

Supplier selection among manufacturing companies based on their MSME partners' supply chain finance adoption capability using BWM and VIKOR

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Abstract

Purpose – The purpose of this paper is to identify and prioritise supply chain finance (SCF) adoption enablers and develop a novel comprehensive framework to select supplier firms based on their SCF adoption capability.

Design/methodology/approach – The study deploys a three-phase method to identify and prioritise SCF adoption enablers, followed by developing a model to select suppliers according to their SCF adoption capability. An extensive literature review, followed by a Delphi approach-based expert interview, has been used to finalise the enablers. Using the Best Worst Method and the Vlsekriterijumsko KOmpromisno Rangiranje technique, a supplier selection model has been developed in the context of a case company.

Findings – The financial health and technological advancement variables received the top priority, followed by collaborative efficiency, whereas the human resources and organisational variables received the slightest significance. A supplier selection framework has also been developed by using the adoption capability of these factors by the supplier partners. In this study's model, Supplier 4 exhibited better SCF adoption capability and received the top priority.

Research limitations/implications – Manufacturing supply chains in a developing country are the scope of the current study. Extensive future studies are required to derive a global consensus.

Practical implications – The proposed framework of this study can be used to select supplier firms based on their SCF adoption capability. Policymakers can emphasise the most critical enablers of SCF adoption to assist small supplier firms to be a part of the advanced global supply chains.

Originality/value – The current study established a novel comprehensive framework for supplier selection based on the Supply Chain Finance adoption capability of MSME supplier firms.

Keywords Supply chain finance, SCF, Supplier selection, SCF enablers

Paper type Research paper

Introduction

Micro-, small- and medium-sized enterprises (MSMEs) are one of the primary generators of national and social development on a global scale. Inadequate infrastructure, lack of adequate and expeditious access to capital, lack of technological proficiency, etc., remain obstacles for the SME sector. According to a study by the International Finance Corporation (IFC), 78%, or INR 25.5tn (\$510 billion), of the total financing requirement of INR 32.5tn (\$650bn) is either self-financed or from informal sources (IFC, 2018). The study also indicates that despite all efforts, a significant funding imbalance of INR 20.9tn (\$418bn) still needs to be addressed.

Supply chain finance (SCF) is one of the automated solutions in which the buyer firm provides immediate payment of the

supplier firm's invoices through a financial intermediary. Unlike the factoring process, the SCF programme discounts the supplier bills based on the creditworthiness of the buyer firms, which makes the process faster at less cost (Demica, 2007; Jongejans *et al.*, 2014). This helps the supplier firms, generally MSMEs with low credit ratings, to get an immediate settlement for their sales to a buying firm. This is significant because it is found that delayed payments are a great concern to MSMEs, which have constrained factoring services to discount their bills (Bose, 2013). Rajaguru *et al.* (2022) found a sequentially mediating relationship between supply- and demand-oriented performances with SCF and business performance. Studies such as Hofmann *et al.* (2019), Vu *et al.* (2022) and Bi *et al.* (2022) also found that SCF significantly affects supply chain financing and organisational performance. Recent studies also established a relationship between SCF and corporate

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sustainability performance (Wang *et al.*, 2023). Factors such as collaboration, digitisation, information sharing and financial institutions enable better SCF adoption, which eventually leads to supply chain effectiveness (Beka Be Nguema *et al.*, 2020).

By realising the benefits of an SCF programme, countries around the world have been adopting various innovative SCF practices and solutions, such as the “SCF scheme” by the UK Government and the Trade Receivables Electronic Discounting System (TReDS) platform by the Reserve Bank of India, enabling faster settlements of the MSME bills. However, lack of funds remains the biggest challenge for MSMEs worldwide (Yan *et al.*, 2017), especially in emerging economies such as India (More and Basu, 2013). Also, it is found that the SCF integration can help the buying firms to reduce their net working capital requirements by an average of 13% (Seifert and Seifert, 2009). However, there is a need for studies that help companies select their supply chain partners based on their SCF adoption capability. This is critical for buying firms to on-board suppliers with higher SCF adoption capability.

From the existing literature, it is evident that the studies extensively focused on understanding the benefits of SCF (Hofmann *et al.*, 2019; Vu *et al.*, 2022; Bi *et al.*, 2022) or exploring the SCF adoption challenges (Garg and Kashav, 2021) or identifying the SCF adoption enablers (Beka Be Nguema *et al.*, 2020; Sahoo and Thakur, 2023) and less on developing comprehensive models which helps buying firms to identify and select supplier partners based on their SCF adoption capability. Even though Wuttke *et al.* (2013b) tried to identify the reasons for SCF adoption and the role of suppliers in the SCF process through qualitative research work, a gap exists for a comprehensive supplier selection framework. Therefore, this research paper develops a novel framework to assist buying firms in identifying and selecting supplier MSME firms based on their SCF adoption capability in India using a combination of Best Worst Method (BWM) and Vlsekriterijumsko KOmpromisno Rangiranje (VIKOR) approaches.

Two crucial research questions guide our research work:

RQ1. What are the SCF adoption enablers in MSMEs?

RQ2. How do we frame a model to select supplier MSME firms based on their SCF adoption capability?

The rest of the paper is organised as follows. All relevant and essential studies are depicted in second section. The data collection process and research methodology are presented in the third section. The study shows the analysis and results in fourth section, followed by the conclusion and scope for future research.

Literature review

Gelsomino *et al.* (2016) categorised SCF research based on themes and methodologies for 119 papers published in international peer-reviewed journals between 2000 and 2014. Two perspectives on SCF were outlined in the study: the financial and the supply chain perspectives. Research papers on SCF under both perspectives primarily focus on the enablers, challenges and benefits of SCF adoption. For example, Nguema *et al.* (2021) explored SCF adoption factors and their impact on manufacturing firms. The research found that SCF positively

impacts supply chain effectiveness through information sharing, collaboration and digitalisation. Li *et al.* (2023) studied how information quantity and information quality influence the relationship between supply chain collaboration and SCF adoption. The results indicate that supply chain collaboration is positively related to SCF adoption.

Studies such as Alora and Barua (2019) and Garg and Kashav (2021) emphasised exploring the SCF adoption barriers by MSMEs in India. Poor financials of the MSME firms and lack of technological sophistication are some of the prime challenges they face in the SCF adoption. This could be why MSME shareholders experience a significant dip in their wealth during supply chain disruptions (Alora and Barua, 2021). Chatnani (2018) analysed the current state of the Reserve Bank of India's trade receivable exchange platform called TReDS. The central bank rolled out this bill discounting platform for MSME firms in 2017. The study states that similar to global platforms, India, too, faces the challenges of lack of volume and liquidity.

In a more recent study, the impact of SCF on firm performance was empirically studied. According to the study, the SCF significantly reduces supply chain risks and improves organisational performance. The researchers use structural equation modelling (SEM) to test the model based on data from China (Beka Be Nguema *et al.*, 2022). Based on the resource-based view theory, Ali *et al.* (2018) found that SCF adoption significantly improves MSME performance. Some contemporary works, such as (Moretto and Caniato, 2021), through a focus group study, attempted to understand whether SCF helps mitigate the financial disruption caused by the Covid-19 pandemic. The research stated that the SCF is assisting companies in mitigating financial risks along with improving their environmental and social performance in the short term.

Studies such as Vu *et al.* (2022) analysed the influence of SCF on SME performance in Vietnam. The results indicate that credit quality, supply chain integration, information exchange, etc., have a significant effect on the performance of SCFs and SMEs. The response of small and medium enterprises in Vietnam to SCF has been measured by Nguyen *et al.* (2022). According to the results, the SCF has a considerable positive influence on supply chain effectiveness, SME performance and supply chain risk resilience.

More recent studies, such as Supriyanto *et al.* (2023), investigated the effect of SCF on the profitability of manufacturing firms. The study also stated the significance of the cash conversion cycle on profitability. Chen *et al.* (2023) found that SCF is vital in supply chain management through functional and structural innovations and helps to solve the capital constraint problems in the agricultural development process. The role of financial intermediaries in facilitating SCF and assisting with financial performance is also explored in the literature. Guo *et al.* (2023) analysed the e-commerce SCF on MSME financial performance. The results indicate that e-commerce SCF platforms facilitate MSME financing, which helps in financial performance.

There are academic contributions in developing SCF models. Some studies, such as Jiang *et al.* (2022), developed a trust transitivity model to maximise the value-added and transmission effect of the manufacturing industry chain and alleviate the MSME financing shortage. Another model was developed by Wang *et al.* (2022), who used machine learning

techniques to predict the credit risk of MSME in SCF. The model was constructed using financial information, operational information, innovation-based information and adverse events. The ratio of operating expenses to operating revenue and net income to business revenue is the most predictive of credit risk.

Various factors that facilitate SCF adoption in suppliers have been recognised based on an extensive literature review of SCF aspects and are discussed below under five categories:

Financial health-related factors: Assessing financial health helps understand a supplier's financial stability and reliability. Credit ratings help assess financial health, and higher credit ratings indicate good financial health (Jongejans *et al.*, 2014; Wuttke *et al.*, 2013a). Firms facing difficulty in availing credit from financial institutions can resort to SCF, and hence, non-availability of credit from financial institutions can be considered a factor (Palia and Sopranzetti, 2004; Tanrisever *et al.*, 2012; Wuttke *et al.*, 2019). Moreover, firms with strong working capital positions, higher costs of financing and lower costs of SCF implementation contribute positively to SCF adoption. Hence, other factors that indicate financial health include strong working capital positions (Hofmann and Kotzab, 2010), higher financing costs (Wuttke *et al.*, 2019) and low implementation costs.

Technological capability-related factors: SCF adoption and implementation is driven by technology (Wuttke *et al.*, 2013a; Nguema *et al.*, 2021; Bi *et al.*, 2021). It requires the firms to use third-party platforms for settlements, familiarise themselves with blockchain technology and appoint skilled labour to operate. Hence, technological capability is crucial for the successful adoption of SCF. A recent study (Sahoo and Thakur, 2023) indicates that the variables of "real-time exchange of information" and "transparent platform" have significant influence and play a crucial role in the implementation of blockchain technology in SCF in Indian MSMEs.

On this basis, factors such as a high degree of digitalisation, availability of e-platforms from third parties (Wuttke *et al.*, 2013a) and skilled labour to operate the technology (Haskel and Heden, 1999; Kiley, 1999; Yang and Li (2010), technical capability (Gupta and Barua, 2016; Wuttke *et al.*, 2013a) and blockchain adoption capability (Hofmann *et al.*, 2019; Chen *et al.*, 2021; Jiang *et al.*, 2022) help evaluate the technological competency of firms.

Human resource-related factors: Schuler and MacMillan (1984) stated that effective management of human resources is crucial to the growth, prosperity and competitive advantage of an organisation. Randall and Theodore Farris (2009) find that the SCF approach improves trust, commitment and profitability in the supply chain. Hence, a higher level of trust among supply chain partners enables SCF adoption (Kwon and Suh, 2004; Handfield and Bechtel, 2002; Wuttke *et al.*, 2013a, 2013b). The other important factors related to the role of human resource in SCF adoption include commitment of the team (Mentzer *et al.*, 2001; Fawcett *et al.*, 2006), robust relationship with partners (Christopher and Ryals, 1999), shared vision among supply chain partners (More and Basu, 2013), perception of the management towards adoption of SCF (Jongejans *et al.*, 2014) and level of influence of buying firms on supplier firms (Wuttke *et al.*, 2016).

Organisational factors: Small firms are likely to adopt SCF faster than larger firms (Wuttke *et al.*, 2019). Hence, firm size facilitates SCF adoption. Secondly, the members of the

TReDS platform are more likely to adopt SCF than non-members, making membership of TReDS an influencing factor. Other organisational factors that facilitate SCF adoption include a straightforward job design in the firm (Wuttke *et al.*, 2013b), innovation capability (Chen *et al.*, 2022) and strong risk prevention ability (Zhang, 2015) of the firm.

Collaborative efficiency-related factors: Collaboration or cooperation among supply chain partners is essential for the successful adoption and implementation of SCF. Hence, a high level of collaboration among supply chain partners ensures SCF adoption (Kelle and Akbulut, 2005; Bi *et al.*, 2021; Zhang, 2015). Strong cooperation between supply chain partners and smooth facilitation of SCF is also evident when they have shared objectives (More and Basu, 2013), common interest (Viswanathan and Piplani, 2001), information sharing (Nguema *et al.*, 2021) and good communication between partners (More and Basu, 2013; Wuttke *et al.*, 2013a). Moreover, the awareness of SCF among partners also contributes to SCF adoption (Wuttke *et al.*, 2013a).

A comparative table that shows the previous critical studies on SCF and supplier selection is provided in Table 1.

Theoretical underpinnings

We develop our constructs with the help of principal-agent theory and Transaction Cost Theory (TCE). Principal-agent theory sheds light on various problems hindering successful supply chain collaboration, preventing potential improvements (Wandfluh *et al.*, 2016). Principal-agent theory is mainly concerned with two main issues. The first one is concerned with the issues about the conflicts arising from the misunderstanding of the problems between principal and agent. The second issue relates to the understanding of risk sharing and the challenges arising due to the attitude towards risk by the principal and agent. The intensity and experience of these risks vary based on factors such as government policies, competitor actions, economic climate, technological climate, etc. and can lead to uncontrollable variation in outcomes (Eisenhardt, 1989). These issues can also be present in buyer-supplier relationships in supply chains (Lundin and Norrman, 2010) and will affect supply chain financial management practices. Authors such as Wandfluh *et al.* (2016) have applied this theory in depicting the benefits of internal financing in supply chains. Hence, the lens of principal-agent theory is ideal for the base of such a complex model. Based on these theoretical insights, we have considered SCF adoption drivers from a principal-agent perspective in the model. Risks arising from principal-agent relation (buyer-supplier), such as delivery default risk, credit risk, complexity in settlements, cash flow risk and extending trade credit, can also affect the effective adoption of SCF. According to TCE, incorporating information technology in supply chain management improves stakeholder collaboration and reduces coordination costs by increasing supply chain visibility and transparency.

Research methodology

This study used a three-phase methodology to evaluate the selection of MSME suppliers based on their SCF adoption capability (see Figure 1). This three-step methodology's objective is to conclude the selection criteria for MSME

Table 1 Comparative table on previous studies on SCF and supplier selection

Author	Key findings	Methodology used
Bi <i>et al.</i> (2022)	SCF helps in mitigating supply chain risks and thereby improving organizational performance	Partial least squares-based SEM
Wanget <i>al.</i> (2023)	SCF affects corporate sustainability performance. Corporate financial performance is also found to promote the positive effect of SCF and environmental, social and governance performance	Fuzzy-set qualitative comparative analysis
Beka Be Nguema <i>et al.</i> (2020)	Information sharing, digitization and financial institutions, external collaboration helps to mitigate firm risk and thereby enhancing the supply chain effectiveness	Structural equation modelling
Soni <i>et al.</i> (2022)	Developed a hesitant fuzzy-based technology selection framework to determine the most suitable Industry 4.0 technology for sustainable supply chain finance	Hesitant fuzzy-based technology selection framework
Afrasiabi <i>et al.</i> (2022)	16 economic, environmental, social, or resilient assessment factors are listed. According to the case study, "pollution control," "environmental management system" and "risk awareness" are the most important factors for researching manufacturing-related sustainable-resilient supplier selection problems	Fuzzy BWM and TOPSIS
Chen <i>et al.</i> (2020)	Developed a model to identify smart-sustainable supply chain management practices as supplier selection criteria for a smart supply chain	DEMATEL-TOPSIS
Jia <i>et al.</i> (2020)	Created an integrated conceptual framework to show how SCF providers manage risks, build capabilities and connect the financial supply chain (SC)	Literature review-based conceptual approach
Lekakos and Serrano (2016)	Model a supplier's inventory replenishment problem as a multi-stage dynamic program and derive the supplier's optimal inventory policy	Multi-stage dynamic program
Ma <i>et al.</i> (2020)	Top management support, trust and IT infrastructure are the factors considered the most important by financial service providers in SCF	Interpretive structural modelling
Pamucar <i>et al.</i> (2022)	Job creation and occupational health and safety systems are two top criteria during supplier selection in health-care supply chain management during the Covid-19 pandemic. The supplier selection model is also developed using MACBETH method	Measuring attractiveness through a categorical-based evaluation technique (MACBETH)
Tong <i>et al.</i> (2022)	Developed a sustainable supplier selection evaluation framework. Cost, credit and corporate irregularities are the vital aspects for MSMEs to evaluate supplier performance	Extended PROMETHEE II method
Wuttke <i>et al.</i> (2013a, 2013b)	A framework is proposed for the interrelated innovation adoption processes of buying firms and their supplier firms in SCF	Multiple case study approach; conceptual approach
Wuttke <i>et al.</i> (2019)	Suppliers with less financing implement SCF sooner. Suppliers also embrace SCF faster if it reduces their finance costs more	Cox proportional hazard rate model with buyer fixed effects
Current study	Developed a novel comprehensive framework to select supplier firms based on their SCF adoption capability	BWM and the VIKOR technique

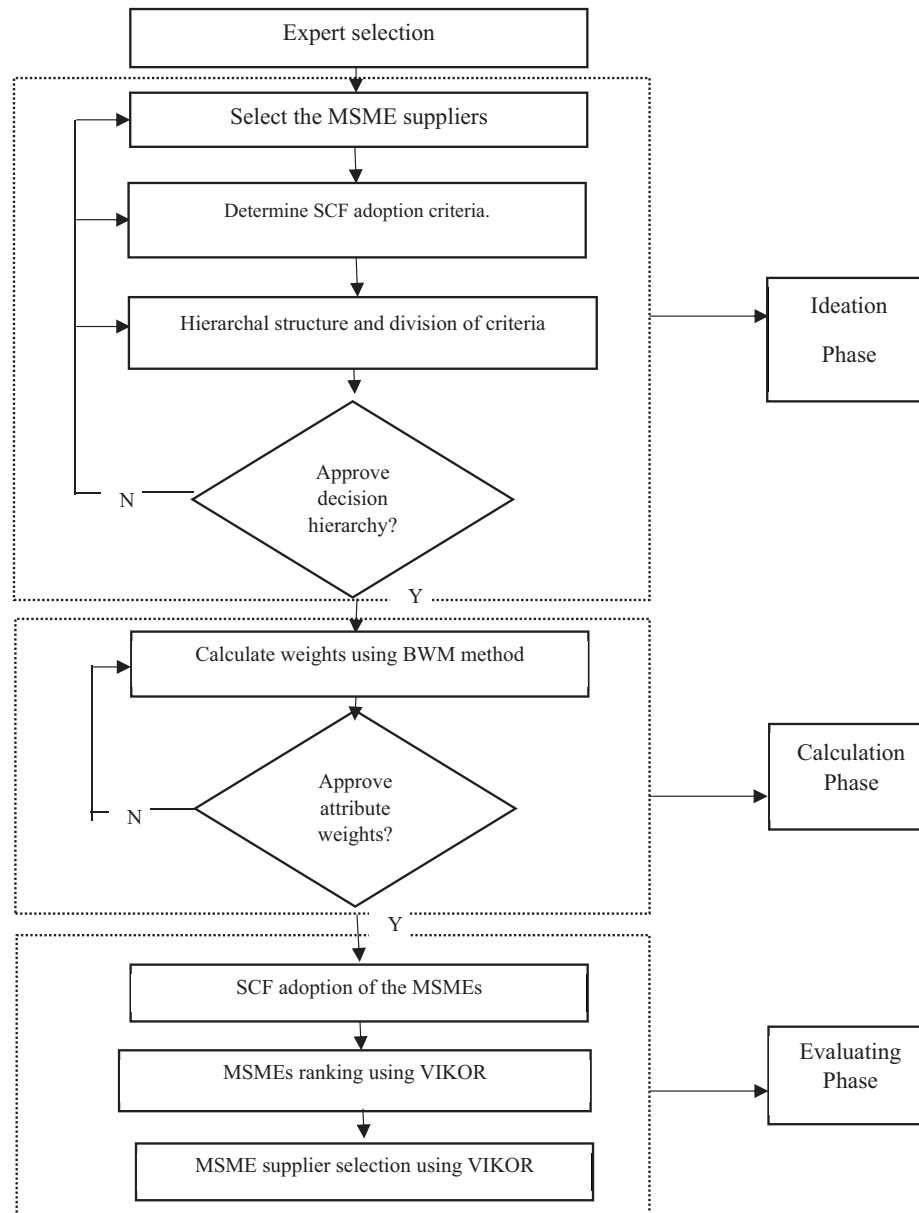
Source: Authors' own work

suppliers by using a mix of expert opinion, quantitative analysis and a review of the relevant literature. Following the completion of the first step, which involves the identification of the assessment criteria using exhaustive research of the pertinent literature, the second phase consists of finalising these criteria using a panel discussion with industry professionals using the Delphi technique. The third phase uses BWM to rank the evaluation criteria for the SCF adoption capabilities of MSMEs. It uses the VIKOR approach to evaluate the performance of selected enterprises based on these criteria.

The Delphi technique is a structured and systematic approach within multi-criteria decision making (MCDM) used to collect input and insights from a panel of experts, enabling the attainment of consensus or well-informed decisions in complex and uncertain scenarios. MCDM pertains to assessing and contrasting multiple criteria or attributes to facilitate

informed decision-making. This method is particularly advantageous when a single decision maker or a straightforward voting process may prove insufficient, given the intricacies and potential subjectivity inherent in the issue.

In the context of data collection, Delphi techniques were used to identify barriers and devise strategies to overcome them. The Delphi technique is chosen for its structured communication approach. It facilitates soliciting expert opinions from a group of individuals, typically aimed at making informed decisions or predictions regarding a specific topic or issue (Ahmad and Wong, 2019). The procedure entails a sequence of questionnaires or surveys distributed to a panel of experts who provide their opinions and feedback anonymously. Typically, the process involves a facilitator identifying a group of experts within a specific field or industry. The facilitator subsequently distributes a series of questionnaires or surveys to

Figure 1 Schematic for phases of methodology

Source: Authors own work

these experts, requesting their input on a particular topic or issue. The responses are then collated and analysed by the facilitator, who may offer feedback to the experts in subsequent rounds of inquiry. The Delphi technique's design is geared towards reducing bias and diminishing the influence of dominant or vocal individuals within the group (Kumar *et al.*, 2020; Kusi-Sarpong *et al.*, 2023).

The primary and sub-attributes finalised are given in Table 2.

The BWM, developed by Jafar Rezaei in 2015, is a MCDM technique used to assess and rank alternatives based on their performance against a set of criteria. It is beneficial when decision-makers must determine which choices are the best and worst among a group of options (Rezaei, 2015, 2016). The BWM helps assign weights to criteria and subsequently prioritise

the alternatives. The process involves selecting the best and worst alternatives for each criterion and then calculating scores for each alternative. These scores can be used to rank the alternatives. In our study, we adopted the BWM to assess the relative importance of criteria in our decision-making process and to determine the best and worst criteria, calculate weight scores, and rank criteria based on their significance. The BWM enables us to prioritise the criteria effectively, contributing to the robustness of our decision-making framework.

The VIKOR method is another MCDM technique used to rank alternatives with conflicting criteria (Shumaiza *et al.*, 2019). It works on compromise programming, which makes this technique better than other techniques. The VIKOR method is a compromise priority approach helpful in

Table 2 Main and sub-attributes

Broad criteria	Explanation	Literature
Financial health		
Higher credit ratings (F1)	Indication of good financial health	Wuttke <i>et al.</i> (2013a, 2013b), Jongejans <i>et al.</i> (2014)
Non availability of credit from financial institutions (F2)	Financially constrained firms might adopt SCF faster than non-finance constrained firms	Palia and Sopranzetti (2004), Tanrisever <i>et al.</i> (2012), Wuttke <i>et al.</i> (2019)
Strong working capital positions (F3)	Firms with strong working capital positions may try to adopt new methods such as SCF	Hofmann and Kotzab (2010), Expert view
Higher financing costs (F4)	A higher financing cost will lead greater SCF adoption	Wuttke <i>et al.</i> (2019)
Low implementation cost (F5)	SCF is a win-win situation if implementation costs are low	Expert view
Technological capability		
High degree of digitalization (T1)	SCF is a technology driven system	Wuttke <i>et al.</i> (2013a, 2013b), Nguema <i>et al.</i> (2021), Bi <i>et al.</i> (2021)
Availability of E-platforms from third parties (T2)	SCF makes use of third-party platforms for settlements	Wuttke <i>et al.</i> (2013a, 2013b)
Availability of skilled labour to operate technology (T3)	Technology need skilled labour to operate	Kiley (1999), Haskel and Heden (1999), Yang and Li (2010)
Technological capability (T4)	Higher degree of technological capability by the firm	Gupta and Barua (2016), Wuttke <i>et al.</i> (2013a, 2013b), Caniato <i>et al.</i> (2019), Chen <i>et al.</i> (2021)
Blockchain adoption capability (T5)	Blockchain technology drives SCF innovation	Hofmann <i>et al.</i> (2019), Chen <i>et al.</i> (2021), Jiang <i>et al.</i> (2022)
Human resource factors		
Higher degree of trust among partners (H1)	The longer the association, the higher the trust	Handfield and Bechtel (2002), Kwon and Suh (2004), Wuttke <i>et al.</i> (2013a, 2013b)
Commitment of the team (H2)	A highly committed team can adopt SCF faster	Fawcett <i>et al.</i> (2006), Mentzer <i>et al.</i> (2001)
Robust relationships with partners (H3)	Good relationships with upstream and downstream partners	Christopher and Ryals (1999)
Common vision (H4)	A common vision among partners to adopt SCF in the supply chain	More and Basu (2013)
Perception of the management (H5)	A positive perception of the management towards new methods	Jongejans <i>et al.</i> (2014)
Level of influence (H6)	Higher influence of buying firms on supplier firms leads to faster SCF adoption	Wuttke <i>et al.</i> (2016)
Organisational factors		
Firm Size (O1)	Small firms tend to adopt SCF faster than larger firms	Wuttke <i>et al.</i> (2019)
Clear job design in the firm (O2)	A clear job design will help in SCF adoption	Wuttke <i>et al.</i> (2013a, 2013b)
Member of TREDIS platform (O3)	A platform developed by the central bank to facilitate bill discounting	Expert contribution
Innovation capability (O4)	Ability of the firm to innovate	Chen <i>et al.</i> (2022)
Strong risk prevention ability (O5)	It leads to higher motivation to adopt SCF	Zhang (2015)
Collaborative efficiency		
Cooperation among partners (C1)	Higher level of cooperation among SC partners	Kelle and Akbulut (2005), Bi <i>et al.</i> (2021), Zhang (2015)
Shared objective among partners (C2)	A greater extend of shared objectives among SC partners	More and Basu (2013)
Common interest among partners (C3)	Higher level of common interest among the partners	Viswanathan and Piplani (2001), Power (2005)
Good communication between partners (C4)	Communication between partners is essential for the smooth SCF adoption	More and Basu (2013), Wuttke <i>et al.</i> (2013a, 2013b)
Level of awareness on SCF (C5)	The higher the awareness, the faster the adoption	Wuttke <i>et al.</i> (2013a, 2013b)
Higher level of information sharing (C6)	Information sharing among partners can affect SCF adoption	Nguema <i>et al.</i> (2021)
Source: Authors' own work		

optimising multiple responses. It is based on a multi-attribute ranking index obtained from the comparison of the closeness of each attribute to the ideal alternative (Garg and Sharma, 2020). VIKOR is preferred in alternative selection as compared to

other MCDMs, i.e. TOPSIS, ANP, ELECTRE, etc. because it measures closeness to a positive ideal solution, which reduces the risk in decision-making and optimises the decision maker's choice (Liang *et al.*, 2021). The VIKOR is particularly useful

when decision-makers seek a balance between the best and worst-case scenarios while considering multiple criteria. Moreover, the VIKOR approach chooses the best alternative with accuracy and optimises the results.

The following are some of the stages.

Finalisation of supply chain finance adoption criteria and determination of micro-small and medium-sized enterprises' supply chain finance adoption capabilities using Best Worst Method

Using a combination of literature review, the Delphi method and a panel discussion, the enablers for SCF adoption in MSMEs have been finalised. BWM is a highly effective MCDM technique used by numerous researchers.

The stages outlined by Rezaei (2016) and Rezaei *et al.* (2016) are described in detail below.

Step one is the selection of attributes for analysis based on a review of the relevant literature and expert opinion, as shown in Table 2. In step two, attributes have been classified as best and worst variables with the help of experts. Step three consisted of requesting from each expert a preference rating on a scale from 1 to 9, as shown in Table 3. Step four involved the experts providing a preference rating for each attribute relative to the worst attribute. Step 5 involved calculating the optimised weights ($w_1^*, w_2^*, \dots, w_n^*$) for each attribute. The profile of the respondents is given in Table 4.

The purpose of this study is to determine attribute weights that minimise the utmost absolute differences for all j can be minimised for $\{|w_B - a_{Bj}w_j|, |w_j - a_{jW}w_W|\}$. The subsequent minimax model turns out to be:

$$\begin{aligned} \min \max \quad & \{|w_B - a_{Bj}w_j|, |w_j - a_{jW}w_W|\} \\ \text{s.t.} \quad & \sum_j w_j = 1 \\ & w_j \geq 0, \text{ for all } j \end{aligned} \quad (1)$$

Model (1) converted into a linear model yields superior results; the resulting model is depicted below.

$$\begin{aligned} \min \quad & \xi^L \\ \text{s.t.} \quad & |w_B - a_{Bj}w_j| \leq \xi^L, \text{ for all } j \\ & |w_j - a_{jW}w_W| \leq \xi^L, \text{ for all } j \\ & \sum_j w_j = 1 \\ & w_j \geq 0, \text{ for all } j \end{aligned} \quad (2)$$

Model (2) may be resolved for optimised weights ($w_1^*, w_2^*, \dots, w_n^*$) and optimal value ξ^L .

Consistency (ξ^L) of attribute comparisons close to 0 is desired (Rezaei, 2016).

Table 4 Profile of the experts

Relevant dimension	Profile
Job positions of the respondents	16% senior level 63% middle level 21% lower level
Qualification of respondents	32% postgraduate 42% undergraduate 26% diploma
Experience of respondents (years)	16% >11 31% > between 5 and 10 53% <5

Source: Authors' own work

Ranking the alternatives using Vlsekriterijumsko KOmpromisno Rangiranje

The steps of the VIKOR methodology are discussed below:

Step 1: Using Table 5's scale, a pairwise matrix of criteria and options was essential.

Step 2: By using equation (3), the average decision matrix is developed as follows:

$$F = \frac{1}{k} \sum_{k=1}^k F_k \quad (3)$$

Where k is decision makers, and F is the average decision matrix.

Step 3: By using formulas (4) and (5), the best f_b^* and the worst f_b^- values of all the criteria, $b = 1, 2, \dots, n$ is computed:

$$f_b^* = \text{Max } (f_{ab}) \quad (4)$$

$$f_b^- = \text{Min } (f_{ab}) \quad (5)$$

where f_b^* is the positive ideal solution and f_b^- is the negative ideal solution for the b_{th} attribute.

Step 4: Compute the S_a and R_a values for $a = 1, 2, \dots, m$ using equations (6) and (7):

Table 5 Linguistic scale for pairwise comparison for VIKOR methodology

Scale for VIKOR methodology Linguistic variables	Importance rating
Least important	1
Moderately important	2
Strongly important	3
Very strongly important	4
Extremely important	5

Source: Authors' own work

Table 3 Linguistic scale for pairwise comparison for best worst methodology

Scale of BWM								
Equally important	Equal to moderately more important	Moderately more important	Moderately to strongly more important	Strongly more important	Strongly to very strongly more important	Very strongly more important	Very strongly to extremely more important	Extremely more important
1	2	3	4	5	6	7	8	9

Source: Authors' own work

$$S_a = \sum_{b=1}^n W_b [(f_b^* - f_{ab}) / (f_b^* - f_b^-)] \quad (6)$$

$$R_a = \text{Max}_b [W_b (f_b^* - f_{ab}) / (f_b^* - f_b^-)] \quad (7)$$

The solution provided by S_a and R_a are based on the value maximum group utility (majority rule) and minimum individual regret of the opponent, respectively, and W_b depicts the weights of the criteria as stated by Ebrahimnejad *et al.* (2012).

Step 5: By using equation (8), the scores for Q_a were computed as follows:

$$Q_a = v \left(\frac{S_a - S^*}{S^- - S^*} \right) + (1 - v) \left(\frac{R_a - R^*}{R^- - R^*} \right) \quad (8)$$

Where, $S^- = \text{Max}_a S_a$, $S^* = \text{Min}_a S_a$, $R^- = \text{Max}_a R_a$, $R^* = \text{Min}_a R_a$ and v depicts the weight of the strategy of “the majority of criteria” (or the maximum group utility), where $v = 0.5$. This solution is stable within a decision-making process, which could be: “voting by majority rule” (when $v > 0.5$ is needed) or “by consensus” $v = 0.5$, or “with veto” ($v < 0.5$) (Opricovic and Tzeng, 2004; Sanayei *et al.*, 2010) Q_a denotes VIKOR index.

Step 6: By using Q_a values, the ranking of the alternatives is done.

Step 7: The ranking of the alternatives is carried based on the minimum Q_a values obtained by the below simultaneously satisfying two conditions:

Condition 1: $Q(A(1))$ is chosen if $Q(A(2)) - Q(A(1)) \geq 1/n - 1$, where $A(2)$ is the alternative that has the second rank in the analysis and n is the total alternatives.

Condition 2: $Q(A(1))$ also obtains the first rank according to both S_a and R_a values.

Step 8: Alternatively, the obtained minimum score in Q_a is ranked first.

Case analysis and application using the proposed methodology

This research study analyses the Indian manufacturing industrial sector. This study analysed five MSME OEM suppliers of a major Indian automobile company to determine the optimum MSME supplier based on SCF adoption. The panel consensus method was used to gather expert data. Table 3 shows the scales the five experts used to rate the MSME attributes for BWM. Table 5 shows the scale for pairwise comparison for VIKOR. Expert 1 is a managing director and CEO of a renowned automotive company with over 35 years of industry experience. Expert 2 and Expert 3 are Executive Vice Chairman and Executive Managing Director of an Automotive manufacturing company with over 15 years of industry expertise. Expert 4 is the branch manager of a bank who specialises in bills discounting of the corporates. Expert 5 is an entrepreneur of a small-scale business which manufactures OEM components for automotive companies. We sought the assistance of another ten experts to validate the results, which accounts for the total number of experts involved in the study to fifteen.

Finalisation of attributes of supply chain finance adoption capability

The extensive literature review and expert interview resulted in 5 categories of variables and 27 sub-attributes of SCF adoption capabilities in MSMEs.

Attributes weights calculation using the Best Worst Method

The experts were requested to choose the best and the worst attributes among all the finalised attributes. Experts determined the best attribute on a 1–9 scale, with one being equally significant and nine being extremely important. Table 6 shows the optimised attribute weights and consistency values from equations (2) and (3).

Ranking of the alternatives using the VISe Kriterijumsko KOMPromisno Rangiranje method. Once the weights and rankings of all the variables are generated using the BWM, the next step is to prioritise them based on the weights of the attributes using the VIKOR method using the linguistic scale provided in Tables 3 and 5. After obtaining the individual responses from the experts, the average rating is calculated using equation (3) and is shown in Table 7. The weighted average of these results is shown in Table 8. The maximum and the minimum values of these variables were calculated using equations (4) and (5). Further, using equations (6)–(8), the values of S, R and Q are calculated and are shown in Table 9. The alternatives are ranked based on Q values; the alternative with the lowest Q value is selected as the best alternative subject to satisfying two conditions, as mentioned in Step 7 of Phase 3 of the methodology. Here, Supplier 4 (S4) obtains the first rank, as it has the lowest Q value and also satisfies both the conditions, i.e. $Q(S1) - Q(S4) \geq 1/(5-1)$ and also Q (S4) obtains the first rank as per both R and S values as evident from Table 9.

Table 6 Weights and ranking of main and sub-attributes

Broad criteria	Weight	Code	Weight	Global weight	Rank
Financial health (1)	0.290	F1	0.184	0.053	10
	0.290	F2	0.217	0.063	4
	0.290	F3	0.218	0.063	3
	0.290	F4	0.087	0.025	16
	0.290	F5	0.295	0.085	1
Technological capability (2)	0.180	T1	0.341	0.061	5
	0.180	T2	0.307	0.055	7
	0.180	T3	0.056	0.010	25
	0.180	T4	0.121	0.022	18
	0.180	T5	0.176	0.032	14
Human Resource factors (4)	0.072	H1	0.184	0.013	23
	0.072	H2	0.193	0.014	22
	0.072	H3	0.208	0.015	21
	0.072	H4	0.244	0.018	19
	0.072	H5	0.075	0.005	27
	0.072	H6	0.096	0.007	26
Organisational factors (5)	0.239	O1	0.223	0.053	11
	0.239	O2	0.219	0.052	12
	0.239	O3	0.266	0.064	2
	0.239	O4	0.229	0.055	8
	0.239	O5	0.063	0.015	20
Collaborative efficiency (3)	0.219	C1	0.245	0.053	9
	0.219	C2	0.101	0.022	17
	0.219	C3	0.202	0.044	13
	0.219	C4	0.119	0.026	15
	0.219	C5	0.277	0.061	6
	0.219	C6	0.056	0.012	24

Source: Authors' own work

Table 7 Average rating of 8 experts

Suppliers	F1	F2	F3	F4	F5	T1	T2	T3	T4	T5	H1	H2	H3	H4	H5	H6	O1	O2	O3	O4	O5	C1	C2	C3	C4	C5	C6
S1	3.625	3.875	3.250	2.750	3.125	2.875	4.375	3.375	3.250	3.500	3.375	2.750	4.125	3.625	3.750	2.250	4.875	3.375	3.375	2.500	2.875	3.250	4.125	2.875	3.250	3.375	3.750
S2	2.875	3.500	3.250	2.875	2.375	4.125	3.750	3.625	3.000	3.500	2.500	3.750	3.000	3.125	3.375	3.500	3.000	3.750	3.625	3.000	3.625	2.750	3.125	3.125	3.250	3.375	3.500
S3	3.875	4.125	2.125	3.500	2.375	3.125	3.625	2.750	3.875	3.375	3.625	3.375	3.625	3.000	3.125	2.750	1.875	2.125	3.500	2.375	3.625	3.500	3.250	3.625	2.875	2.750	3.625
S4	4.250	4.750	3.250	3.750	2.750	3.875	4.000	3.000	4.125	3.250	3.500	3.250	4.125	3.500	4.125	4.625	3.875	3.750	4.000	4.000	4.500	3.750	3.125	4.375	3.000	2.625	4.625
S5	2.500	3.250	2.750	3.125	3.125	3.375	4.125	3.250	3.750	3.500	3.875	4.125	3.500	3.500	3.250	3.625	4.125	3.250	3.750	3.000	3.625	3.125	3.500	3.500	3.500	3.500	3.250

Source: Authors own work

Table 8 Weighted average

Suppliers	F1	F2	F3	F4	F5	T1	T2	T3	T4	T5	H1	H2	H3	H4	H5	H6	O1	O2	O3	O4	O5	C1	C2	C3	C4	C5	C6
S1	0.019	0.037	0.000	0.025	0.000	0.061	0.000	0.003	0.017	0.000	0.005	0.014	0.000	0.000	0.002	0.007	0.000	0.012	0.064	0.051	0.015	0.027	0.000	0.044	0.010	0.009	0.008
S2	0.042	0.052	0.000	0.022	0.095	0.000	0.046	0.000	0.022	0.000	0.013	0.004	0.015	0.014	0.004	0.003	0.033	0.000	0.038	0.034	0.008	0.053	0.022	0.037	0.010	0.009	0.010
S3	0.011	0.026	0.063	0.006	0.085	0.049	0.055	0.010	0.005	0.016	0.002	0.008	0.007	0.018	0.005	0.005	0.053	0.052	0.051	0.055	0.008	0.013	0.019	0.022	0.026	0.052	0.009
S4	0.000	0.000	0.000	0.000	0.043	0.012	0.028	0.007	0.000	0.032	0.004	0.009	0.000	0.004	0.000	0.000	0.018	0.000	0.000	0.000	0.000	0.000	0.022	0.000	0.021	0.061	0.000
S5	0.053	0.063	0.028	0.016	0.000	0.037	0.018	0.004	0.007	0.000	0.000	0.000	0.008	0.004	0.005	0.003	0.013	0.016	0.025	0.034	0.008	0.033	0.014	0.026	0.000	0.000	0.012

Source: Authors' own work

Table 9 The S, Q and R values and ranking of suppliers

Suppliers	S	Rank	R	Rank	Q	Rank
S1	0.429	3	0.064	3	0.243	3
S2	0.578	4	0.085	4	0.836	4
S3	0.734	5	0.085	5	1.000	5
S4	0.259	1	0.061	1	0.000	1
S5	0.428	2	0.063	2	0.227	2

Source: Authors' own work

Discussion of results

The present study uses the BWM to prioritise the assessment criteria for the SCF adoption capabilities of MSMEs. The Delphi technique is used to gather information and perspectives from a group of experts for the study. Additionally, the study uses the VIKOR technique to assess the performance of the chosen supplier businesses, considering the evaluation as mentioned in the above criteria. The financial health of an organisation has received the highest weight (0.290) and, as a result, the first rank among the five primary SCF adoption facilitators. The term “financial health” refers to various factors, including more substantial credit ratings, solid working capital balances, higher financing costs, etc. Because the financial capability of a supplier company will play a direct deciding role in the adoption of advanced technology, innovations, risk prevention and mitigation ability, which will lead to higher adoption of SCF, it is evident that the financial enablers are found to be the significant SCF adoption enabler. The significance of financial capabilities is emphasised in the previous research as well (Wagner, Bode and Koziol, 2009; Wetzel and Hofmann, 2019; Alora and Barua, 2019). Therefore, the current study aligns with the existing literature on the importance of financial aspects of SCF. Financial capabilities are also found to be a critical factor in selecting socially responsible suppliers in the banking industry in earlier studies (Ojadi *et al.*, 2023). Under the five subcategories, Low implementation cost (F5) received the first place, followed by solid working capital positions (F3), non-availability of credit from financial institutions (F2), higher credit ratings (F1) and higher financing costs (F4).

Industry 4.0 technologies, such as the Internet of Things, big data, cloud computing, are vital in SCF adoption in MSMEs (Soni *et al.*, 2022). The capacity for technological advancement (0.180) was awarded second place among the primary factors. Based on the tenets of TCE, the primary objective of using information technology within supply chain management is to enhance collaboration among supply chain stakeholders and mitigate coordination costs by auguring supply chain visibility and transparency. Technology will make it possible for businesses to transact their bills and receive discounts from a variety of partners in a systematic manner. The vast majority of bill discounting in India occurs on the TReDS platform, which the country's central bank controls. When it comes to registering, listing bills and conducting business among the intermediaries, technology plays an essential role. Hence, the present study's findings assert that the technology adoption capabilities of supplier firms play a crucial role in facilitating SCF implementation, potentially leading to a reduction in transaction costs (TCE) and an enhancement in corporate performance (Subrahmanya, 2011). The sub-attributes under technological advancement were ranked

as follows: High degree of digitalisation (T1), Availability of E-platforms from 3rd parties (T2), Blockchain adoption capability (T5), Technological capability (T4) and Availability of skilled labour to operate technology (T3). The availability of digital SCF platforms was not considered in the literature (Soni *et al.*, 2022; Wu and Zhang, 2022; Li *et al.*, 2023). However, the results of the current study depict the significance of this in easier SCF adoption, as this received the second ranking among the sub-categories of the capacity for technological advancement variable.

The significance of collaboration is evident in the SCF literature (Li *et al.*, 2023; Laorden *et al.*, 2022; Beka Be Nguema *et al.*, 2020). Collaborative efficiency comes in at number three on the list of critically significant enablers for SCF adoption (0.219) in the current study. Collaboration between financial institutions and suppliers is essential for successful SCF, as SCF focuses on a collaborative inter-organizational financing approach (Ma, Wang and Chan, 2020). Communication and settlements must take place on a timely basis for SCF programmes. The level of awareness on SCF (C5), which rates best among the subcategories of collaboration, is followed by Cooperation among partners (C1), Common interest among partners (C3), Good communication between partners (C4), Shared objective among partners (C2) and Higher level of information sharing (C6).

Regarding the primary criteria, the human resource factors and the organisational factors come in at positions four and five, respectively. The authors believe these factors are also crucial for seamless SCF adoption. Top management support and trust among the supply chain partners are critical SCF enablers in the past research (Ma *et al.*, 2020).

The adoption drivers of SCF have been examined in our model from a principal-agent approach. Many risks can hinder the successful adoption of SCF from the principal-agent relationship between buyers and suppliers. As the results indicate, these risks can come mainly from a lack of cooperation among supply chain partners, lack of common interest among the supply chain partners, poor communication between the supply chain partners, lack of integrated technology among the partners, and poor credit ratings of the buyer firms.

Following the assessment of the factors facilitating the adoption of SCF, a subset of suppliers was chosen and then evaluated using the VIKOR approach based on the established criteria. The suppliers have been rated in the following manner: S4>S5>S1>S2>S3. The findings suggest that Supplier 4 (S4) has the highest level of capacity in adopting SCF. The managers of the other supplier businesses can emulate the characteristics of S4 to enhance their efficiency in adopting SCF and meet the expectations of their buying firms.

Conclusions and scope for future research

Persistent economic downturns and financially constrained supply networks paved the door for SCF solutions. SCF adoption is expected to improve the cash flows, reduce the cost of capital and improve the relationships between supply chain partners. Most of the supplier firms in developing countries such as India are MSMEs, which need more capabilities of better SCF adoption, such as better financials, technological capabilities, collaborative efficiency, human resources and organisational capabilities. Therefore, in this study, an

innovative and comprehensive framework for buying companies to select suppliers based on their SCF adoption capabilities was simulated. The research focused on five original equipment manufacturers that supply a prominent Indian vehicle manufacturer. A comprehensive assessment of the relevant literature uncovered 5 main SCF enablers and 27 sub-enablers in the first phase. The next step consisted of finalising the SCF adoption enablers by conducting expert interviews using the Delphi method. Finally, the BWM and the VIKOR were used in the process of ranking these enablers of SCF adoption and selecting the best suppliers based on these criteria.

According to the findings of the analysis, the element of financial health was given the highest importance, followed by the factor of technological capability, collaborative efficiency, the human resource factor and the organisational factors. MSMEs typically have supply chains that are financially constrained and lack technological capabilities. By prioritising the above factors and their sub-factors, supply chain partners can effectively adopt SCF, which can reduce default risk, access short-term capital, minimise settlement complexity and improve cash flows. These findings may inspire policymakers and managers to provide the necessary attention to these areas in the future, which will assist small- and medium-sized enterprise suppliers adopt SCF more expediently. A similar hypothesis could be tested in subsequent studies involving various types of businesses or geographic regions. In addition, more sophisticated methods such as regression, ANOVA, SEM or DEMATEL could be used in future research to validate the findings obtained.

Implications of the study

The current study developed a novel comprehensive framework to select supplier firms based on their SCF adoption capability. The integrated BWM and VIKOR analysis highlight the following implications: A framework to evaluate suppliers based on their SCF adoption capabilities could facilitate supplier selection for organisations worldwide. Given the widespread presence of the SCF ecosystem in many nations, the variables facilitating its adoption may exhibit some degree of commonality but not necessarily their relative significance. The managers could make use of the developed model and investigate the areas in which their company faces difficulties and work to improve those areas to accommodate the growing needs of their buying partners and to participate in a variety of SCF programmes. This framework can help these companies enhance their financial and technological capabilities, which will, in turn, enable them to take advantage of possibilities in more competitive business environments. Factors such as low cost, more vital working capital positions, good credit ratings, the level of digitalisation are found to be critical enablers in SCF adoption. The managers can try to advance on these parameters to facilitate seamless SCF adoption and benefit.

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Further reading

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