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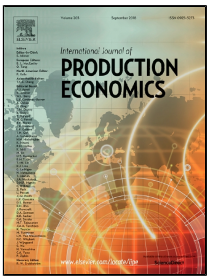

Decision-making model for sustainable supply chain finance under uncertainties

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Greetings

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Abstract

Supply chain finance has received increasing attention. The combination of sustainable development and supply chain finance requires a deeper discussion to address the theoretical and managerial gaps. Thus, this study adopts the fuzzy Technique for Order of Preference by Similarity to Ideal Solution (fuzzy TOPSIS) to develop a sustainable supply chain finance model under uncertainty to identify the existing problems and deficiencies of financing patterns. Expert assessments were performed, and the results indicate that economic factors have a significant effect on other aspects and that delivery management policies are the most effective tools for reinforcing sustainable supply chain finance practices. Moreover, the findings provide a theoretical foundation that can reinforce the understanding of sustainable supply chain finance, and the managerial implications provide a precise guideline for firms to improve their performance.

Keywords: Sustainable Development; Supply Chain Finance; Sustainable Supply Chain Finance; Triple Bottom Line; Fuzzy TOPSIS

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1. Introduction

Vietnam's textile industry has been experiencing rapid growth in recent years, and as a result, it has generated numerous employment opportunities nationwide. In addition, this industry plays an important role in the layout of the worldwide sustainable supply chain. To improve sustainable development (SD), Vietnamese textile firms have been aggressive in balancing the triple bottom line (TBL). Ahi and Searcy (2013) presented, the SD principles require significant political engagement due to the constant requirement for seeking equilibrium among the TBL aspects (i.e., economic, environmental and social aspects). The TBL offers a comprehensive method of evaluating these aspects (Lozano, 2012). For example, organizations can benefit from cost reductions, reputation improvements, and resource savings by solving environmental issues (Tseng et al., 2018). Hence, these issues have become important to firms because their stakeholders, such as regulatory authorities, customers, competitors, non-governmental organizations, and employees, are increasingly demanding that firms address issues pertaining to environmental and social sustainability in their business operations (Carter & Easton, 2011). However, previous studies of supply chain finance (SCF) focused on economic aspects have failed to address the social and environmental dimensions. Sustainable Supply Chain Finance (SSCF) helps to establish the connection and build equilibrium among the TBL aspects. To efficiently enhance SSCF, an analysis that can identify the relationships among the TBL parameters and the factors necessary for improvement is essential.

In the literature, SD is defined as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland Commission, 1987). SD possesses the complexity, dynamism and uncertainty features that exist in the context of economic and human activities. This complexity is manifested via interactions between the social aspects, such as companies and projects, and the environmental aspects, each of which has evolving properties that together compose the world of SD (Roome, 2013; Rammel and van den Bergh, 2003). Furthermore, SD addresses the integrated TBL of activities that create value for the project and the parent organization and thus simultaneously contribute to the sustainable world and sustainability (Keeys and Huemann, 2017). On the one hand, SCF is one of the key categories of finance (He and Tang, 2012). Given the benefits of SCF, the decision to adopt and promote SCF increases the exposure and willingness of the suppliers' executives to explore and adopt SCF (Wuttke et al., 2016). On the other hand, experts have argued that SD only pertains

to environmental issues (Lozano et al., 2015) and SD measurements are often perceived to be highly isolated and lacking in completeness and continuity (Lozano et al., 2015). Therefore, Hubbard (2009) identified that SD measurements lack any connection between the economic and environmental-social components of SD and lack empirical verification by theoretical normative works. Though, these attributes are important for obtaining SD in SCF, the abovementioned gaps must be filled and a connection among the TBL measures must be established. Accordingly, improving SSCF is receiving substantial attention.

Multiple attributes of SSCF have been addressed in previous studies. However, despite their significant roles in SSCF, these attributes have not been comprehensively evaluated in the current literature. Hence, the objectives of this study are to link SCF and SD, create a model to conduct a comprehensive study of SSCF and identify the factors that impact the implementation of SSCF by answering the following two research questions:

- What is the decisive decision-making model for SSCF?
- Which attributes should be improved to enhance SSCF in the industry?

To achieve these objectives, the fuzzy Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method is proposed in this study because it can evaluate multiple alternatives from among the selected criteria and combine quantitative and qualitative data into the decision-making process. Moreover, this method reduces the vagueness and uncertainties in the qualitative judgments of experts. In addition, the results of the ranking offer a guideline for firms seeking to improve their performance under resource constraints.

This study contributes to the theory of SSCF by providing theoretical insights and empirical findings. By identifying the set of attributes, the study extends the understanding of SSCF and leads to a comprehensive examination that allows firms to enhance SSCF. In addition, this study focuses on the textile industry, which is a highly competitive industry characterized by a complex network of participants engaged in SD. The remainder of this study is organized as follows. Section 2 provides a review and discusses the related literature on SD and SCF. Section 3 presents the case information, describes the data sampling, and explains the proposed methodology. Section 4 presents the results of the study, and Section 5 discusses the results as well as managerial and theoretical implications. The final section presents the concluding remarks and possible future studies.

2. Literature Review

This section provides a review of SD and SSCF, reviews the definitions and the proposed study method, explores the specific attributes that influence SSCF

according to the literature and the opinions of experts and then develops the corresponding measurements.

2.1 Sustainable Development

SD is a process that holistically addresses the integrated TBL well-being of all developmental activities (Keeys and Huemann 2017). Tseng et al. (2008) presented the application of a sustainable production framework for assessing the relative performance of the in environmental operations and management activities, which is useful for reviewing and improving sustainable and strategic development, Ahi and Searcy (2013) stated that the SD principle requires significant political engagement due to the constant need to seek equilibrium among the TBL. SD issues are generally beyond a firm's core activities; thus, firms are challenged to recreate new managerial and organizational capabilities to prepare for and move towards SD.

Moreover, SD highlights the promotion of values and behaviors that are consistent with the firm's principles, and it involves teaching and learning about the concept of SD for stakeholders, i.e., employees, faculty, community, and policymakers. This educational endeavor must take into account industrial requirements (Tseng et al., 2009; Milutinovic and Nikolic, 2014). SD also requires the consideration of an extensive and integrated set of objectives while also monitoring the outcome of development activities based on a wide range of indicators. SD recognizes that although challenging and insightful theoretical analyses have been performed, supportive rhetoric is observed in governmental policies and aspirations, multilateral agencies, and private sector statements (Crossley and Sprague, 2014; Tseng et al., 2008).

Furthermore, Delmas and Toffel (2004) suggested that a firm's competitiveness, economic benefits, and community social responsibility can be created by proactive sustainability. Sustainability is often used interchangeably with the term SD, and it represents the ideal state of SD efforts and the continual meeting of human needs balanced with the environment, a goal that is based on the ethics and values of SD actors. As a continuously evolving state, sustainability is a moving target characterized as a continuous process with no endpoint (Keeys & Huemann, 2017), and as such, it involves transitions that must be managed (Kemp et al., 2007). In addition, SD requires a more efficient and accurate attribute measurement model. Accordingly, numerous prior studies have focused on higher-level SD principles given that SD plays such an important role in the success of firms.

2.2 Supply Chain Finance

Wuttke et al. (2016) investigated suppliers' SCF adoption decisions to gain

insights into SCF by considering the optimal SCF decisions of buyers with respect to timing and payment terms. SCF can improve supply chain performance by facilitating longer payment terms for buyers and better access to financing for suppliers. Moreover, in the promotion of their SCF products, firms emphasize that SCF promotes the provision of financing to supply chain members in consideration of the operation status of the whole supply chain and their transaction background (He and Tang, 2012). Despite these clear benefits, empirical evidence has shown hesitation and resistance regarding the adoption of SCF, which is manifested in an often substantial time lag between the buyer's introduction and the adoption of SCF by all targeted suppliers. Hence, many buyers may be well-advised to postpone their SCF implementations.

Shang et al. (2009) discussed the relevance of SCF by implementing coordination mechanisms in decentralized serial inventory systems. Tanrisever et al. (2012) studied the quantitative implications of SCF by analyzing the effect of SCF on operational decisions under uncertainty, and they concluded that SCF is most beneficial in supply chains where the level of the credit spread between a buying firm and its suppliers is high (Wuttke et al., 2016). Moreover, Pfohl and Gomm (2009) proposed a general framework to evaluate joint supply chain efforts for financial improvement. While Hofmann (2005) provided conceptual insights into the operations and finance interface, Lozano (2012) clarified that the TBL focuses on incorporating the environmental and social aspects while complementing and balancing the economic indicators in company management, measurement and reporting processes. A modified decision-making model is proposed in this study to improve SSCF.

3. Method

Hwang and Yoon (1982) proposed TOPSIS, which is the most well-known technique for solving Multi-Criteria Decision Making problems. TOPSIS is based on the concept that alternatives should have the shortest geometric distance from the positive ideal solution and the longest geometric distance from the negative ideal solution. However, TOPSIS is unable to overcome the uncertainty in expert assessments. Thus, this study adopts fuzzy TOPSIS because it offers the advantage of changes in alternatives, changes in criteria, agility in the decision-making process, and different quantities of criteria and alternatives (Lima-Junior et al., 2014). Furthermore, both qualitative and quantitative data can be utilized in the decision-making process. Expert assessments need to apply fuzzy set theory to transform qualitative data into quantitative figures for further computations. Specifically, the quantitative data needs to be transposed into weights and then integrated into the

decision matrix to balance the subjective opinions. The proposed method background and proposed measures are discussed in the following subsection.

3.1 Proposed Method Background

Prior studies have proposed different methods of analyzing SCF. Wuttke et al. (2016) utilized a social contagion model to capture the suppliers' consideration of SCF and determined that such consideration depends on their exposure to successful SCF cases. He and Tang (2012) proposed a method of building a supply chain visualization platform to incorporate innovations into the SCF business pattern. Zhu et al. (2007) was the first to propose the impawn financing pricing model under conditions of permissible delay in payments. Moreover, several previous studies have explored the facets of SD. Keeys and Huemann (2017) conducted an exploratory study by employing a qualitative and interpretive method to explore the benefits of the joint development of SD projects. However, limited studies have explored the decision-making model of SSCF under uncertainty. Additionally, the supply chain is a transversal process involving several attributes that are considered to have interrelationships with suppliers and buyers in the world of business and finance. Hence, this study applies the fuzzy TOPSIS method to identify the driving attributes that influence SSCF and explore the interrelationships among the attributes.

Recently, the fuzzy TOPSIS technique was demonstrated as an efficient practical engineering and problem-solving tool. Previous studies have adopted the fuzzy TOPSIS method to investigate a variety of topics in the field of risk management. For example, Zhang et al. (2013) developed an evaluation model based on the interval analytic hierarchy process and extended TOPSIS using interval data to improve the reliability of risk identification for a hydropower project. Zhou and Lu (2012) employed the fuzzy TOPSIS and the fuzzy analytic network process in their risk evaluation of dynamic alliances to help firms choose a coalition partner and develop a reasonable benefit allocation plan. Lee et al. (2013) developed a new procedure that combines the Delphi method with the fuzzy TOPSIS technique to assess flood risk and manage vulnerability. Mahdevari et al. (2014) used fuzzy TOPSIS to assess the risks to human health and to safety management in underground coal mines. Based on the benefits of this methodology, this study applies fuzzy TOPSIS to address SSCF.

3.2 Proposed Measures

The social factor is a critical aspect of SSCF. As an aspect of the social factor, stakeholder engagement (C1) is defined as the collaborative or participative actions

that stakeholders undertake to help a corporation find solutions to environmental problems and develop a proactive strategy to address environmental problems (Ahi and Searcy, 2015). A higher level of stakeholder empowerment (C2) results in improved planning processes for firms (Wu et al., 2016). Cho et al. (2012) argued that stakeholders/customers' satisfaction (C3) focuses on establishing, maintaining and enhancing relationships with stakeholders/customers that lead to mutual benefits. Stakeholder regulations (C4) are the set of policies and rules that help firms maintain their relationships and increase the interests of their key stakeholders (Ahi and Searcy, 2015). The buyer-supplier partnership level (C5) refers to the strength of the partnership that exists between service firms and suppliers (Cho et al., 2012). An effective partnership results in a win–win situation that leads to a more efficient and effective service supply chain.

The environmental aspect includes four criteria: environmental policy (C6); reduce, reuse, and recycle of wastewater/energy (C7); environmental costs (C8); and green technology (C9). Garcia and Pargament (2015) defined environmental policy (C6) as the commitment of the organization to the laws, regulations, and other policy mechanisms related to environmental issues, such as air and water pollution, waste management, ecosystem management, biodiversity maintenance, and natural resource protection. Reduce, reuse, and recycle of wastewater/energy (C7) criterion allows resources and materials to be part of the production and consumption processes until they are physically degraded, which involves longer time spans (Garcia and Pargament, 2015). Environmental costs (C8) is defined as a reduction in air emissions, a reduction in air pollution and a reduction in the costs of environmentally friendly materials (Ahi and Searcy, 2015). Ahi and Searcy (2015) discussed green technology (C9) as the application of one or more of the products or concepts of environmental science, such as green chemistry, the use of electronic devices to monitor the environment, the conservation of the natural environment and its resources, and the curbing of the negative impacts of human activities.

The economic aspect includes five criteria: trade credit (C10), cash management (C11), inventory control (C12), raw material procurement (C13), and service delivery management policies (C14). The first four criteria were defined by Vliet et al. (2015). Trade credit (C10) is defined as the trade-off between lost sales when the policy is too tight and credit loss when the policy is too loose. Cash management (C11) is described as the basic reasons for holding cash, which principally include transaction costs, caution regarding adverse shocks and/or costly access to capital markets, taxes, and agency problems. Inventory control (C12) is defined as the relationship between inventory and the accounts receivable policy. Raw material procurement (C13) refers to the budgets established for buying environmental raw materials.

Finally, Cho et al. (2012) argued that service delivery management policies (C14) significantly impact returns on investments. Thus, how the costs associated with each asset combined with the turnover of the asset affect the total cash flow and the relevant time for that cash flow must be determined.

(INSERT Table 1)

3.3 Fuzzy TOPSIS

Step 1: Generate the assessment matrix, which consists of m alternatives and n criteria with the final assessment x_{ij}; these assessments are rearranged into an assessment matrix $[x_{ij}]_{m \times n}$.

Step 2: Normalize the matrix $[x_{ij}]_{m \times n}$ transfers to $R = [r_{ij}]_{m \times n}$ by applying the normalized method $r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}^{k}}, i = 1,2,\cdots,m; j = 1,2,\cdots,n.$

Step 3: Calculate the weighted normalized decision matrix

$t_{ij} = xr_{ij}, i = 1,2,\cdots,m; j = 1,2,\cdots,n.$ In addition, $w_{ij} = {w_i}/{\sum_{j=1}^{n} w_i}$ has to satisfy $\Sigma w_i = 1$, where w_i is the original weights applied to the indicator $v_j = 1,2,\cdots n.$

Step 4: Determine the worst alternative A_w and the best alternative A_b:

$$A_w = \left\{ \left[\frac{max\left(\frac{t_{ij}}{i} = 1,2,\ldots,m\right)}{j} \in J^- \right], \left[\frac{min\left(\frac{t_{ij}}{i} = 1,2,\ldots,m\right)}{j} \in J^+ \right] \right\} = \left\{ \frac{t_{wj}}{j} = 1,2,\ldots,n \right\},$$

$$A_b = \left\{ \left[\frac{max\left(\frac{t_{ij}}{i} = 1,2,\ldots,m\right)}{j} \in J^- \right], \left[\frac{min\left(\frac{t_{ij}}{i} = 1,2,\ldots,m\right)}{j} \in J^+ \right] \right\} = \left\{ \frac{t_{bj}}{j} = 1,2,\ldots,n \right\},$$

where $J^+ and J^- = \{j = 1,2,\cdots,n\}$ represent the positive and negative impacts, respectively.

Step5: Calculate the L2-distance among the target alternative i with the worst condition A_w and the best condition A_b.

$$d_{iw} = \sqrt{\sum_{j=1}^{n} (t_{ij} - t_{wj})^2}, i = 1,2,\cdots,m$$

$$d_{ib} = \sqrt{\Sigma_{j=1}^{n}\left(t_{ij} - t_{bj}\right)^2}, i = 1,2,\cdots,m$$

where d_{ib} and d_{iw} are L2-norm distances from the target alternative i to the worst and best conditions, respectively.

Step 6: Acquire the similarity of the worst condition:

$$S_{iw} = \frac{d_{iw}}{(d_{iw} + d_{ib})}, 0 \leq S_{iw} \leq 1, i = 1,2,\ldots,m$$

If $S_{iw} = 1$, then the alternative solution yields the best condition; otherwise, the alternative solution yields the worst condition.

Step 7: Rank the alternatives according to S_{iw}, $i = 1,2,\cdots m$.

4. Results

4.1 Case Background

Vietnam's textile industry plays an increasingly important role in the country's economy and produces products that are exported to over 50 countries. Of those countries, the U.S. is the largest importer. Furthermore, the government has proposed strategies to support green production, particularly to those textile firms whose goals include building SSCF. However, along with the growth of the industry, the textile supply chain has spread throughout the world, creating a complex network of participants linked to multiple end-markets. As a result, the textile supply chain faces several challenges, such as the complicated global supply chain, uncertain demand, short product life cycles, etc. An increasing number of firms must juggle inward and outside assets while maintaining overall standards. Furthermore, to achieve the goals of SD, firms must emphasize SSCF in practice. This study aims to identify the aspects of SSCF that will enhance the economic, environmental and social TBL perspective of the industry.

To understand how the Vietnamese textile industry achieves such performance, this study seeks to identify the decisive aspects related to SSCF. By so doing, this study provides significant managerial insights for firm management teams. The analysis outlined in the following section describes the process followed by and the recommendations provided to the textile industry in Vietnam. As a result, certain shortcomings of the industry are exposed, such as the imbalances between SCF and the environment. The need to integrate the environmental aspect into SCF is apparent, and the importance of the environmental factor must be understood. Hence, because of the urgent need to upgrade SCF to enhance the value of key export sectors, it is necessary to contribute to and manage SSCF. This study was

conducted within this framework, and the objective was to provide textile industry managers with the necessary knowledge on the attributes that drive SSCF in the industry.

4.2 Analytical Results

1. Experts were asked to evaluate each criterion using five scores, each of which represented a linguistic term, and then code the terms to triangular fuzzy numbers, i.e., unimportant (0.0, 0.1, 0.3); less important (0.1, 0.3, 0.5); important (0.3, 0.5, 0.7); moderately important (0.5, 0.7, 0.9); and very important (0.7, 0.9, 1.0). These criteria were selected from the literature for the purpose of maintaining reliability and then reviewed by experts to confirm their validity.

   Prior studies developed the questionnaire that was used to obtain the fuzzy weights for the criteria from the experts by coding their linguistic terms to triangular fuzzy numbers. Table 2 presents the fuzzy importance weight and the ranking of each criterion. The rankings of the most significant criteria of SSCF are as follows (most important to least important): stakeholder engagement (C1), buyer-supplier partnership level (C5), stakeholder and customer satisfaction (C3), inventory control (C12), and raw material procurement (C13). Experts are chosen from among academics and those working in the industry who have a minimum of seven years of experience.

(INSERT Table 2)

2. The fuzzy TOPSIS method is also used to test the influence of each criterion on each aspect. To evaluate the alternatives, the experts completed the designed questionnaire using the linguistic terms. The aggregated fuzzy decision matrix is developed according to Step 1, and it is presented in Table 3.

(INSERT Table 3)

3. The fuzzy decision matrix is normalized by applying Step 2, and it is presented in Table 4. This normalized decision matrix is multiplied by the weights of the assessed criteria to acquire the weighted normalized fuzzy decision matrix according to Step 3, and it is presented in Table 5.

(INSERT Table 4)
(INSERT Table 5)

4. Based on the weighted normalized fuzzy decision matrix, the fuzzy positive-ideal solution (A_b) and fuzzy negative-ideal solution (A_w) are calculated by adopting Step 4, which assists in the calculation of the distance of the three aspects of SSCF from the A_w and A_b. The calculated distances are then applied to Steps 5 to 7 to evaluate the similarities and rank the priority of the social, economic, and environmental aspects, and they are presented in Table 6.

(INSERT Table 6)

5. Implications

This section provides the theoretical implications to reinforce the theory of SSCF and the managerial implications, which offer guidelines for improving performance.

5.1 Theoretical Implications

The objective for the efficient management of SSCF is to improve the working capital position of both buyers and suppliers (Vliet et al., 2015). To enhance working capital, the management of cash flow is crucial because it relates directly to trade credit, cash management, inventory control and financial budgets, which firms use to purchase raw materials (Vliet et al., 2015). Additionally, because service delivery management policies also have a significant impact on the returns on investment, they indirectly affect the total cash flow (Cho et al., 2012). These factors are all economic attributes. The economic aspect is not only a part of SD but also has a critical impact on improving SCF. In fact, the results of this study confirm that the economic aspect (AS3) has the greatest influence among the three attributes on SSCF. Thus, as enhancing this economic attribute requires the strengthening of the financial statements of the supply chain, firms should prioritize the economic aspect when seeking to increase the sustainability of SCF.

This study further reveals that the social aspect (AS1) is the second most important attribute of SSCF. The critical role of the social factor is related to the impacts of SSCF on society, health, and the well-being of the people in the supply chain, including the suppliers, customers, and other stakeholders involved in the SD of SSCF (Marshall et al., 2014). To help firms create, enhance and protect their social capabilities and improve sustainability, a prior study developed a set of practices that can be applied to identify the strengths and weaknesses of current firm practices (Cho et al., 2012). When evaluating social aspects, the attendance and involvement of indirect stakeholders and community groups in the decision-making process should be considered (Marshall et al., 2014). However, this study stresses

that improving the relationships among direct stakeholders, buyers-suppliers and firms-customers increases the capabilities of the decision-making processes regarding firm SSCF.

In conclusion, this study contributes to increasing our knowledge of SSCF by exploring its decisive attributes, which provides greater insights for future studies. This study also provides evidence that economic (AS3) and social (AS1) aspects are the two decisive attributes. Therefore, these two attributes should be prioritized when making decisions regarding SSCF. Moreover, this study does not find empirical evidence to support the conjecture that environmental aspects impact SSCF, although they do play an important role in SD. This finding can be considered a theoretical implication of this study.

5.2 Managerial Implications

Stakeholder engagement (C1) is one of the most important driving criteria of SSCF. Specifically, Vietnamese textile firms must engage with their stakeholders in an effort to determine what social and environmental issues have the greatest impact on performance. Therefore, firms have a strong motivation to improve both their accountability and decision-making processes. Stakeholder engagement provides opportunities to further align business practices with social needs and expectations, which then promote long-term SD and shareholder value. However, most firms experience challenges when dealing with too many stakeholders. To effectively address this situation, firms should divide their stakeholders into groups based on their level of interest and the extent of their influence in the firm. Grouping stakeholders in such a way allows firms to develop different plans for the different types of stakeholders, thus addressing their specific purposes and building strong relationships within each group.

The buyer-supplier partnership level (C5) results in win-win situations that leads to a more efficient and effective service supply chain. Accordingly, firms should strive to establish collaborative relationships with their suppliers rather than transactional relationships or alliances. In a collaborative relationship, there is mutual respect and a desire to establish a long-term relationship. Recognizing the need for interdependence and cooperation results not only in a reduction in total costs but also in improvements in product quality. The relative level of certainty and continuity of demand in collaborative relationships increases the likelihood of investments in research and development, training, and the procurement of new, more efficient equipment focused on customer demands. While developing, managing and maintaining a strong partnership requires a huge investment by the firm in human resources, time and energy, the results of these investments are extremely attractive

from the perspective of the firm.

Stakeholder and customer satisfaction (C3) is the responsibility of everyone who works for the firm. Normally, gaining new customers costs five to eight times more than retaining existing clients, which is why firms must benchmark and track customer satisfaction to reduce costs. Because measurements such as watching sales volume and counting the frequency of complaints are now outdated and unreliable, firms should design a survey for their customers that allows them to collect information about their customers' expectations, requirements, levels of satisfaction, purchasing trends, etc. An analysis of this information then provides the firms with the data necessary to improve performance and thereby increase customer satisfaction. By increasing customer satisfaction, the firm gains customer loyalty, which in turn results in repurchasing behaviors. In a similar manner, stakeholder satisfaction and customer satisfaction, both of which are key social factors with respect to the TBL, have a major impact on SSCF.

As the lifeblood of the supply chain, inventory must be well managed to improve SSCF. For instance, too little inventory leads to a loss of customers and sales, whereas too much inventory requires more money, more transportation, more labor, etc. Accordingly, inventory control (C12) becomes one of the most important criteria of SSCF, and as a consequence, the inventory account records of the firm must be maintained and kept up-to-date. Furthermore, because loss of inventory caused by theft or damage may not be reported in the inventory account, a physical count is a critical measure. Because firms are encouraged to develop an inventory plan that includes assessing all business processes, creating a plan that is based on accurate collected data, executing that plan, measuring performance and ensuring continuous improvement allows firms to optimize inventory control management.

Nearly half of all textile materials used in the Vietnamese textile firms, including cotton, fiber, silk, etc., are imported. Therefore, enhancing SSCF in this industry translates to improve the raw material procurement (C13). The efficiency and effectiveness of raw material procurement are affected by trade regulations, political crises, exchange and/or interest rate fluctuations as well as certain external influences, such as changes in customer demand, technological development, bargaining power of large suppliers, and changes over time in the supply and quality of raw materials. Hence, to increase their competitive advantage, firms should establish an effective management strategy that includes the control of purchasing, storing, and transporting raw materials as well as the development of an ecologically sustainable process and a reduction in the costs of procurement. However, minimizing the risks associated with raw material procurement requires firms to either sign more contracts with new suppliers or seek alternative materials.

Vietnamese textile firms are capable of enhancing SSCF. The results of this study reveal that to enhance their SSCF, firms can improve stakeholder engagement (C1), buyer-supplier partnership level (C5), stakeholder and customer satisfaction (C3), inventory control (C12), and raw material procurement (C13) in order. Those five driving criteria help firms achieve a win-win result for both buyers and suppliers. Specifically, the working capital can be optimized for the buyers and an additional operating cash flow can be generated for the suppliers. Once firms succeed in strengthening their capabilities, they are capable of minimizing risks across the supply chain and creating an increasingly sustainable supply chain.

6. Conclusions

The Vietnam textile industry has encountered difficulties establishing an efficient SSCF by launching the TBL. In addition, although the two main streams SCF and SD have been investigated in recent years, limited studies have discussed the link between these two streams as a method of balancing the economic, social and environmental considerations as part of SSCF (Samuel et al., 2011). To overcome this gap, 14 criteria and three aspects are selected from the literature and then confirmed by experts to ensure their reliability and validity. Moreover, fuzzy set theory was adopted to transform the experts' judgments from linguistic preferences into quantitative figures. The quantitative data were then shifted to the weights and integrated into the decision-making matrix. Subsequently, integrating all data into TOPSIS resulted in the prioritization of the aspects and criteria necessary for guiding the Vietnamese textile firms as they seek to improve their SSCF performance.

The findings reveal that economic and social aspects are the two top aspects influencing environmental characteristics in the development of SSCF. The integration of SCF and SD must prioritize economic growth and fulfill social expectations. Particularly, the economic aspect must strengthen the financial statement of supply chains. With respect to the social aspect, it must enhance the relationships among direct stakeholders as well as the relationships between buyers and suppliers and between firms and customers to improve the decision-making processes regarding the SSCF of firms. Once these two aspects reach a certain level, the environmental aspect will be improved automatically. In addition, the results of this study provide the basis for bridging the theory to reinforce our understanding of SSCF.

The results of this study include three important contributions. First, the results provide the theoretical basis to support SSCF by bridging SCF with SD. Second, the proposed method enables the consideration of both qualitative and quantitative data to overcome the complexity and uncertainty of the process and enhance the

decision-making accuracy. Third, the rankings offer the Vietnamese textile industry a precise guideline to improve the performance of SSCF under resource constraints. To achieve efficient SSCF, inventory control (C12) and raw material procurement (C13) are needed to optimize inventory management and control purchasing, storage, and transport while also reducing the cost of procurement. Furthermore, the social aspect is another critical attribute of SSCF. Due to the importance of stakeholder engagement (C1), buyer-supplier partnership level (C5) and stakeholder and customer satisfaction (C3), textile firms must engage all supply chain stakeholders and build strong partnerships to increase customer satisfaction.

This study has several limitations. (1) Because the selected aspects and criteria are chosen from the current literature, they may not represent the most comprehensive perspectives. Therefore, future studies must incorporate additional aspects and criteria into the investigations. (2) Because the experts in this study are selected from Vietnam, external generalizability remains an issue. Hence, to eliminate opinion boundaries, further studies should select experts from various countries. (3) Because the textile industry is the only focus of this study, future studies should consider multiple industries when conducting sensitivity comparisons. (4) Although both qualitative and quantitative data are considered in this study, social media data should also be considered in future studies to better enhance the decision-making accuracy. (5) Although this study attempts to integrate fuzzy set theory with TOPSIS to obtain ranking results, more hybrid methods could be adopted in future studies.

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References

1. Ahi, P., Searcy, C., (2013). A comparative literature analysis of definitions for green and sustainable supply chain management. Journal of Cleaner Production 52, 329-341.
2. Ahi, P., Searcy, C., (2015). An analysis of metrics used to measure performance in green and sustainable supply chains. Journal of Cleaner Production 86, 360-37.
3. Carter, C. R., & Liane Easton, P. (2011). Sustainable supply chain management: evolution and future directions. International journal of physical distribution & logistics management, 41(1), 46-62.

4. Cho, D.W., Lee, Y.H, Ahn, S.H., Hwang, M.K., (2012). A framework for measuring the performance of service supply chain management. Computers & Industrial Engineering 62, 801-818.
5. Crossley, M., & Sprague, T. (2014). Education for sustainable development: Implications for small island developing states (SIDS). International Journal of Educational Development, 35, 86-95.
6. Delmas, M., & Toffel, M. W. (2004). Stakeholders and environmental management practices: an institutional framework. Business strategy and the Environment, 13(4), 209-222.
7. Garcia, X., Pargament, D., (2015). Reusing wastewater to cope with water scarcity: Economic, social and environmental considerations for decision-making. Resources, Conservation and Recycling 101, 154-166.
8. He, X., Tang, L., (2012). Exploration on building of visualization platform to innovate business operation pattern of supply chain finance. Physics Procedia 33, 1886-1893.
9. Hofmann, E. (2005). Supply chain finance: some conceptual insights. Beiträge Zu Beschaffung Und Logistik, 203-214.
10. Hubbard, G., (2009). Measuring organizational performance: beyond the triple bottom line. Business Strategy and the Environment 18(3), 177-191.
11. Hwang, C.L. and Yoon, K. (1981). Multiple Attribute Decision Making: Methods and Applications, Springer-Verlag, New York, United States.
12. Keeys, L.A., Huemann, M., (2017). Project benefits co-creation: Shaping sustainable development benefits. International Journal of Project Management 35(6), 1196-1212.
13. Kemp, R., Loorbach, D., & Rotmans, J. (2007). Transition management as a model for managing processes of co-evolution towards sustainable development. The International Journal of Sustainable Development & World Ecology, 14(1), 78-91.
14. Lee, G., Jun, K. S., & Chung, E. S. (2013). Integrated multi-criteria flood vulnerability approach using fuzzy TOPSIS and Delphi technique. Natural Hazards and Earth System Sciences, 13(5), 1293-1312.
15. Lima-Junior, R.F., Osiro, L., Carpinetti, L.C.R., (2014). A comparison between Fuzzy AHP and Fuzzy TOPSIS methods to supplier selection. Applied Soft Computing 21, 194-209.
16. Lozano, R., (2012). Towards better embedding sustainability into companies' systems: an analysis of voluntary corporate initiatives. Journal of Cleaner Production 25, 14–26.
17. Lozano, R., Carpenter, A., Huisingh, D., (2015). A review of 'theories of the firm'

and their contributions to Corporate Sustainability. Journal of Cleaner Production 106, 430-442.

18. Mahdevari, S., Shahriar, K., Esfahanipour, A., (2014). Human health and safety risks management in underground coal mines using fuzzy TOPSIS. Science of the Total Environment 488, 85-99.
19. Marshall, D., McCarthy, L., Heavey, C., McGrath, P., (2014). Environmental and social supply chain management sustainability practices: construct development and measurement. Production Planning & Control 26(8), 673-690.
20. Milutinovic, S., Nikolic, V., (2014). Rethinking higher education for sustainable development in Serbia: An assessment of Copernicus charter principles in current higher education practices. Journal of Cleaner Production 62, 107-113.
21. Pfohl, H. C., & Gomm, M. (2009). Supply chain finance: optimizing financial flows in supply chains. Logistics research, 1(3-4), 149-161.
22. Rammel, C., & van den Bergh, J. C. (2003). Evolutionary policies for sustainable development: adaptive flexibility and risk minimising. Ecological economics, 47(2-3), 121-133.
23. Roome, N. J. (2013). Sustainable development: social innovation at the interface of business, society and ecology. In Social Innovation (pp. 299-308). Springer, Berlin, Heidelberg.
24. Samuel, K. E., Goury, M. L., Gunasekaran, A., & Spalanzani, A. (2011). Knowledge management in supply chain: An empirical study from France. The Journal of Strategic Information Systems, 20(3), 283-306.
25. Shang, K.H., Song, J.S., Zipkin, P.H., (2009). Coordination mechanisms in decentralized serial inventory systems with batch ordering. Management Science 55(4), 685–695.
26. Tanrisever, F., Cetinay, H., Reindorp, M. & Fransoo, J. (2012), Value of reverse factoring in multi-stage supply chains, Working Paper, Department of Industrial Engineering and Innovation Sciences, Eindhoven University of Technology, The Netherlands.
27. Tseng, M. L., Wu, K. J., Chiu, A. S., Lim, M. K., & Tan, K. (2018). Service innovation in sustainable product service systems: improving performance under linguistic preferences. International Journal of Production Economics, 203, 414-425.
28. Tseng, M.L., Chiang, J.H., Lan, W.L., (2009). Selection of optimal supplier in supply chain management strategy with analytic network process and choquet integral. Computer and Industrial Engineering 57 (1), 330-340.
29. Tseng, M.L., Wu, W.W., Lin, Y.H., Liao, C.H., (2008). An exploration of relationships between environmental practice and manufacturing performance

using the PLS path modeling. WSEAS Transactions on Environment and Development 4 (6), 487-502.

30. Vliet, K., Reindorp, M.J., Fransoo, J.C., (2015). The price of reverse factoring: Financing rates versus payment delays. European Journal of Operational Research 242, 842–853.
31. Wu, K.-J., Liao, C.-J., Tseng, M.-L., Chiu, Kevin K.-S., (2016). Multi-attribute approach to sustainable supply chain management under uncertainty, Industrial Management & Data Systems, 116(4), 777-800
32. Wuttke, D.A., Blome, C., Heese, H.S., Protopappa-Sieke, M., (2016). Supply chain finance: Optimal introduction and adoption decisions. International Journal of Production Economics 178, 72-81.
33. Zhang, S., Sun, B., Yan, L., Wang, C., (2013). Risk identification on hydropower project using the IAHP and extension of TOPSIS methods under interval-valued fuzzy environment. Natural hazards 65(1), 359-373.
34. Zhou, X., Lu, M., (2012). Risk evaluation of dynamic alliance based on fuzzy analytic network process and fuzzy TOPSIS. Journal of Service Science and Management 5, 230-240.
35. Zhu, W., Zhu, D., Zhu, X., (2007). Pricing Model for Inventory Impawn Financing under Conditions of Permissible Delay in Payments. Systems Engineering-Theory and Practice 12, 1-7.

Tables

Table 1. Proposed Measures of Sustainable Supply Chain Finance

Aspect	Criteria		Description	Literature
Social (AS1)	C1	Stakeholder Engagement	Collaborative or participative actions that stakeholders undertake to help a corporation find solutions to environmental problems and develop a proactive strategy to address environmental problems.	Wu et al. (2016)
	C2	Stakeholder Empowerment	A higher level of empowerment results in improved planning processes for firms.	
	C3	Stakeholders/Customer Satisfaction	It focuses on establishing, maintaining and enhancing relationships with stakeholders/customers that lead to mutual benefits.	Ahi & Searcy (2015)
	C4	Stakeholder Regulations	Set of policies and rules that help firms maintain their relationships and increase the interests of their key stakeholders.	Cho et al. (2012)
	C5	Buyer-Supplier Partnership Level	The strength of partnership that exists between service firms and suppliers. A partnership results in win–win situations, leading to a more efficient and effective service supply chain.	
Environment (AS2)	C6	Environmental Policy	It is the commitment of the organization to the laws, regulations, and other policy mechanisms related to environmental issues, such as air and water pollution, waste management, ecosystem management, biodiversity maintenance, and natural resource protection.	Garcia & Pargament (2015)
	C7	Reduce, Reuse, and Recycle of Wastewater/Energy	3Rs allows resources and materials to be part of production and consumption processes until they are physically degraded, to be part of these processes for a longer time.	

Economic (AS3)	C8	Environmental Costs	A reduction in air emissions, a reduction in air pollution and a reduction in the costs of environmentally friendly materials.	
	C9	Green Technology	The application of one or more of environmental science, green chemistry, environmental monitoring and electronic devices to monitor, model and conserve the natural environment and resources, and to curb the negative impacts of human involvement.	Ahi & Searcy (2015)
	C10	Trade Credit	Trade-off between lost sales when the policy is too tight and credit losses when policy is too loose.	
	C11	Cash Management	That describes the basic reasons for holding cash, which principally include transaction costs, caution regarding adverse shocks and/or costly access to capital markets, taxes, and agency problems.	Vliet et al. (2015)
	C12	Inventory Control	The relationship between inventory and the accounts receivable policy.	
	C13	Raw Material procurement	Budgets that use for buying environmental raw materials.	
	C14	Service Delivery Management Policies	These have a significant impact on returns on investments. It is essential to determine how the costs associated with each asset, combined with its turnover, affects the total cash flow time.	Cho et al. (2012)

Table 2. Fuzzy Importance Weight and Ranking

Criteria	Weight			BNP	Normalized weights	Fuzzy importance weight	DBNP	Final Weights	D-Ranking
C1	3.700	0.729	0.886	1.771	0.475	0.346	0.421	0.841	1
C2	0.357	0.557	0.743	0.552	0.573	0.319	0.426	0.317	8
C3	0.500	0.700	0.871	0.690	0.498	0.349	0.434	0.344	3
C4	0.529	0.729	0.886	0.714	0.390	0.284	0.345	0.279	12
C5	0.471	0.671	0.857	0.667	0.543	0.365	0.465	0.362	2
C6	0.529	0.729	0.886	0.714	0.403	0.293	0.357	0.288	10
C7	0.529	0.729	0.900	0.719	0.454	0.331	0.409	0.326	7
C8	0.471	0.671	0.843	0.662	0.505	0.339	0.426	0.334	6
C9	0.557	0.757	0.900	0.738	0.386	0.292	0.347	0.285	11
C10	0.529	0.729	0.886	0.714	0.363	0.264	0.321	0.259	13
C11	0.329	0.529	0.714	0.524	0.382	0.202	0.273	0.200	14
C12	0.529	0.729	0.886	0.714	0.478	0.348	0.423	0.341	4
C13	0.643	0.843	0.971	0.819	0.410	0.346	0.398	0.336	5
C14	0.500	0.700	0.886	0.695	0.437	0.306	0.387	0.304	9

Table 3. Aggregating Fuzzy Decision Matrix

	AS1			AS2			AS3		
C1	6.14	8.14	9.57	3.86	5.857	7.71	5.57	7.57	9.14
C2	4.43	6.43	8.29	3.29	5.286	7.29	4.71	6.71	8.57
C3	5.86	7.86	9.29	5.57	7.571	9.14	5.57	7.57	9.14
C4	6.14	8.14	9.57	4.14	6.143	8.00	5.57	7.57	9.14
C5	4.14	6.14	8.14	3.00	5.000	7.00	4.43	6.43	8.43
C6	5.57	7.57	9.14	6.14	8.143	9.57	4.71	6.71	8.57
C7	5.57	7.57	9.14	6.43	8.429	9.71	5.29	7.29	9.00
C8	5.57	7.57	9.00	5.29	7.286	9.00	6.14	8.14	9.57
C9	5.57	7.57	9.29	6.43	8.429	9.71	5.86	7.86	9.43
C10	5.86	7.86	9.29	4.71	6.714	8.57	5.57	7.57	9.14
C11	7.00	9.00	10.00	4.71	6.714	8.57	5.29	7.29	8.86
C12	6.43	8.43	9.71	4.43	6.429	8.29	5.00	7.00	8.71
C13	6.43	8.43	9.71	5.29	7.286	8.86	5.29	7.29	8.86
C14	5.29	7.29	8.86	5.57	7.571	9.14	5.57	7.57	9.14

Table 4. Fuzzy Normalizing Decision Matrix

	AS1			AS2			AS3		
C1	0.614	0.814	0.957	0.397	0.603	0.794	0.582	0.791	0.955
C2	0.443	0.643	0.829	0.338	0.544	0.750	0.493	0.701	0.896
C3	0.586	0.786	0.929	0.574	0.779	0.941	0.582	0.791	0.955

C4	0.614	0.814	0.957	0.426	0.632	0.824	0.582	0.791	0.955
C5	0.414	0.614	0.814	0.309	0.515	0.721	0.463	0.672	0.881
C6	0.557	0.757	0.914	0.632	0.838	0.985	0.493	0.701	0.896
C7	0.557	0.757	0.914	0.662	0.868	1.000	0.552	0.761	0.940
C8	0.557	0.757	0.900	0.544	0.750	0.926	0.642	0.851	1.000
C9	0.557	0.757	0.929	0.662	0.868	1.000	0.612	0.821	0.985
C10	0.586	0.786	0.929	0.485	0.691	0.882	0.582	0.791	0.955
C11	0.700	0.900	1.000	0.485	0.691	0.882	0.552	0.761	0.925
C12	0.643	0.843	0.971	0.456	0.662	0.853	0.522	0.731	0.910
C13	0.643	0.843	0.971	0.544	0.750	0.912	0.552	0.761	0.925
C14	0.529	0.729	0.886	0.574	0.779	0.941	0.582	0.791	0.955

Table 5. Fuzzy Weighted Normalizing Decision Matrix

	AS1			AS2			AS3		
C1	1.080	0.282	0.403	0.698	0.209	0.334	1.023	0.274	0.402
C2	0.778	0.222	0.349	0.594	0.188	0.316	0.866	0.243	0.377
C3	1.029	0.272	0.391	1.008	0.270	0.396	1.023	0.274	0.402
C4	1.080	0.282	0.403	0.750	0.219	0.346	1.023	0.274	0.402
C5	0.728	0.213	0.343	0.543	0.178	0.303	0.813	0.232	0.370
C6	0.979	0.262	0.385	1.111	0.290	0.415	0.866	0.243	0.377
C7	0.979	0.262	0.385	1.163	0.300	0.421	0.971	0.263	0.396
C8	0.979	0.262	0.379	0.956	0.260	0.390	1.128	0.294	0.421
C9	0.979	0.262	0.391	1.163	0.300	0.421	1.075	0.284	0.414
C10	1.029	0.272	0.391	0.853	0.239	0.371	1.023	0.274	0.402
C11	1.230	0.311	0.421	0.853	0.239	0.371	0.971	0.263	0.389
C12	1.130	0.292	0.409	0.801	0.229	0.359	0.918	0.253	0.383
C13	1.130	0.292	0.409	0.956	0.260	0.384	0.971	0.263	0.389
C14	0.929	0.252	0.373	1.008	0.270	0.396	1.023	0.274	0.402

Table 6. The Ranking of Aspects

	d_{iw}	d_{ib}	S_{iw}	Rank
AS1	2.170	2.911	0.573	2
AS2	2.362	2.405	0.505	3
AS3	2.134	8.093	0.791	1