A two-phased decision-making based grey theory framework for the best choice of payment methods in international trade

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ABSTRACT

This study aims to propose a two-staged Analytic Hierarchy Process and COMplex PROportional ASsessment model-based Grey Theory (AHP-G and COPRAS-G) to explore critical elements affecting international payment method selection in the case of import-export Small and Medium-Sized Enterprises (SMEs) from emerging countries. First, the AHP-G model is applied to determine the relative weights of essential factors. Second, the COPRAS-G approach prioritizes international payment method alternatives. From the literature review and experts’ opinions, five main criteria were established, including: “relationship between the two parties” (RE), “type of goods” (GO), “political-economic framework factor” (MA), “characteristics of payment method” (PA); “opinions and requirements of external parties” (EX) and four international payment methods are considered as frequent payment alternatives. A real-world case study from Vietnamese SMEs in the import-export industry is presented to exemplify the applicability and robustness of the proposed approach. The weighting results indicated that (PA) had the most significant impact on international payment method selection, followed by (MA) and (RE). Letter of credit (L/C) is considered the most reliable payment method for SMEs. Furthermore, a comparative analysis was performed to examine the validity of the proposed model. The proposed approach would assist stakeholders in import-export SMEs and other industries in effectively selecting suitable payment methods in international trade.

1. Introduction

Economic links play a crucial role in international relations because they provide as the basis for the existence and growth of other international ties. Economic exchange operations produce demand for payment and payment transfers between entities in other countries, resulting in the emergence and growth of international payment activities in which banks serve as a conduit [1]. As indicated by the initial concept, international payments serve both economic and noneconomic purposes. Commercial bank laws typically divide international payment activities into two distinct categories. Trade payments are contingent on the market price of imported and exported goods and the provision of commercial services to other nations. Non-trade payments have nothing to do with importing or exporting goods or supplying services abroad. This is remuneration for noncommercial actions [2, 3]. International payments (IP) are made globally, employing the world bank’s network to support business, investment, and international collaboration. Therefore, IP activities are conducted following international rules and trade practices while also being governed by national laws, economic policies, international policies, and foreign exchange policies of payment-participating countries. The international chamber of commerce has developed standards such as Uniform Customs & Practice for Documentary Credits (UCP), Uniform Rules of Collections (URC), and International Commercial Terms (INCOTERMS), among others, to create a level playing field for parties involved in international trade and payment operations [4].

IP facilitates the expansion and promotion of international economic contacts, a precondition for constructing a bridge across nations’ payment relationships. It is also a significant step in acquiring and selling goods and services between persons and organizations from different countries and is a vital link in the chain of national economic activity. Moreover, intellectual property aids in the concentration and control of domestic foreign currency sources, as well as the efficient use of foreign currencies, hence facilitating the government’s foreign exchange management system. Assisting the government in successfully managing import and export operations in accordance with the established international trade policy [5]. Without IP, foreign commercial activity will confront numerous obstacles to its survival and growth. Moreover, vice versa, once IP activities are implemented effectively, it will in-
crease the prestige of each country on the international market, increase the amount of foreign currency, contribute to the improvement of the balance of payments, and simultaneously attract investment capital to develop the domestic economy and promote robust international economic activities.

IP operations are primarily employed for import-export businesses to meet the payment demands of import-export goods and services. IP operations aid organizations in mitigating risks associated with implementing import-export contracts and instilling client confidence in their international trading partnerships. By adopting international payment systems, exporters and importers will be able to protect their interests and avoid risks on the other side poses. When an exporter conducts business, they can manage and control their products by managing the paperwork according to the characteristics of the appropriate payment methods, ensuring that they can control the products until the importer pays. Using appropriate international payment methods, importers can also protect their funds if they have not precisely described what they desire in the contract. Consequently, IP plays a crucial role in import-export businesses; it facilitates transactions and protects the interests of both parties, provided they choose the suitable payment mechanism [6]. In practice, the payment mechanisms utilized in international trade are identical to those used in domestic trade. Methods of payment can be divided into numerous categories based on the method or the time period [7]. The four fundamental methods of payment utilized today, categorized by how the payment is made and by the parties’ and banks’ roles, are presented in Fig. 1.

International payments are fundamentally international banking transactions. They are founded and evolved based on international trade contracts and currency transactions. In international transactions, payment tools such as money orders, wire transfers, drafts, promissory notes, and checks printed in foreign currencies regularly replace cash [4]. Understanding, recognizing, and assessing the elements that influence international payment methods is crucial, especially in the context of highly emotive worldwide economic integration. Each payment method mentioned in Fig. 1 provides different benefits and risks for exporters and importers as follows:

Document collection method (A1): Document collection is a sort of trade financing in which an exporter is paid for its goods by an importer following the exchange of the necessary documentation between the exporter’s and importer’s banks. The exporter’s bank receives cash from the importer’s bank in exchange for paperwork transferring ownership of the shipping items, typically after the products have arrived at the importer’s location [8, 9].

Open Account method (A2): This is a payment method in which things are delivered, and papers are returned to the customer, along with a request for payment at the appropriate time, which may be immediately or at an agreed-upon future date. A transaction on an open account ensures that things are shipped and delivered before payment is due, which is often due within 30 days, 60 days, or 90 days [10, 11].

Letter of credit method (A3): Documentary Credit is defined as follows in Article 2 of UCP 600, International Chamber of Commerce (ICC) Publication No. 600, issued in 2006: Credit refers to any agreement, regardless of its name or description, which is irrevocable and constitutes a firm commitment by the issuing bank to fulfill a compliant presentation. Documentary credits ease international payments by providing the exporter and importer security. The seller receives an advance payment guarantee upon submission of documents conforming to the terms and conditions of the letter of credit. The buyer is assured that the bank will not pay unless the seller has presented documents strictly adhering to the documentary credit [12, 13].

Cash in Advance method (A4): Cash in advance is a condition in international trade that requires the importer to pay the items’ owner in cash prior to exporting the goods. The importer pays the exporter by telegraphic transfer or international check before the exporter ships the item. The parties may also agree to “cash on order” so that payment occurs before the sale, or they may need credit cards for transactions involving considerable amounts of money [8].

Vietnam has taken the initiative and actively participated in multilateral and regional economic institutions, with the essential milestones of joining the Association of Southeast Asian Nations (ASEAN), Asia-Pacific Economic Cooperation (APEC), founding member of The Asia- Europe Meeting (ASEM), and especially joining the Organization World Trade (WTO) signifying the globalization of its economy. In addition, Vietnam has participated in numerous bilateral and multilateral Free Trade Areas (FTAs) to promote its international trade activity. Following 2016-2020, the global economy will be confronted with numerous obstacles and hurdles, which will negatively impact export growth. The US-China trade dispute began in April 2018, and the COVID-19 outbreak that emerged at the start of 2020 is still not under control, which significantly influences world trade. According to preliminary statistics from the General Department of Customs, the overall value of imports and exports for the entire country in the first quarter of 2021 reached 154.01 billion US dollars, an increase of 25.2% over the same time the previous year. During which exports climbed by 23.7% and imports by 26.8%. In addition, Vietnam has utilized the new generation of free trade agreements, particularly the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP), the European-Vietnam Free Trade Agreement (EVFTA), and the Regional Comprehensive Economic Partnership (RCEP) Agreements, to promote import and export activities, improve opportunities for competition, and increase the value of exports of precious Vietnamese goods [14, 15].

In international trade, once a contract has been executed, the seller is concerned with payment, while the buyer is concerned with the delivery of products. However, there are various complexities surrounding the parties’ geographical distance, time zone differences, and currencies. This has led to the creation of specific payment mechanisms to accommodate global payment requirements [16]. It is well-noted that international trade provides a range of risks, which creates uncertainty over the timeliness of payments between exporter (seller) and importer (buyer) (foreign buyer). Any sale is considered a gift until payment is received. Thus, exporters prefer to collect money as quickly as possible, usually immediately after an order is placed or before the items are shipped to the importer. Until the products are received, importers view any payment as a charity. Hence, importers want to get the items as quickly as possible while delaying payment for as long as possible, ideally until the commodities are resold and enough revenue is generated to pay the exporter.

Choosing an optimal international payment methods can be regarded as a multi-criteria decision-making (MCDM) problem, because stakeholders including buyers and sellers require a detailed understanding of the key characteristics of payment methods (as selection criteria) and select appropriate payment methods of international trade (as alternatives) [17]. Decision-makers (DMs) can employ various MCDM techniques to reach appropriate conclusions in realistic applications [18]. Even though numerous studies utilize Grey theory systems to address real-world problems [19, 20, 21], there is no study utilizing the combination of AHP-G and COPRAS-G frameworks to rank and prioritize international payment methods for exporting SMEs in emerging countries, particularly Vietnam. As a result, the novelities of this study are elucidated by the following:
Table 1. Proposed Criteria.

| Code | Criterion | Description |
|------|-----------|-------------|
| (RE) | Relationship between the two parties | Having a long-term cooperation relationship or having no late payment or delivery in previous cooperation processes will boost the reliability and affecting payment options to reduce payment risk [29]. |
| (GO) | Type of goods | The characteristics of commodities related to quantity, quality, seasonality will affect to choose international payment methods with a primary level of security and minimum risk [31]. |
| (MA) | The political-economic situation of partner | If a country is politically unstable, exporters may choose a safer payment method. In such markets, exporters may encounter foreign currency controls. Their international payment methods may be constrained [41]. |
| (PA) | Characteristics of each payment method | Each payment method has benefits and drawbacks, including the cost, the level of risk involved, and the speed of payment processing [2]. |
| (EX) | Opinions and requirements of external parties | The banks as third parties have knowledge and experience to select an appropriate payment option and banks, sometimes, provide guidance and recommendations during trade, influencing the trader’s decision-making [36]. |

(1) Based on the opinions of experts and an examination of the relevant literature, a list of crucial factors affecting global payment systems was established.

(2) To avoid the shortcoming of previous research, an extended model is put forward for solving complex MCDM problems on the Grey theory settings. In which, the subjective weights of criteria are obtained by the AHP-G and then, the rankings of alternatives are evaluated by COPRAS method.

(3) A case study from Vietnam is conducted to demonstrate the efficacy of the suggested method applied to the international payment method selection problem. In addition, a comparison analysis is conducted to validate the results.

The study is organized as follows: Section 2 briefly review the literature on international payment methods and established MCDM models. Section 3 develops the research model. Section 4 presents numerical results and discussions. Finally, Section 5 provides conclusions of this study.

2. Literature review

As aforementioned, many efforts have been made in international payment methods and trade [22, 23, 24]. It is possible to conclude that most previous studies used statistical regression to confirm or explore the critical variables influencing international payment activities in the case of SMEs. A case study of the different payment alternative selection was investigated by using firm-level data [9]. Binet et al. [23] devised a system for qualifying overseas payments. Hwang and Im [8] investigated the factors influencing the considerable change in Korea’s export payment conditions between 1997 and 2015. Zhou et al. [25] provided recommendations for international payment issues in the case of China’s private SMEs. Mizan [26] investigated the legal foundation of factoring, contemporary changes, and the challenges and prospects of adopting international factoring from a Bangladeshi standpoint and indicated that Bangladesh’s exports and imports are increasing, businesses are using letters of credit to settle transactions. Puneri [27] provided an investigation on the payment methods utilized in international trade, particularly the traditional and Islamic Letters of Credit usage. In this study, the author found that Islamic Financial Institutions around the world were attempting to develop Islamic Letters of Credit; however, implementing Islamic Letters of Credit presented certain new obstacles and difficulties. As shown in the study of [28], Bank Payment Obligation, a new form of the payment methods utilized in international trade, was also examined. El-adaway et al. [6] examined the payment clauses of the most commonly used standard construction contracts on a national and worldwide scale. Although various studies have been conducted on international trade, a set of critical aspects influencing the selection of a payment method is rather modest. Therefore, it is necessary to assess the criteria associated with the connection between importers and exporters [29]. Among factors in the previous studies, product characteristics were considered by Agbonika [30]. Also, Becker [31] suggested that enterprises should exercise caution when selecting a payment mechanism for custom-made and customized goods. In addition, Laurel Delaney [32] also indicated that businesses should consider transaction value aspect as an important factor. On the basis of the literature analysis and the perspectives of experts in the context of Vietnamese import-export SMEs, Table 1 outlines a set of essential parameters influencing the selection of global payment methods.

In terms of international payments for import-export activities, it has been discovered that the selection of the most appropriate technique for global payments becomes complex due to the presence of many qualities, hence posing an MCDM problem. However, different MCDM strategies may yield varying results; so, it is prudent to employ two or more MCDM strategies for more precise results in order to ensure successful outcomes [34].

The traditional MCDM methods can be classified according to similar characteristics. The pair-wise comparison methods are beneficial for determining the weight of various criteria and comparing alternatives concerning a subjective criterion. The problem with these methods is that they rely solely on the decision-makers’ knowledge. Furthermore, different decision-makers may have different perspectives on the same issue. The Analytic Hierarchy Process (AHP) was the first pair-wise method presented and is still one of the most commonly used in decision-making problems today. The Analytic Network Process (ANP) is a method that attempts to solve the problem of the AHP criteria’s independence.

Among various MCDM models, AHP is widely used due to its aptitude for breaking down a choice problem into hierarchically arranged essential components. Nguyen [35] pointed out that AHP was utilized extensively for decision-making and addressing more complicated problems by integrating AHP and other MCDM methods [36]. One of the key benefits of the AHP technique is that it allows for group decision-making, combining all group members’ decisions to ensure the best choice takes into account all group members’ opinions based on experience and knowledge. Linguistic values are inherently inconsistent, so ambiguity is required to reduce the risk of making incorrect decisions. The main point is that the classical method should be applied when the information is uncertain; when the information is uncertain, the grey theory should be used [37].

Among distance-based MCDM methods, Compromise Solution Višekriterijumsko kompromisno rangiranje (VIKOR) and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), evaluated based on distance from average solution (EDAS) are widely-used to calculate the distance between each alternative and a specific point.

The scoring approaches are the most fundamental MCDM methodologies. Evaluation of options utilizing elementary arithmetic operations serves as their basis. The Simple Additive Weighting (SAW) and Complex Proportional Assessment (COPRAS) methods compute the sum of all the weighted normalized values. SAW is the most traditional MCDM method, and it allows for the consideration of maximizing criteria. COPRAS is a development of SAW. The distinction between the two is that COPRAS allows for considering both maximizing and minimizing criteria [38, 39]. The COPRAS method’s capabilities include ease of calculation, low calculation time, total scenario ranking, simultaneous use of quantitative and qualitative criteria, and the ability to calculate positive (maximum) and negative (minimum) criteria separately.
in the evaluation process, as well as adapting to local and empirical conditions and realities. Regarding these advantages, various authors have recently extended the COPRAS approach into various disciplines. The classical COPRAS approach has been extended under different uncertainties due to the increasing complexity and uncertainty of MCDM problems [39, 40, 41, 42]. However, there have been few studies on applying the COPRAS method in the case of SMEs’ international payment activities. Based on a comprehensive literature review, given the limited use of MCDM techniques in the study of international trade and payment methods, as well as the absence of studies on factors affecting payment terms choice and the lack of ranking methods for payment terms selection, this study aims to fill the research gap by incorporating two-phased MCDM approach and Grey theory to reduce ambiguity and uncertainties for evaluating international payment methods. The criteria matrix and the group decision matrix were formed in this study after determining the group of decision-makers, criteria, and alternatives. By combining with grey numbers, the criteria weights were obtained using the AHP, and the COPRAS approach was then applied to evaluate and prioritize alternatives. Finally, a comparative analysis is conducted to compare the final rankings of the proposed method and distance-based methods such as TOPSIS and EDAS based on grey numbers.

3. Materials and methods

3.1. Research framework

Fig. 2 presents the proposed research framework consisting of two phases. The AHP-G technique is applied to identify Grey weights (GW) of proposed criteria based on grey-linguistic scales in phase I. In phase II, the COPRAS-G model evaluates four payment alternatives regarding international trade. Furthermore, a comparative analysis is performed to ensure the robustness and validity of the proposed procedure.

3.2. Grey theory systems

3.2.1. Grey numbers

Grey theory was proposed by Deng [43]. It is an effective method used to solve uncertainty problems with discrete data and incomplete information. The theory includes five significant parts: grey prediction [44], grey relational analysis (GRA) [45], grey decision, grey programming, and grey control. Here, we give some basic definitions of the grey system, grey set, and grey number in grey theory.

Definition 1. A grey system contains uncertain information presented by a grey number and grey variables (Fig. 3).

Definition 2. Let X be the universal set. Then a grey set G of X is defined by its two mappings LG(x) and RG(x) as shown in Equation (1):

\[
\begin{align*}
L_G(x) & : x \rightarrow [0, 1] \\
R_G(x) & : x \rightarrow [0, 1]
\end{align*}
\]

\[L_G(x) \geq R_G(x), \ x \in X, \ L_G(x) \text{ and } R_G(x) \text{ are the upper and lower membership functions in } G, \text{ respectively. When } L_G(x) = R_G(x), \text{ the grey set } G \text{ becomes a fuzzy set. It shows that the grey theory considers the condition of the fuzziness and can deal flexibly with the fuzziness situation.} \]
Definition 3. The grey number can be defined as a number with uncertain information. For example, the linguistic variables describe the ratings of attributes; there will be a numerical interval expressing it. This numerical interval will contain uncertain information. Generally, the grey number is written as $\otimes G_i (\otimes G = G_i^L)$, as shown in Equation (2):

$$\otimes G_i = \left[ G_i^L, G_i^H \right]$$

3.2.2. Grey operations

(1) Additive operation as shown in Equation (2):

$$\otimes G_1 + \otimes G_2 = \left[ G_1^L + G_2^L, G_1^H + G_2^H \right]$$

(2) Subtraction operation as shown in Equation (3):

$$\otimes G_1 - \otimes G_2 = \left[ G_1^L - G_2^L, G_1^H - G_2^H \right]$$

(3) Multiplication operation as shown in Equation (4):

$$\otimes G_1 \times \otimes G_2 = \min \left( G_1^L \cdot G_2^L, G_1^H \cdot G_2^H, G_1^L \cdot G_2^H, G_1^H \cdot G_2^L \right)$$

(4) Reciprocal operation as shown in Equation (5):

$$\otimes G_i^{-1} = \frac{1}{G_i^H}$$

(5) Division operation as shown in Equation (6):

$$\otimes G_i / \otimes G_2 = \otimes G_1 \times \otimes G_2^{-1} = \left[ G_1^L, G_2^H \right] \times \left[ \frac{1}{G_1^H} \right]$$

$$= \left[ \min \left( \frac{G_1^L}{G_2^L}, \frac{G_1^H}{G_2^H}, \frac{G_1^L}{G_2^H}, \frac{G_1^H}{G_2^L} \right), \max \left( \frac{G_1^L}{G_2^L}, \frac{G_1^H}{G_2^H}, \frac{G_1^L}{G_2^H}, \frac{G_1^H}{G_2^L} \right) \right]$$

(6) Scalar multiplication as shown in Equation (7):

$$\otimes G \cdot k = \left[ k \cdot G_i^L, k \cdot G_i^H \right]$$

(7) Scalar power as shown in Equation (8):

$$\otimes G^k = \left[ \left( G_i^L \right)^k, \left( G_i^H \right)^k \right]$$

3.3. Analytic hierarchy process based grey theory method (AHP-G)

The AHP-G model comprised of the conventional AHP technique proposed by Saaty [46] and the Grey theory proposed by Deng [47]. The processing of the AHP-G technique is presented as follows:

Step 1: The goal is to evaluate the available international payment methods and determine the most helpful technique for international payments.

Step 2: Proposing potential criteria based on the literature and experts’ opinions, including “relationship between the two parties” (RE), “type of goods” (GO), “political-economic framework factor” (MA), “characteristics of payment method” (PA); “opinions and requirements of external parties” (EX), respectively.

Step 3: Four international payment methods are applied in this study, including Document Collection (A1), Open Account (A2), Letter of Credit-L/C (A3), and Cash in Advance (A4). Each payment method has distinct benefits and associated risks for exporters and importers.

Step 4: The hierarchy is built based on the selection criteria and options. First, the goal will be placed on top of this structure, and the criteria on lower levels. Then, the available alternatives will be placed at the bottom of the hierarchical framework to make decisions, as shown in Fig. 4.

Step 5: Creating the matrix of paired comparisons using grey linguistic scales and the score of the important index in Table 2, as shown in Equation (9):

$$\otimes A = \left[ \otimes G_{11} \ldots \otimes G_{in} \right] \otimes \left[ \otimes G_{in} \ldots \otimes G_{nn} \right]$$

3.4. Complex Proportional ASsessment model-based grey theory method (COPRAS-G)

In real-world decision-making scenarios, the most viable options always deal with ambiguous information and criteria evaluations stated in linguistic words. As a result, MCDM approaches should be used with exact criteria values and fuzzy values or values within specified intervals. For the reasons mentioned above, the Complex Proportional ASsessment with grey interval numbers (COPRAS-G) technique was created by Zavadskas and Kalkauskas [48] with criterion values given in intervals based on real-world decision-making conditions and applications of Grey systems theory [47]. The application of the COPRAS-G approach consists of the following steps:

Step 1: Applying the essential criteria, describing the alternatives in phase I.
Step 2: Constructing the decision-making matrix using Equation (19).

\[ D = \begin{bmatrix} \left[ \Theta C_{11} \right] & \cdots & \left[ \Theta C_{1n} \right] \\ \left[ \Theta C_{m1} \right] & \cdots & \left[ \Theta C_{mn} \right] \end{bmatrix} = \begin{bmatrix} \left[ C_{11}^L, C_{11}^R \right] & \cdots & \left[ C_{1n}^L, C_{1n}^R \right] \\ \left[ C_{m1}^L, C_{m1}^R \right] & \cdots & \left[ C_{mn}^L, C_{mn}^R \right] \end{bmatrix} \]  

(19)

\[ i = 1, m, j = 1, n \]

Here \( \Theta C_{ij} \) is determined \( C_{ij}^L \) (the smallest value, the lower limit) and \( C_{ij}^R \) (the biggest value, the upper limit).

Step 3: Utilizing grey weights of the criteria (GW_i) based on AHP-G’s results.

Step 4: Normalizing the decision-making matrix \( D \) is calculated by Equation (20):

\[ C_i^L = \frac{C_{ij}^L}{\frac{1}{n} \sum_{j=1}^{n} C_{ij}^L + \sum_{i=1}^{m} C_{ij}^R} = \frac{2C_{ij}^L}{\frac{1}{n} \sum_{j=1}^{n} C_{ij}^L + \sum_{i=1}^{m} C_{ij}^R} \]  
\[ C_i^R = \frac{C_{ij}^R}{\frac{1}{n} \sum_{j=1}^{n} C_{ij}^L + \sum_{i=1}^{m} C_{ij}^R} = \frac{2C_{ij}^R}{\frac{1}{n} \sum_{j=1}^{n} C_{ij}^L + \sum_{i=1}^{m} C_{ij}^R} \]  

(20)

In formula (20) \( C_{ij}^L \) is the lower value of the criterion in the alternative \( j \) of the solution; \( C_{ij}^R \) is the upper value of criterion \( i \) in the alternative \( j \) of the solution; \( m \) is the number of criteria; \( n \) is the number of alternatives compared.

Then, the normalized decision-making matrix \( \hat{D} \) is shown in Equation (21):

\[ \hat{D} = \begin{bmatrix} \left[ \hat{C}_{11}^L, \hat{C}_{11}^R \right] & \cdots & \left[ \hat{C}_{1n}^L, \hat{C}_{1n}^R \right] \\ \left[ \hat{C}_{m1}^L, \hat{C}_{m1}^R \right] & \cdots & \left[ \hat{C}_{mn}^L, \hat{C}_{mn}^R \right] \end{bmatrix} \]  

(21)

Step 5: Calculating the weighted normalized decision matrix \( \hat{D} \).

The weighted normalized values \( \hat{C}_{bij} \) are calculated using Equation (22):

\[ \hat{C}_{bij} = \hat{C}_{ij} \times \text{GW}_i \] or \( \hat{C}_{bij} = \hat{C}_{ij} \times \text{GW}_i \) and \( \hat{C}_{rij} = \hat{C}_{ij} \times \text{GW}_i \) (22)

Where \( \text{GW}_i \), be calculated using Eq. (18), is the Grey Weight of the \( i \)th criterion. Then, the normalized decision-making matrix is calculated using Equation (23):

\[ \hat{D} = \begin{bmatrix} \left[ \hat{C}_{11}^L, \hat{C}_{11}^R \right] & \cdots & \left[ \hat{C}_{1n}^L, \hat{C}_{1n}^R \right] \\ \left[ \hat{C}_{m1}^L, \hat{C}_{m1}^R \right] & \cdots & \left[ \hat{C}_{mn}^L, \hat{C}_{mn}^R \right] \end{bmatrix} \]  

(23)

Step 6: Calculating the sums \( P_i \) of criterion values, whose larger values are more preferable using Equation (24):

\[ P_i = \frac{1}{2} \sum_{j=1}^{n} \left( \hat{C}_{ij}^L + \hat{C}_{ij}^R \right) \]  

(24)

Step 7: Calculating the sums \( R_j \) of criterion values, whose smaller values are more preferable using Equation (25):

\[ R_j = \sum_{i=1}^{m} \left( \hat{C}_{ij}^L + \hat{C}_{ij}^R \right) \]  

(25)
Table 3. Pair-wise comparison matrix of criteria.

| Criteria | GO | EMI | VSI | SI | MI | EI |
|----------|----|-----|-----|----|----|----|
| GO       | 1  | 3   | 8   | 3  | 7  | 7  |
| EMI      | 2  | 3   | 3   | 5  | 3  | 2  |
| VSI      | 2  | 5   | 5   | 2  | 5  | 2  |
| SI       | 4  | 7   | 4   |    |    |    |
| MI       | 3  | 6   | 1   |    |    |    |
| EI       | 1  | 5   | 4   |    |    |    |

Table 4. Crisp matrix (CM) for CR.

| Criteria | GO | EX | MA | RE | PA |
|----------|----|----|----|----|----|
| GO       | 1.000 | 2.822 | 0.439 | 0.582 | 0.210 |
| EX       | 0.354 | 1.000 | 0.721 | 0.807 | 0.270 |
| MA       | 2.280 | 1.387 | 1.000 | 1.661 | 0.541 |
| RE       | 1.719 | 1.299 | 0.602 | 1.000 | 1.000 |
| PA       | 4.773 | 3.701 | 1.849 | 1.000 | 1.000 |
| SUM      | 10.126 | 10.1495 | 6.4110 | 5.0499 | 3.0204 |

R_j = \frac{1}{2} \sum_{i=k+1}^{m} (C^i_j + C^{R}_j), \quad i = k, m

Where m – k is the number of criteria that must be minimized.

Step 8: Determining the minimal value of R_j using Equation (26):

R_{\min} - \min R_{ij}, \quad j = 1, n

Step 9: Calculating the relative significance of each alternative Q_j using Equation (27):

Q_j = P_j + \frac{\sum_{j=1}^{m} R_{j}}{\sum_{j=1}^{m} R_{j}}

Step 10: Determining the optimal criterion by K using Equation (28):

K = \max Q_j, \quad j = 1, n

Step 11: Determining the priority order of the alternatives. Calculating the utility degree of each alternative using Equation (29):

N_j = \frac{Q_j}{Q_{\max}} \times 100\%

4. Results analysis

4.1. A case study

Using an online questionnaire, 15 specialists were surveyed in accordance with worldwide payment methods to collect the data. The method of collecting data required contacting experienced managers and experts at regional universities. Five specialists work for the Vietnam Trade Promotion Agency and Agency of Foreign Trade, while three academics are employed by colleges specializing in international business and foreign trade. The remaining groups consist of Hanoi and Ho Chi Minh City-based managers having at least ten years of experience in the import-export industry. Fig. 4 depicts the hierarchy of five proposed criteria and the four most common foreign payment methods. The AHP-G and COPRAS-G decision support models are introduced to determine the optimal international payment method choices. In addition, a comparative analysis is conducted to illustrate the reliability and usefulness of the suggested method by analyzing ranking results acquired using various methods.

4.2. Results of AHP-G

First, a group of 15 decision-makers looks at five recommended criteria for selecting international payment methods. Table 2 in this study shows a group decision matrix of 15 experts. Each expert is asked to rate the significance of each pair-wise criterion comparison. For example, according to the obtained value linguistic level for paired comparisons matrix in terms of GO in relation to EX, three experts believed that GO is equally important to EX (EI = 3), eight scientists agreed that GO is medium important to EX (MI = 8), three analysts claimed that GO is strongly important than EX (SI = 3). Only one expert considered GO very important compared to EX (VSI = 1). For a more thorough understanding of both the left and right sides of Table 2 throughout the data transmission process, the pair-wise comparison of MA and PA is shown. Regarding the left-hand side of Table 2, one respondent asserted that MA is significantly more critical than PA (SI = 1), one expert concurred that PA is more moderately more essential than PA (MI = 1), and four experts stated that MA and PA are of equal importance (EI = 4). In contrast, according to the right-hand side of Table 3, five experts deemed PA to be of moderate importance compared to MA (MI = 5), and four respondents concurred that PA is more critical than PA (SI = 4).

Second, as illustrated in Table 3–5, the CR computations check the pair-wise comparison matrix’s consistency. The following formula is used to find the CR of pair-wise comparison matrices.

\[ \text{GO in respect to EX} = \frac{\text{SL}_{\text{GO}} \text{ in respect to EX}}{\text{SUM}_{\text{EX}}} = \frac{2.822}{10.1495} = 0.278 \]

\[ \text{MEAN}_{\text{GO}} = 0.099 + 0.278 + 0.095 + 0.115 + 0.069 = 0.1331 \]

\[ \text{WSV} = \begin{bmatrix} 0.7157 & 0.1313 & 5.4505 \\ 0.5601 & 0.1078 & 5.1940 \\ 1.0337 & 0.1903 & 5.4318 \\ 1.9712 & 0.3532 & 5.5805 \end{bmatrix} \]

\[ \text{CV} = \begin{bmatrix} 0.1734 & 0.2173 & 5.3991 \\ 0.1734 & 0.2173 & 5.3991 \\ 0.1734 & 0.2173 & 5.3991 \end{bmatrix} \]

\[ \text{In the following steps, the largest eigenvector (λ max) is measured to assess the consistency index (CI), the random index (RI) = 1.12, n = 5, and the consistency coefficient (CR),} \]

\[ \lambda_{\text{max}} = \frac{5.4505 + 5.1940 + 5.3991 + 5.4318 + 5.5805}{5} = 5.4112 \]

\[ \text{CI} = \frac{\lambda_{\text{max}} - n}{n-1} = \frac{5.4112 - 5}{5-1} = 0.1028 \]

\[ \text{CR} = \frac{\text{CI}}{\text{RI}} = \frac{0.1028}{1.12} = 0.0918 \]

As the result of CR = 0.0918 ≤ 0.1, the pair-wise comparison matrix is satisfactory.

Following that, as shown in Table 6 and Table 7, the results of AHP-G weights are determined. To demonstrate, we calculated the weight assigned to the GO criteria as follows:
Table 5. Normalized matrix for CR.

| GO  | EX  | MA   | RE  | PA  | MEAN | WSV | CV  |
|-----|-----|------|-----|-----|------|-----|-----|
| 0.099 | 0.278 | 0.095 | 0.115 | 0.069 | 0.131 | 0.715 | 5.4505 |
| 0.035 | 0.099 | 0.156 | 0.160 | 0.089 | 0.1078 | 0.5601 | 5.1940 |
| 0.225 | 0.137 | 0.217 | 0.329 | 0.179 | 0.2173 | 1.1734 | 5.3991 |
| 0.170 | 0.122 | 0.131 | 0.198 | 0.331 | 0.1903 | 1.0337 | 5.4318 |
| 0.471 | 0.365 | 0.401 | 0.198 | 0.331 | 0.3532 | 1.9712 | 5.5805 |

Table 6. Integrated grey comparison matrix.

| GO  | EX  | MA   | RE  | PA  | Grey Weights (CW) | Crisp Weights (CW) |
|-----|-----|------|-----|-----|--------------------|--------------------|
| [0.1012,0.1012] | [0.2137,0.3927] | [0.0776,0.1358] | [0.0852,0.1609] | [0.0515,0.0808] | [0.1058,0.1743] | 0.1401 |
| 0.02560,0.0470 | [0.0993,0.0993] | [0.1262,0.2476] | [0.1210,0.2329] | [0.0654,0.1125] | [0.0875,0.1479] | 0.1177 |
| [0.1606,0.2809] | [0.0864,0.1696] | [0.2155,0.2155] | [0.2439,0.4695] | [0.1343,0.2441] | [0.1682,0.2759] | 0.2220 |
| 0.11100,0.2095 | [0.0753,0.1448] | [0.0801,0.1560] | [0.1765,0.1755] | [0.2386,0.4752] | [0.1363,0.2324] | 0.1843 |
| [0.37480,0.5883] | [0.2641,0.4547] | [0.2643,0.4803] | [0.1112,0.2224] | [0.2993,0.2993] | [0.2628,0.4090] | 0.3359 |

Table 7. Results of AHP-G weights.

| Criterion | Optimal direction |Grey weights (GW) | Initial decision-making matrix |
|-----------|-------------------|------------------|-----------------------------|
| GO        | max               | [0.1058,0.1743]  | International Payment Method |
|           |                   | [6.0,8.0]        | A1 [3.6,5.6]                |
|           |                   | [4.4,6.4]        | A2 [4.4,6.4]                |
|           |                   | [6.0,8.0]        | A3 [2.0,3.6]                |
|           |                   | [5.2,7.2]        | A4 [4.4,6.4]                |

Grey weights of criterion GO with [L, R] = [0.1058, 0.1743]

L_{GWGO} = \frac{1}{5} \times (0.1012 + 0.2137 + 0.0776 + 0.0852 + 0.0515) = 0.1058

R_{GWGO} = \frac{1}{5} \times (0.1012 + 0.3927 + 0.1358 + 0.1609 + 0.0808) = 0.1743

Crisp Weights (CW) = \left(1 + \frac{1}{5} \times L_{GWGO}\right) \times \left(1 + R_{GWGO}\right)

= \left[1 + 0.1058\right] \times \left[1 + 0.1743\right]

= 1.1058 \times 1.1743 = 1.0401

The AHP-G weights of the main criteria include Grey Weights (GW) and Crisp Weights (CW). As the results of the abovementioned calculations, the crisp weights of five main criteria are determined (PA > MA > RE > GO > EX). The most important criterion for selecting international payment methods is specified as “Characteristics of each payment method” (PA) with the value of 0.3359, followed by “Political and Economic situations of partner” (MA) with the value of 0.222. Meanwhile, “Opinions of external parties” (EX) is the least relevant criterion with a value of 0.1177.

4.3. Results of COPRAS-G

After summarizing the opinions of 15 experts and following the steps of AHP-G, the weights of evaluation criteria are provided in Table 8. Table 8 also indicates the initial decision-making matrix ⊙D; the evaluation criteria values are described in intervals. The initial decision-making matrix ⊙D has been normalized and weighted initially, and the obtained results (⊙D) are provided in Table 9. Following the steps of COPRAS-G, the evaluation of four international payment methods is computed, and the ranking of international payment methods is finally discovered, as shown in Table 10.

\[ C_{GO} \text{ in respect to } A_1 = \left[ C_{L}^{GO}, C_{R}^{GO} \right] = [0.2927, 0.3902] \]
Table 9. Normalized and weighted-normalized decision-making matrix and the values of evaluation criteria described in intervals.

| Criterion | Normalized decision-making matrix | Weighted-normalized decision-making matrix |
|-----------|----------------------------------|----------------------------------------|
|           | International Payment Method     | International Payment Method           |
|           | A1                               | A2                                     | A3                               | A4                               |
| A1        | [0.2927,0.3902]                  | [0.1756,0.2732]                       | [0.2146,0.3122]                  | [0.1268,0.2146]                  |
| A2        | [0.2353,0.3422]                  | [0.2567,0.3636]                       | [0.2032,0.2995]                  | [0.1070,0.1925]                  |
| A3        | [0.1833,0.2667]                  | [0.2500,0.3333]                       | [0.2167,0.3000]                  | [0.1833,0.2667]                  |
| A4        | [0.1846,0.3261]                  | [0.2000,0.2769]                       | [0.2308,0.3077]                  | [0.2308,0.3077]                  |
| PA        | [0.2018,0.2477]                  | [0.2110,0.2752]                       | [0.2294,0.3119]                  | [0.2294,0.2936]                  |

Table 10. Evaluation of utility degree and alternative rankings.

| International Payment Method | P1 | P2 | 1/R1 | Q | Nj | Ranking |
|-----------------------------|----|----|------|---|----|---------|
| A1                          | 0.2052 | 0.2010 | 0.2150 | 0.1860 | 99.294% | 2 |
| A2                          | 0.0522 | 0.0670 | 0.0596 | 0.0522 | 92.57% | 3 |
| A3                          | 19.1557 | 14.9239 | 16.7771 | 19.1557 | 92.157% | 3 |
| A4                          | 0.2684 | 0.2503 | 0.2704 | 0.2492 | 100.000% | 4 |

Regarding Characteristics of payment method (PA), Im [51] verified that the influence of the characteristics of payment methods was evaluated and measured through various aspects, including transaction processing time, cost of procedures, and the simple or complex nature of payment methods. Obviously, for each different payment method, the transaction processing speed is different because it depends on many factors (set of documents, related parties). Due to processing time, it is first mentioned that the processing time for international payment transactions of banks is different, and the processing time for different types of payment methods is different, some fast/slow depending on the type of transaction (for example, a collection transaction is usually faster than an L/C transaction). Therefore, based on the nature and processing time of the bank may lead to the decision to choose the payment method for enterprises [52].

Of course, each different payment method will have different costs. For a business participating in a transaction, if the cost factor is the top concern in choosing payment methods, they will prioritize Cash in advance or Open Account. According to documents provided by several banks, such as Vietcombank, BIDV, and Agribank, about the L/C service fee schedule and money transfer fee schedule, it can be seen that the cost of opening L/C is very expensive and very complicated due to other costs attached, while the money transfer fee is much less expensive and very simple. Moreover, the complex/straightforward nature of the methods’ operation process also influences the choice decision of enterprises. For payment methods such as Cash in advance, Open account, and Collections, it is pretty easy to understand and grasp, so incredibly new/small businesses may prefer to use it. As for the L/C method, due to the relatively complex nature of the process and understanding/grasping of the relevant international practices UCP 600, International Standard Banking Practice (ISBP 745) is also a complex problem for them, leading to fear of using it [53]. In addition, depending on each transaction, businesses will consider choosing suitable payment methods to minimize risk (shipment, solvency, document disagreement) because no business wants to choose a payment method that brings many risks to them [54].

Regarding the Political and Economic situations of partners (MA), Hwang and Im [8] also assessed several factors such as political stability and legal environment in the context of the political side. In contrast, for the economic aspect, the factors mentioned are economic development, capacity liquidity, and currency exchange rate fluctuations. According to the Global Peace Index (GPI) report released by the Institute for Economics and Peace (IEP) in 2020, Vietnam ranked 64th out of 163 countries in the ranking of the safest countries in the world [55]. The GPI ranks the safety of countries based on 22 factors, including homicide rates, political terrorism, and deaths from internal conflicts. This is quite understandable when Vietnam has stable politics, rarely violence, territorial disputes, security indicators, and people are increasingly improving. With the above conditions, Vietnam’s import and export activities are developing daily with great strides and high trust and confidence from foreign partners. Vietnam’s import-export sector has grown from the above favorable political conditions, both in quantity and value of commercial transactions. Foreign partners have a
certain confidence in the business environment of domestic export and import enterprises. Some payment methods that foreign partners can still trust to use, such as remittance and collection. Even if L/C is used, most of them are standard L/C, no need to confirm because they trust their solvency and do not worry about the risks of the issuing bank, especially under the aspect of political risk in Vietnam [56].

Besides the achievements, Vietnamese SMEs face many potential risks when cooperating with many countries and territories worldwide. The first notable thing is that in 2019, the Ministry of Industry and Trade issued a warning to businesses trading in Turkey. At that time, Turkey conducted a military operation, “Peace Spring,” in Syria, which received a lot of strong objections from the international community. The US government has threatened to impose strong sanctions, affecting export transactions of enterprises, including Vietnamese enterprises. The Ministry of Industry and Trade recommendations apply to the Turkish political situation and all other transactions, and businesses need to learn more about the country with political instability and prepare plans to prevent risks. Therefore, businesses need to monitor the exchange rate of foreign currencies constantly and are safe, and they can choose payment methods at sight to avoid future currency fluctuations. By determining the credit rating, businesses/investors have more information to assess the financial capacity and debt solvency of the subject of credit rating, the financial products specified in the credit rating creditworthiness, and the risks involved. It can be seen that this factor does not directly affect the solvency between businesses but indirectly through the transaction process. In other words, the political and economic issues of the partner country affect the entire transaction process, not just the payment stage of a transaction. In addition, most businesses carrying out large-value transactions often want to use safe methods with the participation of banks such as collection or L/C but are still quite lest because this method is relatively complex. In this case, the authors recommend that businesses use a combination of credit packages to export and import finance from banks to provide financial support. Specifically, for exporters, it is a capital financing service in payment for export goods. From the time of delivery, submit the set of documents to the advising bank until it is recorded “Yes” on the required account must go through a certain period to process and circulate documents. The exporter in need of money can negotiate a set of documents for a discount or advance payment at the bank specified in the L/C or any bank. In the form of discounting a set of documents, the bank will require the set of documents to be perfect and presented on time. The bank opening the L/C must have a good reputation in the international market and regular transaction relationships with the discounting bank. The production and business situation and the enterprise’s financial position are stable, solvency assured, and reputable with the bank. The amount of the discount must be within the credit limit. After receiving the application from the customer, the bank appraises the loan purpose, financial situation, and solvency. The bank checks the documents carefully and logically because if the documents are not reasonable, they can be refused payment by the importer, making it difficult to recover the debt. The bank checks the conformity on the surface of the documents against the terms and conditions stated in the L/C. The bank considers and decides the current discount rate at about 90% of the export L/C value. However, depending on the bank, each case will decide on a discount rate. If the documents are not eligible for a discount, there are errors that the bank does not agree to discount; the exporter can ask the bank to advance the goods. Usually, the advance rate is about 50-60% of the export value. The primary cause of this challenge is that the internal capacity of SMEs is still inadequate, in which the founders of SMEs have not concentrated on the reality of the business model but also focused too much on ideas leading to a lack of information to seek support from the government. Secondly, difficulties in accessing capital are not only in SMEs but also in banks. Many banks are still not interested in the SME segment due to the evaluation based on capital business efficiency. With the limited human resources of banks, when processing a set of loan applications for SMEs, usually small loans, the collection of documents, appraisal, and management during and after the loan still have to comply with the regulations. The loan program is as complete as the loans of ordinary enterprises, so, with the exact management costs and resources, the lending efficiency of SMEs is not commensurate. Design specific loan products suitable for SME customers in each industry group to flexibly meet customer requirements. These will help SMEs struggling with credit problems be more willing to learn and use this payment method.

5. Conclusions, implications, and future research

5.1. Conclusions

The study employs qualitative and quantitative research methodologies to generate the most precise results using a combined MCDM model of AHP-G and COPRAS-G. This study provided an overview of the factors influencing the choice of IP methods by import-export businesses across Vietnam’s territory. Timely gives some recommendations for businesses to minimize the risks do not present in the payment process. Hopefully, through this study, there will be more comments and suggestions to contribute to the development of Vietnam’s import-export industry in general and Vietnam’s international payment services shortly, particularly in the context of globalization.

5.2. Managerial implications

First, in any transaction, the business needs to be the person who knows the nature of the goods in their transaction to decide to choose the appropriate IP method. For example, what will impact the business for perishable or seasonal goods when the partner may refuse to receive the goods or pay because the goods are not guaranteed quality after the delivery or shipping time is too long, leading to product loss seasonality. Besides that, businesses must learn and understand the trading procedures in the international market for specific items to fully understand their responsibilities, obligations, and rights in transaction techniques. For example, with petroleum import transactions, the international best practice is to use the L/C payment method, but the documents that need to be presented to claim payment next to the Invoice, Bill of lading usually include a Letter of Indemnity. This practice has required businesses to learn and understand the format of this letter, its content, and how to use it in practice. L/C is also frequently used for seafood export transactions to some markets, such as the United States and the European Union; however, the content of L/C terms is typically unique.

As a result, even if the documents are acceptable, payment may not have been made, and it is also necessary to meet the condition that the products have passed inspection by the importing country’s competent authorities. When exporting seafood to the US, the credit usually requires the following: “Fifty percent is payable at sight against presentation of documents complying with the credit terms. The remaining fifty percent is payable only after the applicant notices that goods have passed US food and drug. Administration inspection requirements. The remaining fifty percent balance payment will be made either immediately upon notification of passage by the applicant if so, instructed by them or no later than one hundred eighty days after the bill of lading date unless we are provided notice by the applicant that the goods have not passed inspection/have not been inspected/have not been released/have been detained or held by US food and drug administration. If we are provided any of the above type notices or any similar notice by the applicant, then our deferred payment obligation becomes null and void at that time”.

The Ministry of Industry and Trade, together with industry associations and trade promotion agencies, have constantly innovated ways to carry out trade promotion activities, diversify trade promotion forms and improve the effectiveness of trade promotion activities. In the context of the increasingly complicated COVID-19 pandemic, the Ministry of Industry and Trade of Vietnam

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has proactively and quickly presided over and coordinated with ministries, branches, localities, and foreign trade promotion agencies to promote the application of information technology and digital platforms in trade promotion, organizing more than 500 international trade promotion conferences in the online form. Online trade promotion activities have helped Vietnamese exporters save costs while maintaining and developing good relationships with foreign partners in 5 continents (55 export markets of Vietnam, including major markets such as China, USA, EU, Japan, and potential markets such as Africa and Australia). In order to innovate trade promotion to adapt to the industrial revolution 4.0 and support businesses to take advantage of opportunities from this revolution, in 2020, the Ministry of Industry and Trade has developed 05 applications. Software, including Customer management, shared database system (CRM); Trade promotion ecosystem (VECOBIZ; Trade promotion traceability portal (www.itrace247.com); Import and export guide portal (https://vietnam.tradeportal.org).

In addition to focusing on the relationship between the two parties, learning about the legal and political environment of the partner is also an issue that businesses need to pay attention to before signing a contract because the Contract signing is sometimes troubled by different legal systems and disagreements in language and business culture. Learning about countries’ laws and business conditions worldwide is essential because each country has its import-export policy and different tariff regulations. For example, CPTPP countries commit to eliminating from 97% to 100% of import tax lines for goods originating from Vietnam, depending on the commitments of each country: Singapore committed to eliminating tariffs on all goods immediately upon implementation of the Agreement; Chile commits to eliminate 95.1% of tariff lines as soon as the agreement comes into effect, equivalent to 60.2% of import turnover from Vietnam and will eliminate tariffs on 99.9% of tariff lines in the 8th year immediately after the implementation of the Agreement; Mexico commits to eliminate 77.2% of tariff lines as soon as the agreement comes into force, equivalent to 36.5% of import turnover from Vietnam and will eliminate tariffs on 98% of tariff lines in the 10th year since the agreement came into effect. Political stability is something that businesses care about when trading goods because politics can significantly impact economic markets. Therefore, it is necessary to be careful when dealing with countries with unstable politics. Businesses can monitor the situation of partner countries through mass media, the internet, or through consults and embassies to be updated on the market situation of the partner country timely. In addition, before signing, it is also necessary to add a specific legal basis to an international sale of goods contract by choosing the law applicable to that contract. The parties must agree on the choice of national law that applies to a contract after its conclusion, even when a dispute arises. In practice, this method is complicated because it is difficult for the parties to agree on applicable law when a dispute has arisen. After all, the seller and the buyer only want to apply the country’s law to protect their interests. In this case, the two parties can only reach an agreement when the chosen law is not too inclined to protect the interests of either party. The Vienna Convention of 1980 is the optimal solution for the parties in this case. Learning about the law and risks before import-export will help us to draw valuable lessons and minimize disputes arising later.

5.3. Future research

The AHP-G and COPRAS frameworks are based on the responses of 15 experts in the current study. For a deeper understanding of import-export SME’s, the questionnaire could be administered to SME’s utilizing the convenience sample method. In the succeeding step, a combination of the MCDM model and Partial Least Squares Structural Equation Modeling (PLS-SEM) is used to identify strongly correlated elements connected to foreign payment methods in international commerce operations. Next, the concept and methodology of the study can be used to assess international payment method selection in other countries and other factors. In the future, this paradigm can be broadened by evaluating the relative performance of MCDM techniques that use emerging current fuzzy extensions or machine learning techniques in solving real-world situations.

**Declarations**

**Author contribution statement**

Phi-Hung Nguyen, Dr: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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**Data availability statement**

Data will be made available on request.

**Declaration of interests statement**

The authors declare no conflict of interest.

**Additional information**

No additional information is available for this paper.

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**Appendix A**

| Alternatives | GO | EX | MA | RE | PA | SI+ | SI- | Rank |
|--------------|----|----|----|----|----|-----|-----|------|
| A1           | 0.500 | 0.533 | 0.500 | 0.601 | 0.645 | 2.779 | 0.556 | 1 |
| A2           | 0.748 | 0.500 | 0.637 | 0.571 | 0.580 | 3.036 | 0.607 | 3 |
| A3           | 0.659 | 0.606 | 0.589 | 0.500 | 0.500 | 2.854 | 0.571 | 2 |
| A4           | 0.895 | 0.769 | 0.500 | 0.512 | 0.530 | 3.206 | 0.641 | 4 |

**Table A1. TOPSIS-G results.**

| Alternatives | Q+ | S+ | Q- | S- | Rank |
|--------------|----|----|----|----|------|
| A1           | [0.0000,0.4836] | [0.0000,0.9349] | [0.0000,0.4258] | [0.1784,1.0000] | 0.528 | 2 |
| A2           | [0.0000,0.4275] | [0.0000,0.8265] | [0.0028,0.4850] | [0.0642,0.9946] | 0.471 | 3 |
| A3           | [0.0000,0.5173] | [0.0000,1.0000] | [0.0000,0.3858] | [0.2566,1.0000] | 0.564 | 1 |
| A4           | [0.0000,0.3911] | [0.0000,0.7561] | [0.0000,0.5182] | [0.0000,1.0000] | 0.439 | 4 |

**Table A2. EDAS-G results.**
