its time-honored traditions and norms while coping with present and oncoming challenges. To be specific, companies in long-term oriented cultures are more inclined to keep durable relationships with their suppliers and customers (Slater and Narver, 1994), and this may improve the effectiveness of GSCM practices. Last but not least, indulgence refers to the extent to which people strive to control their desires and impulses. Employees in countries that rank high on indulgence dimension are more willing to realize their desires with regard to enjoying life, thereby creating a cozier working condition for themselves, which is believed to result in higher productivities and a better performance (Nakata and Sivakumar, 2001).

2.3.2. Substantive moderators

Besides cultural moderators, the effects of substantive moderators investigated in prior literature also deserve careful consideration (Kirca et al., 2005). In our research, substantive moderators on the practice-performance relationship include industry type, ISO certification and export orientation (e.g., Zhu and Sarkis, 2004; Laosirihongthong et al., 2013). Particularly, we find that most relative researches select samples from different industries, and majority of them draw data from various sectors (e.g., Kim and Rhee, 2012; Lai et al., 2013; Lee et al., 2015). There are also some researches collecting data from a single industry, mainly the automotive (e.g., Liu et al., 2016) and electronic industry (e.g., Lo and Shiah, 2016). Del Bufalo (2012) claimed that there should be more variation in the data from multiple industries than a single industry. Hence, in this study, we intend to examine whether the industry type exerts moderating effect on the relationship between GSCM practices and firm performance.

In terms of ISO certification, previous studies have demonstrated a significant effect of quality management on organizational performance (e.g., Yusuf et al., 2007). To be specific, Samon and Terziovski (1999) indicated that quality management, as a powerful operation management technique, could lead to the improvement of operational performance such as quality and efficiency. Moreover, quality management, consisting of total quality management (TQM) and ISO 9000 standards certification, is found to exert positive influence on the environmental performance due to its adoption of green management criteria (King and Lenox, 2001). Simmons and White (1999) also discovered that ISO registered enterprises are generally more profitable than non-ISO registered ones, suggesting the positive effect of ISO certification on financial outcomes.

In addition, some studies have further considered the influence of international customers on the effectiveness of GSCM practices. Those investigations drew samples from exporting companies and found highly correlated relationships between GSCM practices and firm performance (e.g., Zhu and Sarkis, 2004; Lai et al., 2015).

Table 1
Hypotheses about moderators.

	Moderators	Hypotheses
Year of publication		H11
Hofstede (2001)'s dimensions of culture	Power distance	H12 (Low)
	Individualism	H13 (Collectivist)
	Masculinity	H14 (Masculine)
	Uncertainty avoidance	H15 (Low)
	Long-term orientation	H16 (Long-term)
	Indulgence	H17 (Indulgent)
Substantive moderators	Industry type	H18
	ISO certification	H19
	Export orientation	H20

Note: Since practice-performance relationship includes 15 types (5 types of practice × 3 types of performance) in total, it's not necessary to list them one by one in this hypothesis section. However, their test results will all be presented later in Sections 6 and 7.

Therefore, we seek to analyze the distinction between data from firms that are export-oriented and firms for which a specific orientation is not mentioned. In conclusion, we have identified nine factors (i.e., power distance, individualism, masculinity, uncertainty avoidance, long-term orientation, indulgence, industry type, ISO certification and export orientation) as potential moderators of GSCM practice-performance relationship. Hypotheses concerning their impacts are concluded in Table 1 .[1] And last but not least, based on the above discussions, our research framework is thus proposed as Fig. 1, which guides our follow-up meta-analysis.

2.4. Research gaps

Given the rich empirical results in extant GSCM literature, many efforts have already been made to integrate them systematically as mentioned in section 1 (e.g., Jung, 2011; Min and Kim, 2012; Chen et al., 2013; Fahimnia et al., 2015b). For instance, Min and Kim (2012) synthesized the past researches by developing a viable green supply chain strategy. And Fahimnia et al. (2015b) proposed a comprehensive bibliometric analysis that graphically illustrates the theoretical development of GSCM, identifies focus of current studies and gives hints for future directions. However, important as their research findings are, they still fail to quantitatively synthesize the inconsistent results found in prior GSCM literature from a more integrated perspective, and interpret those inconsistencies, which act as two major motivations for us to apply a meta-analysis. Table 2 provides a detailed list of research gaps we try to narrow, and display how we address them in our study.

First, as most extant empirical literature only focus on subsets of GSCM constructs, they are probably unable to offer a comprehensive view of GSCM research, thus reducing the value for practitioners and scholars to some extent. For example, Ameer and Othman (2012) centered on the relationship between GSCM practice and economic performance. Kumar et al. (2013) concentrated on the influence of customer cooperation. In our study, we intend to synthesize those empirical results based on a more integrated GSCM research framework (See Fig. 1). As shown, all five types of GSCM practices (i.e., IEM, GP, CC, IR and ED) and three types of firm performance (i.e., environmental, economic and operational) are included, which may provide practitioners and scholars with an overall view of GSCM research. Second, inconsistencies of empirical results can often be found in prior literature. For instance, Choi (2014) found the relationship between investment recovery and firm performance to be significantly positive, while Abdullah and Yaakub (2014) claimed it to be insignificant. In our study, contingency theory is used to explain this phenomenon. And the impacts of nine potential moderators are further evaluated to reconcile and clarify those mixed findings about practice-performance relationship. To conclude, our study is capable of determining an overall effect between GSCM practices and firm performance, and additionally interpreting the inconsistencies in previous empirical results.

3. Database development

Systematic literature review is a useful means to synthesize previous researches and to provide guidance for future directions (Govindan et al., 2013). According to Saunders et al. (2009), it is usually achieved by procedures of defining proper keywords, searching papers and analyzing the results. Fahimnia et al. (2015b) further extended these processes into a five-step methodology, which turns to be effective in identifying the most influential studies and providing insights for current researches. Therefore, we followed Fahimnia et al. (2015b)'s steps to obtain appropriate database for our meta-analysis. Here, a flow diagram is presented in Fig. 2 to briefly introduce our development process of final dataset.

3.1. Definition of proper search terms

In line with Sarkis et al. (2011), we considered GSCM at the chain level in our paper and defined it as integrating environmental awareness into the inter-organizational activities of supply chains. However, given the broad array of terms in the field of GSCM, there are a number of articles having examined the specific GSCM-related issues (e.g., product stewardship and reverse logistics) without using the keyword 'GSCM', which greatly heightens the difficulty of literature search. Hence, in order to ensure the representativeness and comprehensiveness of our database as much as possible, we followed Gurtu et al. (2015)'s work to determine the proper search terms. Specifically, on the basis of 629 peer-reviewed literature published from 2007 to 2012, Gurtu et al. (2015) identified 13 mostly used keywords[2] and suggested that it could help future researchers to choose GSCM terms with high frequency in a much more convenient way. Besides, since our paper aims at clarifying the relationship between GSCM and its performance, we should also include 3 other keywords (i.e., performance, consequence and outcome) in addition to the 13 ones mentioned above when searching articles.

[1] Additionally, year of publication is also included as a moderator in order to examine whether there is a yearly tendency regarding the strength of practice-performance relationship.

[2] Keywords: closed-loop supply chains, eco-logistics, eco-supply chains, environmentally friendly logistics, environmentally friendly supply chains, green logistics, green reverse logistics, green reverse supply chains, green supply chains, responsible supply chains, reverse logistics, reverse supply chains, sustainable supply chains.

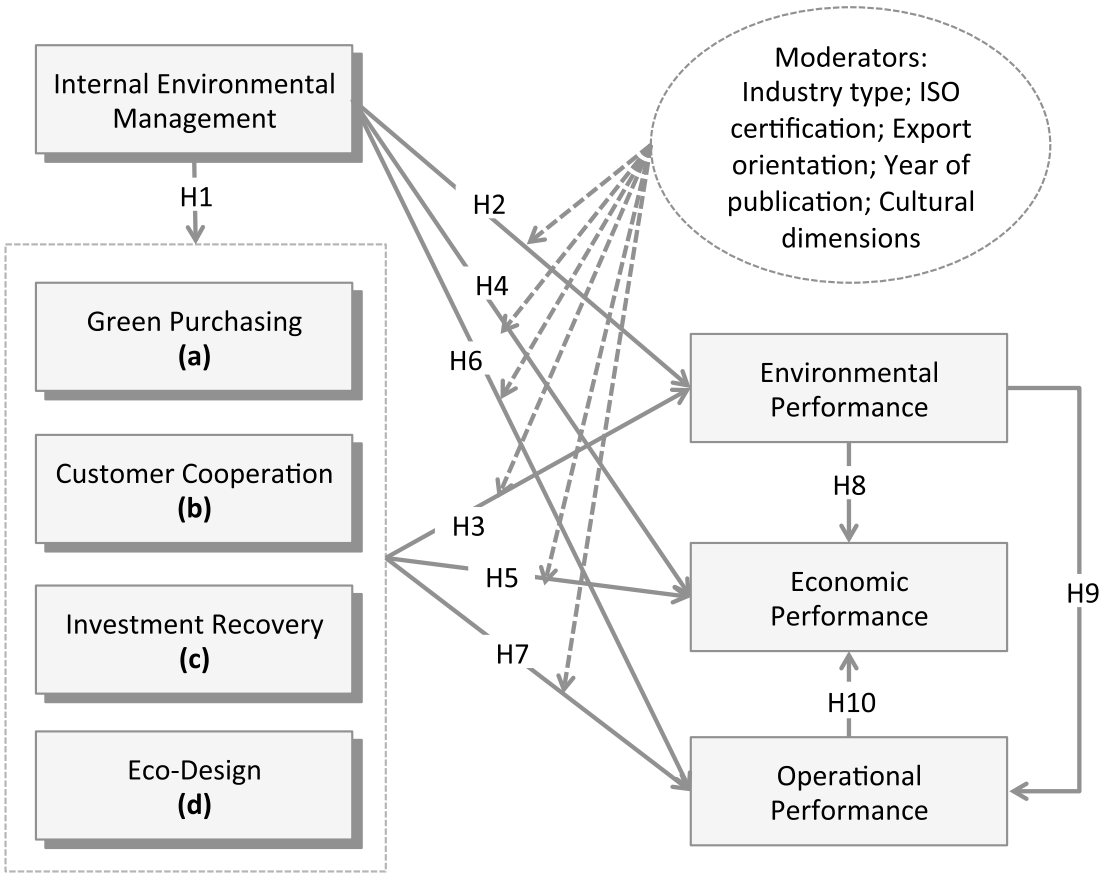

Fig. 1. Research framework.

Table 2
Research gaps.

Research Gaps	Examples	Intended Contributions
Lack of an Integrated Framework	• Ameer and Othman (2012) focused on corporate economic performance. • Kumar et al. (2013) focused on customer cooperation. • Mangla et al. (2013) focused on investment recovery. • Luthra et al. (2014b) focused on green purchasing. • Dubey et al. (2015) focused on environmental performance.	A more integrated research framework is developed in our study to depict a more comprehensive picture of GSCM constructs to scholars and practitioners.
Inconsistencies of Empirical Results	• Rao and Holt (2005) found the relationship between GSCM practice and economic performance to be significantly positive, while Zhu et al. (2007) claimed it to be only slightly positive. • Choi (2014) found the relationship between investment recovery and firm performance to be significantly positive, while Abdullah and Yaakub (2014) claimed it to be insignificant.	Impacts of cultural and substantive moderators on practice-performance relationship are tested to account for the inconsistencies in previous empirical researches.

3.2. Initial literature search

To guarantee the completeness of our database at utmost, three complementary search strategies were jointly employed. First, we conducted a systematic literature search through Scopus[3] database before Jan. 2017 with keywords identified in section 3.1. Second, we manually searched the reference lists of the studies we have obtained in the first step with the method of ancestry approach (See Aguinis et al., 2011). Third, since it is widely acknowledged that papers reporting statistically significant effect sizes are more likely to be published in journals, we also considered unpublished manuscripts such as conference proceedings, working papers and dissertations to reduce the potential bias of our data, which is commonly referred as file-drawer problem (Rosenthal, 1995; Wu and Lederer, 2009). To that end, we searched digital library

[3] Administered by Elsevier publishing group, Scopus (www.elsevier.com/solutions/scopus) is claimed to be the largest abstract and citation database, covering over 20,000 peer-reviewed journals inclusive of those published by Elsevier, Emerald, Informs and Springer etc. In addition, Scopus also contains the most reputable international journals, some of which may be relatively new, but influential.

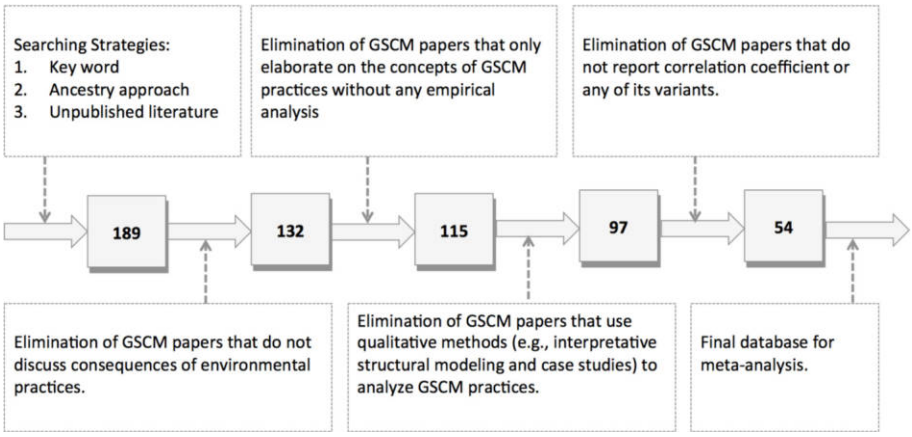

Fig. 2. Process of literature selection.

ProQuest for degree theses, Engineering Village Compendex database for conference articles, Social Science Research Network (SSRN) database and Google Scholar for working papers. As a consequence, we got 189 individual papers.

3.3. Refinement of the initial search

In our analysis, studies were further selected on the basis of five criteria as follows. First, the context should be about performance of various GSCM practices. Second, the analysis must be quantitative and *r* - family effects (i.e., correlation or its variants[4]) need to be reported explicitly. Third, because the GSCM practices were studied at the chain level, we considered non-dyadic data[5] as a constraint in the process of publication screening. Fourth, in accordance with Nunnally (1978), measurements must exhibit an average reliability (i.e., Cronbach's alpha) of at least 0.70 in primary studies. At last, as the credibility of meta-analysis would be violated by the non-independence of datasets (Wu and Lederer, 2009), we only included one dataset if the same sample was used by two or more empirical researches. Contrarily, in cases that two respective samples were presented in a single study, we retained both of them. Therefore, upon completion of refinement of the initial search by applying the five foregoing criteria, we ultimately got a total of 245 effects from 9313 independent samples reported in 54 literature.[6] A summary of articles is listed in Table 3.

3.4. Final dataset

Consistent with the procedures to obtain final dataset in other meta-analyses (e.g., Albertini, 2013; Endrikat et al., 2014), we should prepare a coding frame that straightens out the information needed. In particular, we first designed two drafts of the coding form independently, and then solved the disagreements through group discussion and expert consulting (See Table 4 for the final coding frame). We also coded the sample size of each study for meta-analysis. Additionally, to address the measurement error (scale reliability difference), we revised the obtained effects by dividing the correlation with the product of the square root of reliabilities between the two constructs at the individual level (Hunter and Schmidt, 1990). In case that no reliability was reported or only a single-item measurement was used for a construct, we employed the average reliability of all studies for relevant construct to correct the correlation coefficient (Geyskens et al., 1998).

3.5. Data analysis

As is introduced by Borenstein et al. (2009), the meta-analytic procedure for correlation *r* involves the synthesis of Fisher's *r* - to - *z* -transformed effect sizes weighted by the inverse of the studies' sampling variance. After the meta-analysis, which is conducted by using Fisher's *z* values, the summary effect is then converted back to a correlation coefficient for the convenience of interpretation. The null hypothesis H_0 of meta-analysis is that the mean effect size equals to zero, which will be rejected if the 95% confidence interval did not cover zero (Borenstein et al., 2009). Key points in meta-analysis are elucidated as follows.

3.5.1. Effect size

As is illustrated in Section 3.3, the correlation coefficient is taken as effect size in our research because they are provided by primary studies at most times. And even when the correlation is not directly reported in some literature, it can still be calculated from other presented information, such as standard β coefficient (Petersen and Brown, 2005). When the correlations of all selected studies are available, we need to transform them to Fisher's *z* values by using Formula (1) and calculate the variance V_Z of *z* by Formula (2).

$$z = 0.5 \times \ln\left(\frac{1+r}{1-r}\right) \tag{1}$$

$$V_Z = \frac{1}{n-3} \tag{2}$$

where *n* symbols the sample size, *r* is the correlation coefficient.

3.5.2. Statistical model

Meta-analysis can be conducted by employing both fixed-effect and random-effect model (Borenstein et al., 2009). For fixed-effect model, all the initial studies share a common effect size, the

[4] The variants of correlation refer to the indicators that could be transformed to correlation coefficients (e.g., student's t, chi-square, p-values for group comparisons and regression coefficients; Wolf, 1986; Rosenthal, 1995; Petersen and Brown, 2005; Wu and Lederer, 2009).

[5] Please refer to Montoya-Torres and Ortiz-Vargas (2014) for details about dyadic supply chain.

[6] According to Valentine et al. (2010), "two studies" are sufficient for performing a meta-analysis, however "more studies" indicates more reliable and robust result. In the field of supply chain management, meta-analyses typically include "tens of studies" (e.g., 31 studies are involved in Golicic and Smith, 2013 and 50 studies are involved in Geng et al., 2017). Thus, our meta-analysis, which contains 54 studies, conforms to this typical practice regarding the number of studies included in meta-analysis, and is supposed to provide more reliable estimates.

Table 3
List of reviewed papers.

No.	Author	Year	Sample size	Region	Firm size	Industry	ISO certification	Export orientation
1	Zhu and Sarkis	2004	186	China	2647.312	Various		
2	Rao and Holt	2005	52	15 South East Asian countries	N.S.	Various	Yes	
3	Ann et al.	2006	159	Malaysia	N.S.	Various	Yes	
4	Zhu et al.	2007	89	China	3293.500	Automotive		
5	Zhu et al. (c)	2008	341	China	2777.750	Various		
6	Peng and Lin	2008	101	Taiwan	N.S.	Various		
7	Large and Thomsen	2011	109	Germany	N.S.	Various		
8	Kim et al.	2011	145	South Korea	300.600	Various		
9	Kim and Rhee	2012	249	South Korea	541.900	Various		
10	Giovanni	2012	240	Italy	N.S.	Various		
11	Chan et al.	2012	194	China	1256.000	Various		Yes
12	Lai and Wong	2012	134	China	72.745	Various		Yes
13	Wong et al.	2012	122	Taiwan	N.S.	Electronic		
14	Lee et al.	2012	223	South Korea	97.500	Electronic	Yes	
15	Kim and Lee	2012	168	South Korea	1026.600	Logistics		
16	Zailani et al.	2012	132	Malaysia	596.675	Various	Yes	
17	Huang et al.	2012	349	Taiwan	310.550	Electronic		
18	Lai et al.	2013	128	China	72.745	Various		Yes
19	Laosirihongthong et al.	2013	190	Thailand	N.S.	Various	Yes	
20	Zhu et al.	2013	396	China	1341.100	Various		
21	Lin et al.	2013	208	Vietnam	N.S.	Automotive		
22	Hajmohammad et al.	2013	85	Canada	214.000	Various		
23	Youn et al.	2013	141	South Korea	353.500	Various		
24	Ye et al.	2013	209	China	N.S.	Various		
25	Lee et al.	2014	133	Malaysia	N.S.	Various		
26	Gualandris and Kalchschmidt	2014	77	Italy	372.940	Various		
27	Perramon et al.	2014	374	Spain	N.S.	Tourism		
28	Blome et al.	2014	114	West Europe	N.S.	Various		
29	Yu et al.	2014	126	China	2471.200	Automotive		
30	Choi	2014	NS	South Korea	N.S.	Various		
31	Abdullah and Yaakub	2014	101	Malaysia	N.S.	Various		
32	Huang and Yang	2014	322	Taiwan	254.300	Electronic		
33	Cheng et al.	2014	121	Taiwan	3600.000	Electronic		Yes
34	Lai et al.	2014	134	China	N.S.	Various		Yes
35	Lee et al.	2015	119	Malaysia	87.200	Various	Yes	
36	Dubey et al.	2015	361	India	679.825	Rubber	Yes	
37	Zailani et al.	2015	153	Malaysia	N.S.	Automotive	Yes	
38	Jayaram and Avittathur	2015	65	India	N.S.	Various		
39	Green et al.	2015	225	US	N.S.	Various		
40	Chen et al.	2015	205	Taiwan	1976.000	Various		Yes
41	Jabbour et al.	2015	95	Brazil	N.S.	Various	Yes	
42	Lee	2015	207	South Korea	83.000	Various		
43	Choi and Hwang	2015	230	South Korea	644.600	Various	Yes	
44	Lo and Shiah	2016	174	Taiwan	475.250	Electronic		
45	Sancha et al.	2016	170	Hong Kong	58.195	Garment		
46	Liu et al.	2016	225	China, North America and Europe	2098.000	Automotive		
47	Feng et al.	2016	214	China	303.384	Various		
48	Laari et al.	2016	119	Finland	N.S.	Various		
49	Li et al.	2016	256	China	120.025	Various		
50	Khor et al.	2016	89	Malaysia	N.S.	Electronic	Yes	
51	Woo et al.	2016	103	South Korea	187.000	Construction		
52	Gopal and Thakkar	2016	98	India	N.S.	Automotive		
53	Khaksar et al.	2016	103	Iran	N.S.	Cement		
54	Chan et al.	2016	250	China	N.S.	Various		

Note: 1. Firm size is calculated according to the sample profile provided in each literature. 2. “N.S.” is abbreviation for “Not Specified”.

variation of which is attributed to the sampling error alone. Contrarily, the random-effect model supposes that the true effect size changes from study to study, and the fluctuation of observed effect is the result of both true variation in effect size and sampling error as well (Lipsey and Wilson, 2001). According to Borenstein et al. (2009), the random-effect model is more reasonable because study features, such as respondents and measurements are with a great possibility to be varied in different studies, thus making the assumption of a common effect size underlying the fixed-effects model untenable. However, Hedges and Vevea (1998) put that random-effects model is inferior when used as a tool to test moderating effect, especially in cases where sample sizes for the detection of moderator are modest. This can be well explained by its over-estimation of error variance when testing for moderating impacts (Overton, 1998). Hence, taking all the factors into consideration, we will perform the meta-analysis under random-effect model and examine the influence of substantive moderators by using fixed-effect model.

3.5.3. Moderating effect

The test of 3 substantive moderators is performed using subgroup analysis, because they are coded as categorical variables. In fixed-effect model, subgroup analysis yields a Q-test of the null hypothesis that $r_a = r_b = \cdots = r_m$. And we are able to discuss the moderating effect in detail if the Q-test is statistically significant and the moderator is made of more than two levels (Borenstein et al., 2009). However, for the year of publication and cultural moderators, which are continuous variables, we will then employ

Table 4
Explanations, names and representative articles of each construct.

Constructs	Explanations	Common aliases	Representative articles
Practices			
Internal EM	It includes activities and practices from management within companies, such as total quality environmental management and cross-functional cooperation for environmental improvements.	Internal green management, Internal lean practices	Ahmed, 2001
Green purchasing	Green purchasing is the affirmative choice and acquisition of products or services that most effectively reduce the negative environmental effects over their life cycle.	Green procurement, environmentally preferable purchasing, green inbound	Preuss, 2001
Customer cooperation	Companies need to collaborate with consumers, who stay at the end of supply chain, to reduce total cost, decrease the lead time and improve their satisfaction.	Green marketing, customer collaboration	Zhu et al., 2013
Investment recovery	This consists of green activities that involve benefiting from extant investment, which would be wasted otherwise. For instance, companies can sell excessive raw materials to cut costs for carrying leftover inventories and free up storage space foe other useful materials.	Reverse logistics, recycling, reuse efforts of organization	Zhu et al., 2007; Hsu et al., 2013
Eco-design	It focuses on environmentally conscious design and life cycle analysis of products. Companies need to cooperate with suppliers to make every link of product's life cycle green.	Design for green, the environmental design, design for environment	Stevels, 2002; Srivastava, 2007
Performance			
Environmental	Obviously, negative impacts of production process on environment can be greatly reduced when green supply chain practices are strictly implemented.	Green performance	Zhu et al., 2013
Economic	Green supply chain practices can enhance the economic performance of a firm positively in many ways. Companies with greener products can gain larger market share and reinforce their reputation, which can improve revenue indirectly.	Corporate performance, Business performance	Rao and Holt, 2005; Zhu et al., 2013
Operational	This includes decreases in inventory levels as well as delivery time, and increases in product quality and capacity utilization.	Operating experience, process efficiency	Chan et al., 2012

meta-regression to quantify their impacts on practice-performance relationship.

3.5.4. Heterogeneity analysis

With regard to heterogeneity analysis, it aims to determine the significance and proportion of observed variation in effect size attributed to systematic cross-samples variability. And it remains as a common but intractable problem of systematic reviews. The most frequently used method is *Q*-test, together with I^2 index (Higgins and Thompson, 2002). Huedo-Medina et al. (2006) claimed that although *Q*-test can tell whether heterogeneity exists or not, it fails to further quantify the extent of such heterogeneity. As an important supplement, I^2 index is able to distinguish the degree of heterogeneity in meta-analysis. Hence, both statistics are calculated and reported in our paper.

4. Systematic review

In this section, we conduct a systematic review to help visualize the empirical studies that consider the performance of GSCM practices. The systematic review is organized from three perspectives, i.e., year of publication, region of study and journal. Regarding year of publication, a substantial growth trend from 2004 to 2016 can be visible in Table 3. More specifically, 2 papers published in 2011 and 11 papers published in 2016 suggest the rising concerns about relationship between GSCM practices and firm performance in academia.

In terms of study region, a large quantity of researches focuses on and collects samples from China (13 papers), South Korea (9 papers), Malaysia (7 papers) and Taiwan (7 papers). It indicates a high interest of GSCM papers in Asian regions. Moreover, there are three researches (i.e., Rao and Holt, 2005; Blome et al., 2014; Liu et al., 2016) that draw samples from multiple regions or countries instead of a single region or country.

Table 5 presents the distribution of papers over journals, as well as the 2015 Impact Factor (*IF*) ranking for each of the accessed journal. The indicator *IF* reflects the relative importance of a journal within its field. Journals with higher *IF* are regarded as more important than those with lower ones (Garfield, 2006). In our study, the leading position is now taken by the *Journal of Cleaner Production* with 10 papers, which also has the highest *IF* score (=4.959) within the accessed journals. The second place is held by the *International Journal of Production Economics* (*IF* = 2.782) with 9 papers, which is another renowned academic journal. Additionally, journals on the field of operations and management are found to be home for the majority of GSCM studies.

5. Meta-analysis

On top of the systematic search and selection in section 3, 54 empirical researches ranging from 2004 to 2016 were finally included into our meta-analysis. The consequences are given in Tables 6–9, answering the research questions put forward in section 1.

First of all, Table 6 presents the result of heterogeneity test for all proposed relationships. As indicated, all *Q*-statistics are found to be significant, and all I^2 index are reported to exceed 80%, which means that a large majority of observed variation in effect size can be ascribed to systematic cross-samples variability. The significant result of heterogeneity analysis confirms the use of random-effect model to perform the meta-analysis, and also provides us with a strong motivation to test the impact of potential moderators on practice-performance relationship. Then in Table 7, we display the result of meta-analysis, and start our report with the most influential constructs and focus on the aggregated results for all GSCM practices. At last, we give out the results of moderator analysis (See

Table 5
Distribution of papers (by journal).

Journal	Freq.	*IF*	Percent	Cum.
Journal of Cleaner Production	10	4.959	18.52	18.52
International Journal of Production Economics	9	2.782	16.67	35.19
Supply Chain Management: An International Journal	4	2.731	7.41	42.59
International Journal of Operations & Production Management	3	2.252	5.56	48.15
International Journal of Production Research	3	1.693	5.56	53.70
Journal of Purchasing & Supply Management	3	2.562	5.56	59.26
Production Planning & Control	3	1.532	5.56	64.81
Industrial Management & Data Systems	2	1.278	3.70	68.52
Management Research Review	2	N.A.	3.70	72.22
Operations Management Research	2	0.632	3.70	75.93
Expert Systems with Applications	1	2.981	1.85	77.78
Industrial Marketing Management	1	1.930	1.85	79.63
International Journal of Advanced Logistics	1	N.A.	1.85	81.48
International Journal of Business & Society	1	N.A.	1.85	83.33
International Journal of Logistics Management	1	0.917	1.85	85.19
International Journal of Physical Distribution & Logistics Management	1	2.101	1.85	87.04
International Journal of Services & Operations Management	1	N.A.	1.85	88.89
Journal of Business Ethics	1	1.837	1.85	90.74
Journal of Operations Management	1	4.000	1.85	92.59
Management of Environmental Quality: An International Journal	1	N.A.	1.85	94.44
Omega	1	3.962	1.85	96.30
Technological & Economic Development of Economy	1	1.952	1.85	98.15
Transportation Research Part E	1	2.279	1.85	100.00
Total	54		100.00	

Note: Scores of Impact Factor (*IF*, Year = 2015) are extracted from *Web of Science*.

Table 6
Result of heterogeneity test.

Proposed relationships	***Q*** statistic (***df***)	I^2	τ^2	Hypotheses
Internal EM → Green purchasing	215.62***(16)	92.6%	0.0642	H1 (a)
Internal EM → Customer cooperation	172.69***(12)	93.1%	0.0723	H1 (b)
Internal EM → Investment recovery	107.78***(12)	88.9%	0.0437	H1 (c)
Internal EM → Eco-design	100.09***(16)	84.0%	0.0280	H1 (d)
Internal EM → External EM	**159.78***(22)**	**86.2%**	**0.0357**	
Internal EM → Environmental	146.08***(11)	92.5%	0.0695	H2
Green purchasing → Environmental	100.52***(11)	89.1%	0.0493	H3 (a)
Customer cooperation → Environmental	146.84***(8)	94.6%	0.1073	H3 (b)
Investment recovery → Environmental	131.39***(9)	93.2%	0.0753	H3 (c)
Eco-design → Environmental	266.62***(9)	96.6%	0.1460	H3 (d)
All GSCM practices → Environmental	**274.89***(22)**	**92.0%**	**0.0651**	
Internal EM → Economic	317.86***(17)	94.7%	0.1009	H4
Green purchasing → Economic	168.27***(11)	93.5%	0.0874	H5 (a)
Customer cooperation → Economic	179.52***(10)	94.4%	0.0993	H5 (b)
Investment recovery → Economic	157.30***(13)	91.7%	0.0711	H5 (c)
Eco-design → Economic	141.60***(13)	90.8%	0.0603	H5 (d)
All GSCM practices → Economic	**495.10***(28)**	**94.3%**	**0.0926**	
Internal EM → Operational	79.78***(9)	88.7%	0.0434	H6
Green purchasing → Operational	76.92***(7)	90.9%	0.0738	H7 (a)
Customer cooperation → Operational	31.14***(5)	83.9%	0.0306	H7 (b)
Investment recovery → Operational	38.68***(4)	89.7%	0.0835	H7 (c)
Eco-design → Operational	33.41***(5)	85.0%	0.0469	H7 (d)
All GSCM practices → Operational	**83.74***(10)**	**88.1%**	**0.0420**	
Environmental → Economic	224.15***(17)	92.4%	0.0649	H8
Environmental → Operational	14.64**(3)	79.5%	0.0300	H9
Operational → Economic	204.07**(5)	97.5%	0.1710	H10

Note: $+p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

Tables 8 and 9) to investigate how those moderators affect the practice-performance relationship and under which situations this relationship is the most effective.

5.1. Impact of internal EM on external EM

Cohen et al. (2003) held that a correlation effect size of less than 0.10 is regarded as weak, 0.10–0.30 is moderate and larger than 0.30 is significant. Following this guideline, the impacts of internal environmental management (IEM) on external environmental actions are all observed to be positive and significant in Table 7. The average correlation between IEM and external EM is 0.658 ($p = 0.000$), varying from 0.565 ($p = 0.000$) for investment recovery and 0.751 ($p = 0.000$) for green purchasing. H1 is thus supported.

Table 7
Impacts of GSCM practices on firm performance under the random-effect model.

Proposed relationships	Total effect	Sample size	Simple $\bar{r}$	95% CI		Hypotheses
				Lower	Upper	
Internal EM → Green purchasing	17	3394	0.751	0.625	0.877	H1 (a)
Internal EM → Customer cooperation	13	2495	0.662	0.509	0.814	H1 (b)
Internal EM → Investment recovery	13	2461	0.565	0.443	0.687	H1 (c)
Internal EM → Eco-design	17	3277	0.691	0.603	0.779	H1 (d)
Internal EM → External EM	**23**	**4145**	**0.658**	**0.574**	**0.743**	
Internal EM → Environmental	12	2200	0.631	0.474	0.787	H2
Green purchasing → Environmental	12	2058	0.543	0.409	0.677	H3 (a)
Customer cooperation → Environmental	9	1542	0.618	0.397	0.840	H3 (b)
Investment recovery → Environmental	10	1865	0.502	0.325	0.679	H3 (c)
Eco-design → Environmental	10	2029	0.549	0.308	0.791	H3 (d)
All GSCM practices → Environmental	**23**	**4177**	**0.518**	**0.408**	**0.627**	
Internal EM → Economic	18	3245	0.514	0.362	0.665	H4
Green purchasing → Economic	12	2027	0.580	0.406	0.755	H5 (a)
Customer cooperation → Economic	11	1956	0.606	0.413	0.798	H5 (b)
Investment recovery → Economic	14	2260	0.446	0.299	0.593	H5 (c)
Eco-design → Economic	14	2367	0.559	0.423	0.695	H5 (d)
All GSCM practices → Economic	**29**	**5352**	**0.464**	**0.350**	**0.579**	
Internal EM → Operational	10	1916	0.493	0.354	0.633	H6
Green purchasing → Operational	8	1137	0.485	0.286	0.684	H7 (a)
Customer cooperation → Operational	6	1113	0.407	0.253	0.562	H7 (b)
Investment recovery → Operational	5	548	0.530	0.261	0.799	H7 (c)
Eco-design → Operational	6	771	0.545	0.355	0.735	H7 (d)
All GSCM practices → Operational	**11**	**2035**	**0.481**	**0.350**	**0.612**	
Environmental → Economic	18	3481	0.565	0.442	0.688	H8
Environmental → Operational	4	549	0.638	0.447	0.829	H9
Operational → Economic	6	1476	0.721	0.385	1.057	H10

Note: "Total effect" indicates the number of effect sizes used in each analysis.

Table 8
Result of subgroup analysis under the fixed-effect model.

Proposed relationships	Total effect	Industry type			ISO certification		Export orientation	
		Automotive	Electronic	Various	ISO certified	Not specified	Export oriented	Not specified
Internal EM → Environmental	12	0.899 (1)	–	0.641 (8)	–	0.641 (10)	–	0.672 (10)
Green purchasing → Environmental	12	–	–	0.650 (8)	0.425 (2)	0.610 (8)	–	0.578 (10)
Customer cooperation → Environmental	9	–	–	0.529 (6)	–	0.577 (7)	–	0.595 (7)
Investment recovery → Environmental	10	–	0.266 (1)	0.595 (6)	0.576 (1)	0.501 (7)	–	0.532 (8)
Eco-design → Environmental	10	–	–	0.503 (8)	0.574 (1)	0.486 (7)	–	0.517 (8)
All GSCM practices → Environmental	**23**	**0.838(1)**	**0.266(1)**	**0.535(15)**	**0.509(6)**	**0.499(15)**	–	**0.509(21)**
Internal EM → Economic	18	0.916 (1)	–	0.538 (12)	0.588 (2)	0.495 (14)	0.546 (2)	0.500 (14)
Green purchasing → Economic	12	–	–	0.619 (9)	0.455 (1)	0.598 (9)	0.674 (1)	0.556 (9)
Customer cooperation → Economic	11	–	–	0.576 (7)	–	0.580 (9)	0.774 (1)	0.499 (8)
Investment recovery → Economic	14	0.207 (1)	–	0.472 (10)	0.476 (2)	0.432 (10)	0.344 (2)	0.464 (10)
Eco-design → Economic	14	–	0.371 (1)	0.587 (10)	0.477 (2)	0.577 (10)	0.470 (2)	0.576 (10)
All GSCM practices → Economic	**29**	**0.870(1)**	**0.344(3)**	**0.470(20)**	**0.519(4)**	**0.434(23)**	**0.468(4)**	**0.442(23)**
Internal EM → Operational	10	0.499 (1)	–	0.404 (5)	0.593 (1)	0.446 (7)	0.219 (1)	0.506 (7)
Green purchasing → Operational	8	0.380 (1)	–	0.662 (4)	0.360 (2)	0.637 (4)	–	0.568 (6)
Customer cooperation → Operational	6	0.452 (1)	–	0.355 (2)	–	0.378 (4)	–	0.357 (4)
Investment recovery → Operational	5	–	–	0.493 (3)	–	0.425 (3)	0.259 (1)	0.688 (2)
Eco-design → Operational	6	–	–	0.519 (3)	0.537 (1)	0.475 (3)	0.305 (1)	0.596 (3)
All GSCM practices → Operational	**11**	**0.437(1)**	–	**0.451(6)**	**0.463(2)**	**0.469(7)**	**0.261(1)**	**0.498(8)**

Note: 1. The entries give the mean effects for each level of moderators, with degree of freedom in parenthesis. To ensure the validity of our analysis, we operationally use a dash mark (–) to indicate that we do not conduct the particular moderator test when the degree of freedom for one level of moderator is less than 1 (Palmatier et al., 2006). 2. "Total effect" indicates the number of effect sizes used in each analysis.

The result implies that the successful adoption of external environmental management needs cooperation and coordination with internal sustainability strategies. For instance, as suggested by Green et al. (2012), the external GSCM practices can be implemented only when mid and top-level managers attach importance to the environmental sustainability. And Giovanni (2012) found that external collaborative green practices could be more easily initiated when all firms in a supply chain are with an environmental orientation.

Table 9
Result of meta regression.

Proposed relationships	Year of publication	Uncertainty avoidance	Indulgence	Constant	τ^2	No. of studies
Internal EM → Environmental	0.023 (0.058)	−0.009 (0.007)	–	−46.242 (117.285)	0.083	7
Green purchasing → Environmental	–	–	–	–	–	–
Customer cooperation → Environmental	−0.026 (0.074)	−0.015** (0.005)	–	52.521 (148.574)	0.046	5
Investment recovery → Environmental	−0.021 (0.033)	−0.012*** (0.003)	−0.017** (0.006)	43.106 (66.311)	0.007	6
Eco-design → Environmental	−0.031 (0.072)	−0.008 (0.007)	–	62.520 (145.843)	0.153	8
All GSCM practices → Environmental	**−0.013 (0.045)**	**−0.209*** (0.05)**	**0.001 (0.008)**	**40.277 (88.794)**	**0.058**	**14**
Internal EM → Economic	−0.002 (0.032)	−0.003 (0.004)	0.007 (0.015)	3.569 (64.588)	0.029	11
Green purchasing → Economic	0.142 (0.185)	−0.018 (0.018)	−0.048 (0.061)	−285.455 (371.323)	0.111	8
Customer cooperation → Economic	0.010 (0.116)	−0.007 (0.015)	−0.002 (0.043)	−20.748 (233.718)	0.185	8
Investment recovery → Economic	−0.024 (0.057)	−0.011* (0.005)	−0.015 (0.015)	48.796 (115.184)	0.079	8
Eco-design → Economic	−0.031 (0.054)	−0.006 (0.006)	0.003 (0.025)	61.525 (107.471)	0.103	10
All GSCM practices → Economic	**−0.011 (0.028)**	**−0.006+ (0.003)**	**−0.006 (0.010)**	**21.629 (56.808)**	**0.060**	**16**
Internal EM → Operational	–	–	–	–	–	–
Green purchasing → Operational	−0.007 (0.072)	−0.008 (0.008)	–	13.854 (145.478)	0.100	7
Customer cooperation → Operational	−0.036 (0.050)	−0.003 (0.005)	–	72.937 (100.380)	0.045	6
Investment recovery → Operational	–	–	–	–	–	–
Eco-design → Operational	−0.191 (0.171)	−0.002 (0.003)	–	383.996 (343.950)	0.014	5
All GSCM practices → Operational	**−0.021 (0.037)**	**−0.008** (0.003)**	–	**43.257 (75.269)**	**0.022**	**9**

Note: 1. + $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$. 2. Standard errors are in parenthesis.

5.2. Impact of GSCM practices on firm performance

As shown in Table 7, the impacts of GSCM practices on firm performance are all positive and significant. In particular, the influence on environmental performance turns out to be the largest ($r = 0.518$, $p = 0.000$), followed by operational ($r = 0.481$, $p = 0.000$) and economic ($r = 0.464$, $p = 0.000$) performance. The result is not surprising because GSCM practices are originally designed by firms to enhance environmental sustainability. Hypotheses H2-H7 are thus supported. However, not all types of GSCM exert the same level of influence on environmental performance. It is found that, internal EM ($r = 0.631$, $p = 0.000$) and customer cooperation ($r = 0.618$, $p = 0.000$) have the most conspicuous effects. A large body of papers is in favor of the prominently positive bond between internal green actions and environmental performance, the findings of which show that environmental outcome resulting from internal green practices may include the reduction of wastes, decrease of consumption for toxic materials, decline of environmental accidents and the improvement of employees' health (Geyer and Jackson, 2004; Zhu and Sarkis, 2004; Eltayeb et al., 2011).

Moreover, as regards the positive correlation between GSCM practices and operational performance, Frosch (1994) stated that because GSCM practices request firms to maintain close relations with their suppliers and customers, it should be easier for them to implement management strategies such as total quality management and JIT, which can result in higher operational performance. Researches have further found that firms can improve their operational outcome by enacting GSCM practices in various aspects, such as inventory level, quality, lead time and customer satisfaction (e.g., Vachon, 2007; Seuring and Müller, 2008). In our meta-analysis, eco-design ($r = 0.545$, $p = 0.000$) and investment recovery ($r = 0.530$, $p = 0.000$) are found to have the most significant impacts on operational outcome.

Besides, in spite of the fact that the cost to implement green actions (e.g., 3D printing) can be a critical factor to reduce their financial benefits at the early adoption stage (Zhu and Sarkis, 2004; Lindemann et al., 2012; Baumers et al., 2016), the statistically positive association between GSCM practices and economic performance in our meta-analysis suggests a net profit gain with the adoption of GSCM practices. There is evidence showing that the proactive GSCM actions can help enterprises to get prepared for superior longer-term performance via enhanced management of environmental risks (Bowen et al., 2001). Additionally, among all the GSCM practices, customer cooperation has the strongest influence on economic performance ($r = 0.606$, $p = 0.000$), which corresponds with its equally prominent influence on environmental outcome.

5.3. Linkages among performance

The relationships among environmental, economic and operational performance are also investigated, the result of which is presented in Table 7. We find that, both economic ($r = 0.565$, $p = 0.000$) and operational ($r = 0.638$, $p = 0.000$) performance are positively correlated with environmental performance. H8 and H9 are supported. In terms of the positive connection between environmental and economic performance, Tang et al. (2012) argued that the enhanced reputation and customer satisfaction brought by improved environmental performance could ultimately result in a larger market share and better economic performance. The cost saving nature of environmental performance is also claimed to account for an enhanced economic consequence (Green et al., 2012). Furthermore, as for its favorable impact on operational performance, Frosch (1994) indicated that the improvement in environmental performance could reinforce closer inter-organizational linkages, making it easier for firms to communicate operational requirements with their supply chain partners and thus improving the operational performance.

The relationship between operational and economic performance is found to be positive and significant ($r = 0.721$, $p = 0.000$) as well. H10 is thus supported. The concept of “eco-efficiency” is often used to explain this phenomenon (e.g., Zhu et al., 2013). It tells that the improvement of operational performance makes firms reduce waste output and material consumption, which can help to cut down the cost for waste disposing and material purchasing, and finally contribute to higher economic performance for firms (Porter and Van der Linde, 1995).

5.4. Test of moderators

As reported above, there is statistically significant heterogeneity

among initial studies included in the meta-analysis as regards to practice-performance relationship, which supports a further test of moderating effect. To be specific, for categorical moderators (i.e., industry type, ISO certification and export orientation), we use the subgroup method to analyze the variance in primary samples. But for continuous variables (i.e., year of publication, and the six cultural dimensions), we turn to meta-regression, in which the regression coefficient for the moderator quantifies the influence of moderator on the focal relationship (Borenstein et al., 2009).

5.4.1. Subgroup analysis

In Table 8, we include the influence of three categorical moderators on the linkages between GSCM practices and enterprise performance, the result of which shows that all of them are significant. Hypotheses H18-H20 are thus supported. Regarding the industrial type, we differentiate samples as automotive, electronic and various industries. Accordingly, we discover that, concerning the relationship between GSCM and environmental performance, the impact is positive and significant for all industrial types, but automotive industry ($r = 0.838$, $p = 0.000$) has a greater impact than electronic ($r = 0.266$, $p = 0.000$) and various industries ($r = 0.535$, $p = 0.000$). The finding for the relationship between GSCM and economic performance is similar. This is in accordance with previous meta-analyses, which also discovered that automotive industry has the largest effect in all regions (e.g., Golicic and Smith, 2013; Geng et al., 2017). Particularly, Golicic and Smith (2013) indicated that it is probably because significant attention on environmental practices has been received in automotive industry. Furthermore, positive impacts in electronic industry can be attributed to the large amount of researches done in Taiwan and South Korea, where electronic is a leading industry.

Second, the investigation into influence of ISO certification implies that both ISO certified and not specified firms have a positive relationship between GSCM and firm performance. However, in terms of the association between GSCM and environmental performance, ISO certified companies ($r = 0.509$, $p = 0.000$) show a stronger impact than those without specific certification ($r = 0.499$, $p = 0.000$). The discrepancy is even larger for the relationship between GSCM and economic performance. Previous researches showed that ISO-certified firms are more inclined to take GSCM practices (e.g., Rao and Holt, 2005; Ann et al., 2006; Zailani et al., 2012). Moreover, Zhu et al. (2008a) employed the theory of organizational learning to explain it. They claimed that the knowledge and experience gained from the adoption of ISO certification could help to promote the better performance of GSCM practices. In a similar way, Zailani et al. (2012) suggested that ISO certified companies are more likely to require cooperation with their suppliers, which can help them to improve the effectiveness of their GSCM practices.

Third, the moderating effect of export orientation is also explored. We compare samples from export-oriented firms and those with no indication of their orientation in terms of export status. It shows that the economic performance in both types of firms is strong and significant, but the effect is stronger for export-oriented firms ($r = 0.468$, $p = 0.000$) than those without specification of orientation ($r = 0.442$, $p = 0.000$). A possible explanation may be that, in order to enter the international market, firms with export orientation should conform to the legislation enforced by various governments (Lai et al., 2014).

5.4.2. Meta regression

In this section, we attempt to test the moderating effect of publication year and cultural dimensions on practice-performance relationship by employing a meta-regression method, and the results are presented in Table 9. Concerning the moderating influence of publication year, it is statistically insignificant for all the relationships we test, thus we consider there is no moderating effect of publication year in our meta-analysis.

Moreover, regarding the impact of cultural dimensions, four of them (i.e., power distance, individualism, masculinity and long term orientation) are dropped because their estimates of regression cannot converge. For the remaining two dimensions, only uncertainty avoidance is found to be significant and negative, suggesting that high level of uncertainty avoidance in culture is supposed to reduce the effectiveness of GSCM practices. H15 is supported. This may be due to that, people in countries that rank high on uncertainty avoidance need a lot of structure and predictability in their work life (Hofstede, 2001), which can make their working conditions less comfortable and reduce their productivities consequently (Kirca et al., 2005).

6. Conclusion

Nowadays, greening supply chains is an essential consideration for companies because stakeholders, such as regulatory bodies and customers are becoming growingly concerned about the nature and environment, thus making GSCM a fruitful area of research. Endeavors have been made to test the influence of environmental practices on business performance since last century (e.g., Bloom and Morton, 1991; Beamon, 1999; Carter et al., 2000; Albertini, 2013), but when concentration is directed to the more detailed relationship between GSCM practices and firm performance, a quantitative review of published literature turns out to be a relatively young and emerging research focus. In our analysis, 54 empirical studies with the first appearance in 2004 are included, and the results of meta-analysis confirm the positive relationship between GSCM practices and firm performance, and that there are several moderators impacting the strength of practice-performance relationship.

First, we find that, the impact of internal environmental management on external environmental management is significantly positive, implying that the successful implementation of external green practices needs the cooperation and coordination from internal green practices. Second, it is discovered that all discussed firm performance are positively influenced by GSCM practices, which can be explained from the resource-based view. And in particular, the influence on environmental performance is the largest, succeeded by operational and economic performance. The finding is not surprising, because GSCM practices are initially designed by firms to improve environmental sustainability. It should be noted that, not all types of GSCM practices have the same level of impact on firm performance. Specifically, for environmental performance, internal environmental management and customer cooperation are found to exert the most evident effects. And for economic performance, the prominent effect of customer cooperation persists. While for operational performance, eco-design and investment recovery are discovered to have the most conspicuous impacts. Third, as for the linkages among firm performance, we discover that, both operational and economic performance are positively correlated with environmental performance of GSCM practices, and there is also a significantly positive relationship between operational and economic performance. Last but not least, we further explore the practice-performance relationship from contingency perspective. Since the result of heterogeneity analysis tells that a large quantity of observed variation in effect size can be attributed to cross-samples variability, several potential moderators are selected and subsequently tested in terms of their impacts on the strength of practice-performance relationship. It is found that industry type, ISO certification, export orientation and the cultural dimension of uncertainty avoidance all have significant

moderating effects on the relationship between GSCM practices and firm performance.

To be specific, regarding industry type, the relationship between GSCM and environmental or economic performance is found to be stronger in automotive industry than electronic and various industries. Other single industries (e.g., rubber, cement) are not discussed because there have not been too many papers focusing on them so far. Moreover, we also discover that GSCM practices have better environmental performance in ISO-certified firms than those without specific certification. The discrepancy is even wider for the relationship between GSCM and economic performance. Besides, the influence of GSCM on economic outcome is also found to be larger in export-oriented firms than those without specification of orientation, despite the fact that the influence in both types of firms is significant. In regard with the cultural dimension of uncertainty avoidance, the negative influence is found, indicating that the effectiveness of GSCM practices may be reduced in regions with high level of uncertainty avoidance.

7. Implications and limitations

Our study has some important theoretical implications. First, in spite of the fact that empirical researches in GSCM are conducted in various methods, our meta-analysis allows for the test of many distinct but connected constructs to determine the similarities or differences among them. This type of analysis provides an opportunity for more consistent evaluation of links among constructs. Second, in our meta-analysis, we include a classification of both practices and performance, which has been most widely adopted by empirical studies about GSCM. Our detailed categorizations of green practices as well as firm performance enable an examination of their relationship from a more integrated perspective, which can help to diminish the gap between what we already know and what we need to know. Third, we tend to test the influences of several potential moderators (e.g., industry type, ISO certification and export orientation) on the relationship between green practices and firm performance in order to comprehend what leads to its difference in extant empirical investigations. The testing results can point to fields that need closer attention when upcoming studies are performed about GSCM, and provide researchers with helpful insights on the extension of existing theories (e.g., resource-based theory) to justify why environmental practices are more effective for certain firms or industries. Last but not least, because GSCM is a comparatively young study field, there are possibly not many meta-analyses published. Our research can offer an explanation and serve as a reference of the meta-analysis approach for other researches in similar study areas, thus helping to further promote the development of GSCM discipline.

Practical implications should also be addressed. First, the outcomes of our study are supposed to give more impetus for managers that taking GSCM practices can help to enhance many aspects of firm performance. And also, since many industries such as automobile section, have already adopted GSCM practices for years, the positive outcome may already take place, thus further reinforcing their confidence in implementing those environmental initiatives. Second, our findings show that internal environmental management practice is the most efficient in terms of improving firm performance, especially for environmental and economic performance. Therefore, for managers who are about to adopt green actions, it can be better to start with internal environmental management. Moreover, for ISO-certified companies, the test of moderators tells that their outcome from GSCM practices is better than others. Third, businesses are starting to realize the significance of implementing GSCM practices. But the inconsistencies in various empirical consequences have exasperated this situation. Our results of meta-analysis can give more comprehensive evidence that firms will get enhanced both environmentally and financially from their adoption of GSCM practices.

Our research is not without limitations. First, to some extent, the number of empirical studies included in our meta-analysis is still limited, so some of the proposed hypotheses about cultural moderators (i.e., H12, H13, H14 and H16) cannot be tested. However, our data set covers a long period and is from various regions, ensuring that the results are unbiased. Second, our study does not further reflect on the specific relationship between GSCM practices and individual indicators of each performance category. Future researches can be directed to discovering it. For instance, a specific GSCM practice may be able to improve the environmental performance in general, but this practice may reduce cost for energy consumption, while somewhat increasing environmental accidents and health hazards. Third, despite the fact that relationships between GSCM practices and firm performance are found to be positive in our meta-analysis, readers should be aware that there are some cases when the positive relationships may not hold. Many researches, especially those with mathematical models, focus on the trade-offs between environmental and economic performance of GSCM practices. For example, Tognetti et al. (2015) studied the optimization of green supply chain network by considering the trade-off between firms' environmental and economic objectives. Fahimnia et al. (2015a) also introduced a practical green supply chain optimization model that incorporates both carbon emission and economic objectives. A major philosophy behind the trade-off is that some GSCM practices may raise costs (e.g., high machine costs) for adopting firms, particularly at early adoption stage (Lindemann et al., 2012; Baumers et al., 2016). Hence, future researchers should be conscious of those trade-offs between different outcomes of GSCM, especially when building mathematical models. Fourth, in our meta-analysis, the relationship between GSCM practice and firm performance is linear, and we have not discussed the “win-win” strategy. Whereas, Lai et al. (2014) observed that GSCM practices may involve a cooperation that firms and their supply chain partners tend to create value for each other in implementing GSCM to obtain performance benefits. Thus, it will be interesting to examine whether and how the benefits of adopting GSCM practices by a firm can spillover to its supply chain partners.

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