Foreign market selection of suppliers through a novel REF-Sort technique

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Abstract

Purpose – The present study aims to provide a practical and robust assessment technique for assessing countries' investability in global supply chains to practitioners. Thus, the proposed approach can help decision-makers evaluate and select appropriate countries in the expansion process of the global supply chains and reduce risks concerning country (market) selection.

Design/methodology/approach – The present study proposes a novel decision-making approach, namely the REF-Sort technique. The proposed approach has many valuable contributions to the literature. First, it has an efficient basic algorithm and can be applied to solve highly complicated decision-making problems without requiring advanced mathematical knowledge. Besides, some characteristics differentiate REF-Sort apart from other techniques. REF-Sort employs the value or value range that reflects the most typical characteristic of the relevant class in assignment processes. The reference values in REF-Sort and center profiles are similar in this regard. On the other hand, class references can be defined as ranges in REF-Sort. Secondary values, called successors, can also be employed to assign a value to the appropriate class. REF-Sort can also determine the reference and successor values/ranges independently of the decision matrix. In addition, the proposed model is a maximally stable and consistent decision-making tool, as it is resistant to the rank reversal problem.

Findings – The current papers' findings indicate that countries have different features concerning investment. Hence, the current paper pointed out that only 22% of the 95 countries are investable, whereas 19% are risky. Thus, decision-makers should make detailed evaluations using robust, powerful, and practical decision-making tools to make more reasonable and logical decisions concerning country selection.

Originality/value – The current paper proposes a novel decision-making approach to evaluate. According to the authors' information, the proposed model has been applied to evaluate investable countries for the global supply chains for the first time.

Keywords Sustainable supply chain, Foreign market selection, REF-Sort, Supply chain risks, Enterprise survey, Global supply chain

Paper type Research paper

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1. Introduction

The global supply chains encounter severe and crucial risks in the conditions of competition becoming ever more severe. Minimizing these risks and creating sustainable supply chain systems have become principal and interesting research topics in the academic field (Giannakis and Papadopoulos, 2016; Gurnani *et al.*, 2011; Sodhi *et al.*, 2012; Narasimhan and Talluri, 2009; Rao and Goldsby, 2009; Ecer, 2020; Foerstl *et al.*, 2010). A significant part of these papers focusing on supply chain sustainability highlighted a notable correlation between sustainability and supply chain risks. In recent years, in addition to increasing competition pressure, new and dizzier developments in technology, transportation, and communication force the global supply chains to develop more complicated relationships (i.e. outsourcing) with the potential partners called outsources. Within this scope, supply chains try to develop new strategies to generate a business environment based on strategic alliances with companies from different countries to reduce costs and increase profits. This approach, called the enlargement strategy, increases the risks to the global supply chains. A supply chain manager encounters many uncertainties such as the countries that invested, companies that can make collaboration available in these markets, the total cost of the investment, the local risks, and the private conditions of the countries. Each can be accepted as a decision-making problem by itself.

Besides, the recent COVID-19 (coronavirus disease) pandemic has shown that the supply chains have a considerably weak structure as opposed to popular belief, and they encounter quite severe risks. Before the pandemic, Giannakis and Papadopoulos (2016) indicated that the enlargement of the supply chains led to severe risks and dangerous situations for the global supply chains, making them more vulnerable. The recent developments validate the concerns on this subject. So indeed, the COVID-19 pandemic has paralyzed the supply chain operations and has caused material flows among supply chain actors to come to a halt. Furthermore, it has revealed that the supply chain operations (mainly supplying and retailing) are vulnerable.

On the other hand, the global supply chains found no way out in the first days of the pandemic, so they tried to overcome these problems with non-permanent palliative solutions. For instance, the blockage of the Suez Channel by a container vessel due to a marine accident caused severe and crucial problems for the supply chain actors waiting for raw materials, semi-finished goods, or final products. This accident increased the maritime traffic in the Channel (Ramos *et al.*, 2021; Das, 2021; Reuters, 2021; Tuttle, 2021). This marine accident has proven once again that the risks encountered by the global supply chains are extraordinarily high and intolerable.

Besides exceptional circumstances, supply chains come up against many problems and challenges in familiar situations (Hashemkhani Zolfani *et al.*, 2021). A global supply chain may have to carry on business in different countries and regions. Hence, it may be required to invest in many countries. It can already be accepted as a risk, as uncertainties are pretty high in the global business environment. Furthermore, the impacts of these risks may become higher and more severe for a supply chain. Wal-Mart's German experience can be given as an example of that. Walmart lost approximately $200 million of their supply chain operations in Germany annually, and the pull out of the German market cost approximately 1 billion USD for Wal-Mart (Christopherson, 2007). Even Wal-Mart, a global supply chain managing massive supply chain operations worldwide, failed in Germany. It had to divest its investments despite the enormous level of investment and highly costly promotional activities after ten years. The operational and financial faults of Wal-Mart are not sufficient to explain the failure of this global supply chain in the German retail market. Concerning this issue, Wal-Mart's failure in Germany can be attributed to Wal-Mart having insufficient information about the German culture (Hamza and Nizam, 2016). So indeed, the business culture of a country with different components can directly affect the success of a supply chain (Hoftsede *et al.*, 2010).

In addition to cultural factors, the success of global supply chains in a country is also related to the abilities and capacities of their potential partners and collaborators in a country. When evaluated from this perspective, the traditional retailing system did not work in many countries due to precautions taken by governments and international bodies at the beginning of the pandemic. Many supply chains unable to deliver at the door, online shopping platforms, or perform micro logistics operations lost their competitive power on a vast scale. Hence, in these troubled days, stakeholders of the supply chain with these kinds of abilities provided critical contributions to the global supply chains for survival in the highly competitive business environment. As a result, it is required to rationally evaluate all general and specific conditions related to the country or countries to invest in them.

One of the best ways to reduce risks exposed in the global market for a supply chain is to reduce the uncertainties entirely or at an acceptable level. Hence, an essential requirement is collecting and processing sufficient information and data on market situations. Within this scope, enterprise survey data provided by the World Bank can be an effective tool for supply chains and their stakeholders to make realistic, rational, and reasonable decisions. The World Bank published quite detailed data at the enterprise level such as productivity, employment, crimes, economic risks, informality, financial structure, tax, and so on since 1990. These data can be helpful and practical instruments providing opportunities to make the right and optimal investment decisions related to the potential countries for the global supply chains. Since these data are incredibly comprehensive and complicated, decision-makers may not overcome these complexities. Thus, a robust, powerful, and applicable methodological framework is required to process these data.

1.1 Research gaps

Recently, risks exposed by supply chains and the chains' sustainability have become private research topics for authors and researchers in the academic world. Increasing pressure of competition on the global supply chains forces them to develop new strategies and nonconventional business processes. They try to develop new strategic alliances with potential partners and collaborators in different countries to provide more systematized, well-structured, and regular material flows and reach services, raw materials, and other requirements in better conditions. Also, the ever-increasing competition forces the supply chains to reduce product prices and, indirectly, their profits. Thus, they are searching for investable new markets with the expectation of finding new customers to increase their profits or stay at the same level. While these approaches lead to the enlargement of the global supply chains, they increase the operational and managerial risks for the supply chains on a vast scale. Eventually, increasing risks make a sustainable supply chain system difficult too. Nonetheless, the most suitable way to survive in the highly competitive, unstable, and uncertain business environment is to design and operate a sustainable supply chain system.

Within this scope, sustainability can provide better financial opportunities and advantages to the supply chains (Wang and Sarkis, 2013; Ecer and Pamucar, 2020) and reduce managerial and operational risks (Ecer, 2021). Moreover, it leads to an increase in the self-reliance of the supply chain, as it can manage and overcome these kinds of problems and challenges. Therefore, it helps to reduce panic related to contingencies incurred in the supply chain processes and provides a healthier and more cool-headed evaluation. As indicated in the previous section, selecting the investable countries is quite a strategic and managerial decision affecting the sustainability of the supply chains. These kinds of decisions affect the structure of the supply chains, their network design, and operational processes on a vast scale, as they also determine their partners and stakeholders in the selected countries depending on the particular characteristics of the countries. Eventually, selecting the countries for the supply chains is a critical and crucial decision affecting the sustainability of the supply chains and risks in the global markets.

The supply chains have two significant needs to make optimal decisions on selecting suitable and investable countries. First, decision-makers should reach sufficient, well-classified, and comprehensive information and data on the evaluated countries. Second, a decision-making tool which can provide excellent and accurate results by processing these data and information should be available. Related to the requirement of data and information, the enterprise survey annually published by the World Bank presents quite comprehensive and detailed data and information that can meet these requirements. However, a mathematical model or decision support system that can effectively and reasonably process these data and information is not available. Also, it is a strict requirement for practitioners and supply chain managers. Hence, there is a strong motivation for this issue in the field of the supply chain.

On the other hand, on the issue of sustainability, the first performance indicator that springs to the mind of both practitioners and researchers carrying out previous works is financial competency (Foerstl *et al.*, 2010). Further, the central part of the previous paper focused on environmental sustainability for companies (Cousins *et al.*, 2004; Anderson and Anderson, 2009; Teuscher *et al.*, 2006). These research topics are important, but they cannot provide a holistic approach to developing a strategy for designing a sustainable supply chain system. Hence, the concept of sustainability needs to be evaluated from a broader perspective. Therefore, the first significant issue supply chain managers need to focus on while developing sustainability strategies is the selection of the countries that the supply chain will invest in the enlargement process. The number of studies on this research topic is exceptionally scarce in the existing literature. Although the industry needs evaluations from a broader perspective, some previous studies made examinations only on a particular country(ies) by considering the enterprise survey data. Although it does not reduce the quality of these works and their contributions to the literature, it indicates the weakness of the current paper and these scientific works concerning the main focal points. These papers are not related to supply chain sustainability and the selection of investable countries. Most of them present a general evaluation of the overall performance of a country or a region in a particular issue, such as accessibility of the credit and finance, R&D (research and development) capacity, labour productivity (Aga and Francis, 2015), and so on. As seen, the findings of these previous papers can be mainly used to evaluate the performance of a definite country as an indicator. However, the global supply chains need these kinds of limited assessments for a country or region only in rare situations. The global supply chains need detailed evaluations for all available alternatives by considering all potential evaluation criteria to make optimal, reasonable, and realistic decisions.

Within this scope, the implications of improving the R&D capacity of Small and Medium Enterprises (SMEs) in a country may be interesting and exciting for a few supply chain managers. Supply chains want to enter all markets, providing an opportunity for creating a high level of added value. Hence, they try to evaluate all companies by considering all factors to select the proper and optimal country(ies). At the beginning of the evaluation process, classification of the countries concerning their risks, performance, and advantages can provide an opportunity for eliminating some countries and focusing on more investable, optimal, and suitable countries that can provide high added value. When it is evaluated in general, the noticed gaps in the literature can be summarized as follows.

(1) According to the authors' information, there is no research focused on the classification of the countries concerning countries' performances by considering the enterprise survey data in the existing literature.

(2) The previous works existing in the literature have not provided managerial implications concerning enlargement strategies of the supply chains at a sufficient level.

(3) No methodological framework can make a systematic pre-assessment of the countries' overall performance.

The global supply chains have no pre-admissions in selecting country, market, and partner, and they seek sufficient evidence to identify the investable countries. Hence, the previous papers are far from meeting the requirements of the global supply chains in the pre-assessment process, as long as a supply chain does not decide to invest in a definite country and industry.

1.2 Motivation

The supply chains are obliged to expand to reduce the competition pressure, create a sustainable supply chain system, and provide higher added value. Although the enlargement strategies have a central role and significance, there are severe and surprising gaps in the issue of the applicable and practical approaches. Correspondingly, many past experiences show that many global supply chains had to pull out of the markets by failing despite enormous investments. Therefore, decision-makers' decisions about entering new markets and making investments can fail due to the non-availability of systematic, robust, and practical evaluation tools practitioners can implement. Wal-Mart's German experience shows that the supply chains have to incur high costs due to wrong investment decisions. Furthermore, repairing these kinds of mistakes can also take a long time.

The primary motivation of the current paper is to present an applicable, systematic, and effective decision-making tool that decision-makers can implement in the evaluation processes carried out for solving real-life decision-making problems, which are highly complicated. The other motivations of the works can be summarized as follows.

(1) To provide an opportunity to evaluate all potential countries in detail by considering the criteria and data provided by the enterprise survey.

(2) To propose a methodological frame for all global and local supply chains to evaluate and select countries that will be invested.

(3) To classify the countries for the global supply chains as investable, moderately risky, and highly risky.

(4) To suggest a decision-making model as an early warning system to prevent possible mistakes in investment decisions for practitioners in the global supply chains.

1.3 The empirical approach and implications

The current paper proposes the REF-Sort (Nearest Solution to References-Sort) technique/method as a mathematical decision-making tool. The proposed model has valuable theoretical contributions to the literature. When these contributions are summarized, the proposed model evaluates all alternatives comprehensively and helps decision-makers rank the options in a realistic, reasonable, and rational frame. Besides, the model can reach accurate and reasonable results with fewer computations than many traditional and popular MCDM (multi-criteria decision-making) techniques. Also, being practical and applicable, the basic algorithm of the model can repeat the computations easily. Hence, the results can continuously be updated thanks to the proposed model depending on the updated data by the World Bank. It can be accepted as another advantage of the proposed MCDM framework. We collected data from the official dataset from the enterprise survey database of the World Bank by considering the criteria set proposed by this international body. Then, we classified the countries by considering their relative performance scores identified with the help of the proposed MCDM framework. The suggested technique uses the enterprise survey data published by the World Bank to evaluate the countries invested.

1.4 Research questions

In this study, researchers identified research problems after a comprehensive literature review as follows. (1) Do decision-makers in the supply chains use a mathematical tool or decision support system for identifying the countries to invest in, markets to be entered, and potential partners and stakeholders in these countries? (2) Is it possible to use a mathematical model that can make it easy for the decision makers' business in this issue? (3) Is it likely to classify the countries based on the enterprise survey data for being investable? To find reasonable answers to these questions, we computed the relative performance scores of the countries through the enterprise survey data with the help of the proposed MCDM framework. If the obtained results are evaluated, these results are rational, realistic and suitable for real-life conditions. The sensitivity analysis performed to test the validity of the proposed MCDM framework also approves the validity, applicability, and robustness of the proposed model.

2. Literature review

In the current study, researchers performed a comprehensive literature review. All previous papers in the literature were collected from various databases such as Google Scholar, Web of Science, Scopus, etc. We used some keywords, classified the previous works by considering their concepts, findings, and applied techniques, and evaluated countries and industries. At the end of the process, we noticed that 32 papers exist in the related literature. Once these papers are evaluated in detail, it can be seen that most of them focus on a definite country or region. The previous papers in the related literature are presented in Table 1.

African countries are the most commonly evaluated countries by these previous works (Odusanya and Atanda, 2018; Gelb *et al.*, 2013, 2020; Raggl, 2015; Bennell, 2021; Ramachandran, 2021; Samargandi, 2018; Mensah *et al.*, 2018; Bassey, 2014; Nguimkeu and Okou, 2021; Alosta *et al.*, 2021; Muhammad *et al.*, 2021; Adegboye and Iweriebor, 2018). European countries follow African countries (Bruszt and Campos, 2016; Corsatea, 2014; Hall and Reenen, 2000; Wysmułek, 2019). Further, the most commonly examined topics are access to finance (Esho and Verhoef, 2018; Friesen and Wacker, 2013; Wang, 2016; Xu *et al.*, 2018), corruption (Olken and Pande, 2012; Wysmułek, 2019), R&D (Adegboye and Iweriebor, 2018; Hall and Reenen, 2000; Rahmati and Pilehvari, 2019; Stojanović and Puška, 2021; Baydaş and Elma, 2021), and labour costs and efficiency (Gelb *et al.*, 2013, 2020; Samargandi, 2018; Mensah *et al.*, 2018). There is no study evaluating the performance of all countries by using enterprise survey data in the literature. The previous works evaluated the performances of a selected country by considering an indicator that was determined.

Consequently, these papers dealt with a single criterion, such as R&D capacity, access to finance, etc., instead of evaluating all criteria proposed in the enterprise survey. When these studies are reviewed in general, these papers significantly contribute to the literature. However, as almost each of them focused on the performance and characteristics of a country or a region, their contributions are limited for decision-makers in the global supply chains. Besides, there is no paper evaluating the countries concerning their performance on being investable by applying an MCDM framework in the literature. Furthermore, no mathematical model and decision support system are applied to measure the countries' performance. Therefore, almost no papers in the related literature help the decision-makers make optimal and suitable decisions about selecting countries and markets in the enlargement process at a sufficient level. From this perspective, their contributions to the sustainability of the global supply chains are pretty weak. Thus, there are severe and surprising gaps in the literature on the one hand.

On the other hand, decision-makers and practitioners lack the support of the literature providing theoretical contributions and managerial implications. This situation may increase

Table 1. The previous studies existing in the related literature

Authors	Concept	Model	Countries	Results
Adegboye and Iweriebor (2018)	The role of access to finance in enhancing innovation and productivity among Nigerian SMEs	Logit estimation technique	Nigeria	Ease of accessing bank credit is the most vital positive force in driving all types of innovation among SMEs in Nigeria
Aga and Francis (2015)	The relative importance of small versus large firms and old versus young firms	Situation assessment	117 countries	Small and medium enterprises and older establishments are the dominant employers
Eifert *et al.* (2008)	Labour costs and productivity in selected African countries	Statistical analysis	25 African countries	Industrial labour costs are far higher in Africa than one might expect
Alam *et al.* (2019)	Analyzes the factors that enhance apparel export performance during the post-MFA (multifiber arrangement environment) period	Evaluation of historical data	Mexico and the Philippines	Cheap labour, firm size, product quality, and foreign ownership are the major factors that help gain competitiveness in apparel exports during the post-MFA period
Berning and Holtbrügge (2012)	The current state of research on outward foreign direct investment (OFDI) of Chinese firms	Internationalization theories	China	The majority of studies find these theories not applicable to explaining Chinese OFDI
Raggl (2015)	The determinants of total factor productivity in the Middle East and North Africa region between 1980 and 2009	The method of growth accounting	Eastern and North African countries	Human capital is not only an input factor of production but also a quantity that changes the efficiency by which existing input factors are used
Bassey (2014)	How the Central Bank of Nigeria uses statistics from enterprise surveys to shape economic decisions	Consumer expectation survey	Nigeria	Sample surveys should obtain reliable, accurate, and timely statistics to assess their effects on market expectations and public confidence
Bennell (2021)	National skills development strategies elsewhere in the developed and developing world, its overall analysis is quite limited and superficial	Situation assessment	Sub-Saharan Africa	Governments must take the lead; public-private partnerships which focus on the skills needs of "catalytic" growth sectors are increasingly important
Bruszt and Campos (2016)	Deep Economic Integration and State Capacity	Situation assessment	European countries	The centrality of an intricate relationship between bureaucratic independence and judiciary capacity as the primary driver of institutional change

(*continued*)

Table 1.

Authors	Concept	Model	Countries	Results
Corsatea (2014)	Technological capabilities for innovation activities across Europe	A composite index	European countries	The evolution of the market drives the patterns of innovation activities for all selected technologies
Dethier *et al.* (2008)	Surveys of the literature on productivity and growth in developing countries	Literature review	100 Countries	A good business climate drives growth By encouraging investment and higher productivity
Duranton *et al.* (2016)	Factor misallocation	Misallocation methodology	India	Factor and output misallocation across districts are at least as necessary as misallocation within districts
Esho and Verhoef (2018)	Funding gap and the financing of small and medium businesses	Literature review	General	Small and medium businesses face constraints that are very different from large businesses. Chief amongst these constraints is access to finance
Friesen and Wacker (2013)	Impacts of informal competition on the role of access to finance	Ordered logit model	General	Financially constrained firms face significantly more intense competition from the informal sector, and that this effect is economically significant
Gelb *et al.* (2013)	Africa's industrial labour costs	Situation assessment	South Africa	Industrial labour costs are far higher in Africa than one might expect
Hall and Reenen (2000)	The econometric evidence on the effectiveness of fiscal incentives for R&D	Econometric evidence	Australia, Canada, France, Japan, and Sweden	The tax system has effects on the R&D behaviour of countries
Nguimkeu and Okou (2021)	The role of individual and institutional factors on entrepreneurship and informality in a developing country	Counterfactual analysis	Cameroon	The allocation of skills across occupations and aggregate income
Okano (2019)	Social enterprise	Bibliometric analysis	General	Research on social enterprises develops over time
Olken and Pande (2012)	Corruption in developing countries	Situation assessment	US	Corruption responds to standard economic incentive theory

(*continued*)

Table 1.

Authors	Concept	Model	Countries	Results
Rahmati and Pilehvari (2019)	The productivity trend in Iran evidence from manufacturing firms	Estimation	Iran	R&D expenditures significantly increase productivity growth, while the R&D sales ratio is about 0.5% in manufacturing sectors, about one-fifth of the world average
Ramachandran (2021)	Convergence, development, and energy-intensive infrastructure in Africa	Statistical analysis	African countries	Agricultural yields in Africa are low, and food is costly, while employment in agriculture remains high
Bazaluk *et al.* (2020)	Dynamic development of the global organic food market	Export-oriented model	Ukraine	t was found that Ukraine has unrealized export potential that can be realized using a combination of practices used abroad
Rodrik (2005)	Growth strategy	Statistical analysis	General	Neoclassical economic analysis is a lot more flexible than its practitioners in the policy domain have generally given it credit
Samargandi (2018)	Determinants of labour productivity	The fully modified ordinary least squared (FM-OLS) regression approach	The MENA (the Middle East and North Africa) countries	Innovation was found to be an essential factor in accelerating labour productivity
Sun *et al.* (2019)	Connecting top-down accounting and local impacts	EEIO (environmentally extended input-output) models	General	The temporal and spatial resolution of such approaches and analyze the general advantages and limitations of the modelling framework
Wang (2016)	The biggest obstacles to the growth of SMEs in developing countries	The estimation model of a specific obstacle	General	SMEs perceive access to finance as the most significant obstacle which hinders their growth
Williams and Kedir (2019)	Explaining cross-country variations in the prevalence of informal sector competitors	Multilevel probit regression analysis	Chad and El Salvador	It is not too much or too little state intervention associated with the prevalence of informal sector competition but rather whether the laws and regulations developed by governments are in symmetry with entrepreneurs' norms, values, and beliefs

(*continued*)

Table 1.

Authors	Concept	Model	Countries	Results
Mensah *et al.* (2018)	Structural change, productivity growth and labour market turbulence in Africa	Productivity growth decomposition	West Africa and Southern Africa	More rigid labour markets reduce job reallocation across sectors impeding structural change and productivity growth in Africa
Wysmułek (2019)	Corruption in Europe	Survey	European countries	The trends: a considerable increase in experiential items, more significant differentiation between forms of corruption
Xu *et al.* (2018)	Supply chain finance	The EOQ/EPQ (economic order quantity/economic production quantity)	General	Inventory decisions with trade credit policy under more complex situations, the interaction between replenishment decisions and delay payment strategies in the supply chain, and the roles of financing services in the supply chain
Zanello *et al.* (2016)	The creation and diffusion of Innovation in developing countries	Literature review	General	The capacity for innovation is embedded in and constituted By dynamics between geographical, socio-economic, political, and legal subsystem

the probability of failure in the country and market selection for the global supply chains, increasing managerial and operational risks. As a result, more research and studies are necessary to evaluate the performance of the countries to be investable. The current paper provides valuable contributions to the literature, and it presents a robust, practical, and effective decision-making tool for decision-makers in various industries and supply chains. Moreover, it comprehensively evaluates the enterprise survey data for identifying the proper and optimal markets.

The study includes a novel sorting method. It is helpful to review the literature on MCDM and sorting methods in this context. Decision-makers obtain selection, ranking, elimination, definition, design, or classification results by solving MCDM (Zakeri *et al.*, 2021; Karamaşa *et al.*, 2021). Classification problems are solved by assigning predetermined classes or groups in MCDM methods. Multi-criteria classification problems are evaluated under the nominal (classification) and ordinal (sorting) concepts. The classification includes assigning alternatives to predetermined classes that have no outranking or preference relations with one another. On the other hand, sorting problems means assigning alternatives to predetermined classes with outranking/preference relations (Aytekin, 2020b; Zopounidis and Doumpos, 2002). These methods can be differentiated by reflecting the preferences of decision-makers or experts to solve the problem concerning multivariate statistics and data mining. Besides, most of the multi-criteria classification problems can be considered the derivatives/extensions of methods developed for ranking and selection problems (Ali *et al.*, 2021). AHP-Sort (Analytic Hierarchy Process-Sort), ANP-Sort (Analytic Network Process-Sort), CODAS-Sort (Combinative Distance-based Assessment-Sort), ELECTRE-Tri (Elimination Et Choice Translating Reality-Tri), FlowSort, MACBETH-Sort (Measuring Attractiveness by a Categorical Based Evaluation Technique-Sort), and TOPSIS-Sort (Technique for Order Preference by Similarity to Ideal Solution-Sort) can be exemplified for multi-criteria classification methods (Almeida-Dias *et al.*, 2010; de Lima Silva and de Almedia Filho, 2020; Bozanic *et al.*, 2021; Sabokbar *et al.*, 2016; Ishizaka *et al.*, 2012; Ishizaka and Pereira, 2020; Nemery and Lamboray, 2007, 2008; Pamucar and Ecer, 2020; Ouhibi and Frikha, 2019; Yu, 1992).

It is possible to make a methodological classification for classification problems like ranking and choice. Classification simplifies the standardization of the related concepts and examination of the increased number of methods. However, a general approach to different MCDM methods divides them into two main classes multi-objective decision-making (MODM) and multi-attribute decision-making (MADM). MADM methods can be evaluated theoretically or conceptually under the classes of utility-based or complete aggregation approaches (American School), outranking-based (French or European School), and compromised or reference-based approach (goal, aspiration, or reference level) (Aytekin, 2020a; Colson and De Bruyn, 1989; Ishizaka and Nemery, 2013).

One of the American School multi-criteria sorting methods is AHP-Sort. Border profiles are used in AHP-Sort to assign alternatives to classes. On the other hand, center profiles are employed if border profiles cannot be determined. The Saaty fundamental scale compares the profile values of the classes and alternatives in pairs. Alternatives are assigned to classes in the last stage depending on the aggregated priority value. The critical difference between ANP-Sort and AHP-Sort is that it permits network structure rather than a hierarchical structure. Semantic scale and MACBETH's algorithm are used in MACBETH-Sort, which contains procedures like AHP-Sort (Ishizaka *et al.*, 2012; Ishizaka and Gordon, 2017; Ishizaka and Nemery, 2013; Ishizaka and Pereira, 2020).

Yu (1992) created the ELECTRE-Tri classification method for his doctoral dissertation under Roy's supervision. It is also called ELECTRE-Tri-B because it was created after ELECTRE-A, the content of which was kept a secret. By utilizing boundary profiles, ELECTRE-Tri-B facilitates the classification process. Almeida-Dias *et al.* (2010) proposed the

ELECTRE-Tri-C extension in the following years, which involves the usage of central profiles. In ELECTRE-Tri-B, the assignment of alternatives to classes is based on comparing each alternative with the profiles that define the classes' lower and upper boundaries. On the other hand, for comparisons in ELECTRE-Tri-C, center profiles are used. PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluation) is one of the methods whose extensions have been created to solve multi-criteria classification problems. PROMETHEE-TRI, PROMSORT, and FlowSort stand out among these extensions (Araz and Ozkarahan, 2007; Figueira *et al.*, 2004; Nemery and Lamboray, 2007). FlowSort was regarded as the most appropriate extension of PROMETHEE for classification problems (Brans and De Smet, 2016). The FlowSort method assigns alternatives to predetermined ordinal classes using boundary/limit or centre profiles (Nemery and Lamboray, 2007).

TOPSIS-Sort, CODAS-Sort, and VIKOR-Sort (Multicriteria Optimization and Compromise Solution-Sort) stand out among the reference-based multi-criteria sorting methods. TOPSIS-Sort is used to solve ordinal classification problems (Sabokbar *et al.*, 2016). However, it includes lower and upper bound profiles that may not be needed for classification. TOPSIS-Sort also has a structure open to rank reversal problems observed in the methods used in sorting, selection, or ordinal classification problems. For this reason, de Lima Silva and de Almedia Filho (2020) suggested TOPSIS-Sort B and TOPSIS-Sort C, which are derivatives of the method with a less clear profile structure and no rank reversals. TOPSIS-Sort-B uses boundary profiles, while TOPSIS-Sort-C uses centre profiles in classification processes. CODAS, another compromise solution-based method, is based on the opinion that the worst values in the relevant criterion are taken as a reference, and the best solution will be the farthest from the worst value (negative ideal) (Keshavarz Ghorabaee *et al.*, 2016). CODAS-Sort is the derivative of CODAS proposed by Ouhibi and Frikha (2019) to counter classification problems. CODAS-Sort is based on the opinion that the worst values in the relevant criterion are taken as a reference, and the best solution will be the farthest from the worst value (Aytekin, 2020c; Ouhibi and Frikha, 2019). The VIKOR technique was proposed by Opricovic (1998) based on a compromise solution for problems with conflicting criteria. Demir *et al.* (2018) proposed VIKOR-Sort, an extension of VIKOR that can counter the classification problems arising from VIKOR. They stated that VIKOR-Sort could reflect the pessimistic and optimistic preferences of the decision-maker.

3. Research methodology

The sorting methods specified in the literature section classify the alternatives using border or centre profiles. However, it is impossible to efficiently solve each decision problem via the same methods. In this context, REF-Sort will classify countries based on enterprise survey data. Some characteristics differentiate REF-Sort apart from other methods. REF-Sort employs the value or value range that reflects the most typical characteristic of the relevant class in assignment processes. The reference values in REF-Sort and centre profiles are similar in this regard. On the other hand, class references can be defined as ranges in REF-Sort. Secondary values, called successors, can also be employed to assign a value to the appropriate class. REF-Sort can also determine the reference and successor values/ranges independently of the decision matrix. REF-Sort can provide solutions for decision matrices with zero and negative values. Besides, some of the sorting methods specified in the literature section include ideal and anti-ideal values and class profiles. If the effect of ideal and anti-ideal solution values is strong, the classification process based on class profiles may fail to succeed. That is not a concern with the REF-Sort method because the class profile values are taken into account directly. Finally, REF-Sort does not cause an issue with rank or class change for the current alternatives when adding or removing alternatives from the problem. The methodology used in the study will be presented in detail in the following subsection.

3.1 The proposed MCDM framework

Aytekin (2020a) presented REF-I and REF-II methods to obtain solutions to decision problems according to reference points or ranges. In these two methods, references can be determined as ranges, and acceptance levels of different ranges outside the reference can be assigned. With REF-I, one of these methods, qualitative and quantitative criteria can be used together. In REF-II, on the other hand, the rank reversal problem and the need for recalculation for the existing alternatives in the alternative set change have been eliminated (Aytekin, 2020a, 2021; Aytekin and Durucasu, 2021). Among these newly developed methods, REF-I was employed in the second-hand sport utility vehicle purchasing problem (Aytekin and Durucasu, 2021), while REF-II was used in companies' financial performance analyses (Aytekin, 2021). In this study, the extension of REF that can be used for classification or sorting problems, REF-Sort, will be proposed. Figure 1 depicts the workflow of the proposed framework for evaluating countries.

At this point, it is helpful to give some explanations. A reference is a certain value or range of values to evaluate alternatives in the context of decision criterion j. The references in the criterion j for class k is denoted by ${}_{\lambda}r_{kj}$, where $k = 1, \ldots, p$, and $\lambda = 0,1,2$. If the reference ${}_{\lambda}r_{kj}$ of the k class in the criterion j is determined as a point, it is expressed by ${}_{0}r_{kj}$. On the other hand, if the reference profile ${}_{\lambda}r_{kj}$ of the k class in the criterion j is determined as a range, the lower limit of this range is characterized by ${}_{1}r_{kj}$, and the upper limit ${}_{2}r_{kj}$. However, the preference levels for different ranges outside the reference(s) may differ from each other. In this case, the value/range of secondary importance is called the successor value/range, and the successor value/range of the j criterion is denoted by ${}_{v}v_{kj}$. Accordingly, it is possible to determine q as many successor ranges/values as $v = 1, \ldots, q$ in the criterion j for class k. In criterion j, the decision-maker determines the effect of successor ranges on the decision problem as symmetric or asymmetric. For this purpose, the unacceptance value ${}_{v}\beta_{kj}$ is assigned for each successor value/range in k classes in the criterion j. This value reflects the level of unacceptance of the value within the relevant successor range relative to the reference point/range and takes a value in the range of 0–1. ${}_{v}\beta_{kj}$ is 0 for the reference value/range and equal to 1 for values outside of successor ranges (Aytekin and Durucasu, 2021). The implementation steps of REF-Sort are given in the following section:

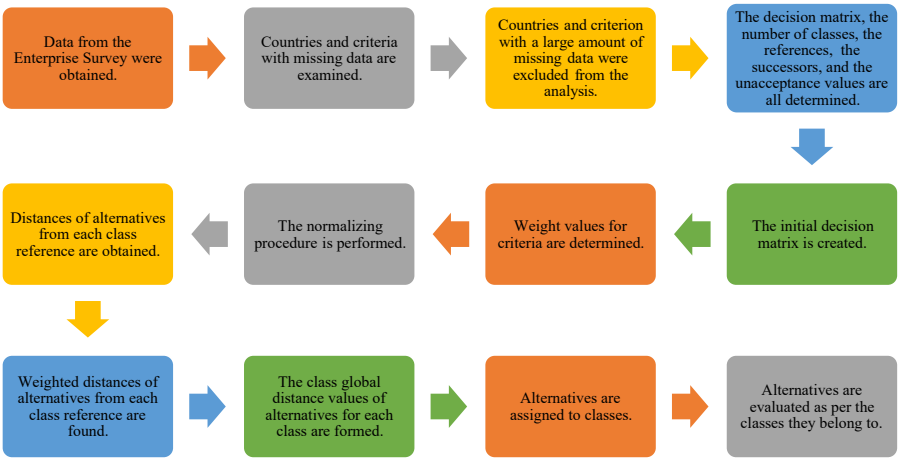

Figure 1.
Structural workflow of the proposed approach

Step 1: Defining the decision problem and creating the initial decision matrix. Assigning alternatives to predetermined classes is carried out in multi-criteria classification problems. The classes to which the alternatives will be assigned and the reference profile values used in assigning these classes are determined. The reference profile can be specified as a point or a range. Also, successor values can be used. Scientific techniques can be used to determine the unacceptance values of the successors. The decision problem, criteria, and alternatives are determined in this stage. Then, the decision matrix specified in Eq. (1) is created.

$$X = \begin{bmatrix} x_{11} & \dots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \begin{matrix} i = 1, \dots, m \\ j = 1, \dots, n \end{matrix} \tag{1}$$

In Eq. (1), the preference, performance value, or the measurement of alternative i in criterion j is represented by x_{ij}.

Step 2: Normalization. Normalization is used to create one-dimensional, comparable values for the alternatives. Eqs (2–4) is used for normalization of the initial decision matrix, reference and successor values, where $k = 1, \dots p, \lambda = 0, 1, 2,$ and $v = 1, \dots, q$.

$$z_{ij} = \frac{x_{ij}}{a_{*j}} \tag{2}$$

$${}_{\lambda}\varphi_{kj} = \frac{{}_{\lambda}r_{kj}}{a_{*j}} \tag{3}$$

$${}_{v}\phi_{kj} = \frac{{}_{v}v_{kj}}{a_{*j}} \tag{4}$$

$$a_{*j} = max_j \left| x_{ij}, {}_{\lambda}r_{kj}, {}_{v}v_{kj} \right| \tag{5}$$

a_{*_j} is the domain value of criterion j, and not changed when an alternative is added or removed from the decision matrix.

Step 3: Creating the distances matrices for each class. After the normalization process, the distances between the alternatives and the references for each class are calculated using Eq. (6), considering the successor and unacceptance values.

$$d_{ij_k} = \begin{cases} 0 & , \ {}_{1}\varphi_{kj} \le z_{ij} \le {}_{2}\varphi_{kj}, \ or \ z_{ij} = {}_{0}\varphi_{kj} \\ \left| z_{ij} - {}_{\lambda}\varphi_{kj} \right| {}_{v}\beta_{kj} & , \ {}_{\lambda}\varphi_{kj} > z_{ij} \ge {}_{v}\phi_{kj} \\ \left| z_{ij} - {}_{\lambda}\varphi_{kj} \right| {}_{v}\beta_{kj} & , \ {}_{\lambda}\varphi_{kj} < z_{ij} \le {}_{v}\phi_{kj} \\ \left| z_{ij} - {}_{\lambda}\varphi_{kj} \right| & , \ else \end{cases} \tag{6}$$

In Eq. (6), the distance value is scaled with ${}_{v}\beta_{kj}$ in the j criterion by determining if the alternative i is within the v successor range.

Step 4: Creating the weighted distances matrices for each class. Weighting techniques in the literature can be used to determine the weight values of the criteria. The weighted distances values (h_{ij_k}) are obtained using Eq. (7), where w_j shows the weight value of the criterion j.

$$h_{ij_k} = d_{ij_k} w_j \tag{7}$$

Step 5: Generating the class global values of the alternatives. For each k-class, the global values of the alternatives are calculated by Eq. (8).

$$U_{i_k} = \sum_{j=1}^{n} h_{ij_k} \tag{8}$$

Step 6: Assigning the alternatives to classes. Alternatives are assigned to classes by considering their class global values. For this purpose, Eq. (9) is used.

$$\begin{array}{lll} i \epsilon C_1 & , & U_{i_1} < U_{i_{k-1}} \quad k-1=2,\ldots,p \\ i \epsilon C_{k-1} & , & U_{i_{k-1}} < U_{i_1} \quad k=1,\ldots,p \end{array} \tag{9}$$

Using Eq. (9), alternatives are assigned to the closest class according to their class global values. In the following subsection, the implementation of the REF-Sort will be illustrated with an example.

3.2 Numerical example

In this section, the applicability of REF-Sort will be explained in detail with an illustrative decision problem. The sample problem has four-six criteria and six alternatives. The criteria have been created with different features to reflect various problem structures or scenarios. As a result, the C1 criterion was created to include values ranging from 0 to 100, the C2 criterion to include negative and positive values, the C3 criterion to include negative, 0 and positive values, and the C4 criterion to include entirely negative values, the C5 criterion to include values ranging from 0 to 1, and the C6 criterion to include values ranging from 1,000–1,000,000. The performance values of the alternatives were produced at random using MS Excel. The formulas = RANDBETWEEN (lower bound value; upper bound value) and = RAND () were employed. However, some numbers were chosen on purpose, such as in C3, to test the impacts of 0. The decision matrix and other information related to the problem are given in Table 2.

Class references are defined as intervals in some criteria and as points in others, as shown in Table 2. The point format references are written to lower and upper reference bounds. As an example, successors are used only for class 1. The data structures of the criteria have been carefully chosen to be as diverse as possible, including negative and zero values. Besides, values for alternatives were generated randomly with MS Excel. As a result, the applicability of REF-Sort to various data structures will be illustrated. After this stage, firstly, a_{*_j} should be determined to implement the normalization. The value of a_{*_1} for K1 is determined as follows.

$$a_{*j} = max_{j=1}\,(|41|, |52|, |62|, |43|, |74|, |95|, |90|, |100|, |80|, |60|, |70|, |40|, |50|) = 100$$

After a_{*_j} is determined, the normalization is generated using Eqs (2–4) as seen below.

$$z_{11} = \frac{41}{100} = 0.41$$

$$_1\varphi_{11} = \frac{90}{100} = 0.9$$

$$_1\phi_{11} = \frac{80}{100} = 0.8$$

After making calculations, the normalized values are created as in Table 3.

Alternatives		Criteria C1	C2	C3	C4	C5	C6
A1		41	46	−38	−409	0.20	93,192
A2		30	−33	−35	−193	0.42	69,751
A3		62	10	0	−72	0.49	670,599
A4		43	41	−28	−174	0.61	174,553
A5		74	3	−16	−597	0.97	316,715
A6		95	47	0	−5	0.10	800,000
w_j		0.2	0.1	0.2	0.1	0.2	0.2
a_{*_j}		100	50	60	597	1.00	1,000,000
Class 1:							
References, successor point/range, and unacceptance values	$_1r_{1j}$	90	45	0	−10	0,00	750,000
	$_2r_{1j}$	100	50	0	−1	0,00	1,000,000
	$_1v_{1j}$	80	40	−20	−50	0,25	500,000
	$_1\beta_{1j}$	0.50	0.75	0.50	0.50	0.50	0.50
Class 2:							
References, successor point/range, and unacceptance values	$_1r_{2j}$	60	20	−30	−150	0.45	300,000
	$_2r_{2j}$	70	30	20	−100	0.55	400,000
	$_1v_{2j}$						
	$_1\beta_{2j}$						
Class 3:							
References, successor point/range, and unacceptance values	$_1r_{3j}$	40	−15	−60	−500	1.00	0.00
	$_2r_{3j}$	50	0	10	−250	1.00	80,000
	$_1v_{3j}$						
	$_1\beta_{3j}$						

Table 2.
Decision matrix and some information for a numerical example

Alternatives		Criteria C1	C2	C3	C4	C5	C6
A1		0.4100	0.9200	−0.6333	−0.6851	0.2000	0.0932
A2		0.3000	−0.6600	−0.5833	−0.3233	0.4200	0.0698
A3		0.6200	0.2000	0.0000	−0.1206	0.4900	0.6706
A4		0.4300	0.8200	−0.4667	−0.2915	0.6100	0.1746
A5		0.7400	0.0600	−0.2667	−1.0000	0.9700	0.3167
A6		0.9500	0.9400	0.0000	−0.0084	0.1000	0.8000
Class 1:							
References, successor point/range, and unacceptance values	$_1r_{1j}$	0.9000	0.9000	0.0000	−0.0168	0.0000	0.7500
	$_2r_{1j}$	1.0000	1.0000	0.0000	−0.0017	0.0000	1.0000
	$_1v_{1j}$	0.8000	0.8000	−0.3333	−0.0838	0.2500	0.5000
	$_1\beta_{1j}$	0.50	0.75	0.50	0.50	0.50	0.50
Class 2:							
References, successor point/range, and unacceptance values	$_1r_{2j}$	0.6000	0.4000	−0.5000	−0.2513	0.4500	0.3000
	$_2r_{2j}$	0.7000	0.6000	0.3333	−0.1675	0.5500	0.4000
Class 3:							
References, successor point/range, and unacceptance values	$_1r_{3j}$	0.4000	−0.3000	−1.0000	−0.8375	1.0000	0.0000
	$_2r_{3j}$	0.5000	0.0000	0.1667	−0.4188	1.0000	0.0800

Table 3.
The normalized values for an illustrative example

In-class evaluations begin after this step. For example, in class 1, the following computations for alternative A1 will be done on six criteria.

(1) d_{11_1}: When checking at the class 1 reference and successor values depending on Eq. (6), it is clear that d_{11_1} is not in the reference or successor ranges. Accordingly, $d_{11_1} = |0.41 - 0.90| = 0.49$.

(2) d_{12_1}: When checking at the class 1 reference and successor values depending on Eq. (6), it is clear that d_{12_1} is in the reference range ($_1\varphi_{kj} \le z_{ij} \le {}_2\varphi_{kj}$; $0.9 \le 0.92 \le 1$). Thus, $d_{12_1} = 0$.

(3) d_{13_1}: When checking at the class 1 reference and successor values depending on Eq. (6), it is clear that d_{13_1} is not in the reference or successor ranges. Accordingly, $d_{13_1} = |-0.6333 - 0| = 0.6333$.

(4) d_{14_1}: When checking at the class 1 reference and successor values depending on Eq. (6), it is clear that d_{14_1} is in the reference or successor ranges. Accordingly, $d_{14_1} = |-0.6851 - 0.0168| = 0.6683$.

(5) d_{15_1}: When checking at the class 1 reference and successor values depending on Eq. (6), it is clear that d_{15_1} is in the successor range ${}_1\phi_{15}$. Accordingly, $d_{15_1} = |0.2 - 0| * 0.5 = 0.1$.

(6) d_{16_1}: When checking at the class 1 reference and successor values depending on Eq. (6), it is clear that d_{16_1} is not in the reference or successor ranges. Accordingly, $d_{16_1} = |0.0932 - 0.75| = 0.6568$.

The distances of alternatives from the class references are calculated using the same procedure for all alternatives. Then, Eq. (7) is used to create h_{ij_k} values like $h_{11_1} = 0.49 * 0.2 = 0.098$. Thus, h_{ij_k} values in Table 4 are obtained.

The class global values for the alternatives U_{ik} are calculated using Eq. (8). For example, $U_{11} = 0.098 + 0 + 0.12667 + 0.06683 + 0.02 + 0.13136 = 0.4429$. After these calculations, the alternatives are assigned to classes based on U_{ik} values. For this purpose, Eq. (9) is used. For example, because A1's class global values are $U_{11} = 0.4429$, $U_{12} = 0.2314$, and $U_{13} = 0.2546$, A1 should be assigned to Class 2 because of $U_{12} < U_{13} < U_{11}$. All assignments are given in Table 5.

The results in Table 3 show that A1, A3, and A4 are in Class 2, while A6 is in Class 1, and A2 and A5 are in Class 3. REF-Sort can be described as having a fundamental and flexible structure. The classification of countries will be carried out in the next section using the Enterprise Survey Data (World Bank, 2021).

	C1	C2	C3	C4	C5	C6
Class 1						
A1	0.0980	0.0000	0.1267	0.0668	0.0200	0.1314
A2	0.1200	0.1560	0.1167	0.0307	0.0840	0.1360
A3	0.0560	0.0700	0.0000	0.0104	0.0980	0.0079
A4	0.0940	0.0060	0.0933	0.0275	0.1220	0.1151
A5	0.0320	0.0840	0.0267	0.0983	0.1940	0.0867
A6	0.0000	0.0000	0.0000	0.0000	0.0100	0.0000
Class 2						
A1	0.0380	0.0320	0.0267	0.0434	0.0500	0.0414
A2	0.0600	0.1060	0.0167	0.0072	0.0060	0.0460
A3	0.0000	0.0200	0.0000	0.0047	0.0000	0.0541
A4	0.0340	0.0220	0.0000	0.0040	0.0120	0.0251
A5	0.0080	0.0340	0.0000	0.0749	0.0840	0.0000
A6	0.0500	0.0340	0.0000	0.0159	0.0700	0.0800
Class 3						
A1	0.0000	0.0920	0.0000	0.0000	0.1600	0.0026
A2	0.0200	0.0360	0.0000	0.0095	0.1160	0.0000
A3	0.0240	0.0200	0.0000	0.0298	0.1020	0.1181
A4	0.0000	0.0820	0.0000	0.0127	0.0780	0.0189
A5	0.0480	0.0060	0.0000	0.0162	0.0060	0.0473
A6	0.0900	0.0940	0.0000	0.0410	0.1800	0.1440

Table 4. The weighted distances for an illustrative example

4. Classification of countries via the REF-Sort method

Enterprise Survey Data obtained from the World Bank database contains data from 146 countries in 108 sub-indicators/sub-criteria under 12 main indicators/criteria (World Bank, 2021). The main criteria and the number of sub-criteria they include are as follows:

(1) Biggest Obstacles (15 sub-criteria)
(2) Corruption (13 sub-criteria)
(3) Crime (6 sub-criteria)
(4) Finance (13 sub-criteria)
(5) Firm Characteristics (7 sub-criteria)
(6) Gender (6 sub-criteria)
(7) Informality (4 sub-criteria)
(8) Infrastructure (12 sub-criteria)
(9) Performance (5 sub-criteria)
(10) Regulations and taxes (9 sub-criteria)
(11) Trade (8 sub-criteria)
(12) Workforce (10 sub-criteria)

The sub-criteria with missing data from the G20 countries Brazil, China, and Italy were excluded from the analysis, such as the percentage of whose recent loan application was rejected (Finance), percentage of firms with the majority of female ownership (Gender), days to obtain an import license (Regulations and Taxes). Also, countries with missing data on the remaining 105 sub-criteria were left out of the analysis. In some countries, such as the United States, Canada, Egypt, and Saudi Arabia, the Enterprise Survey is not implemented, and data is unavailable in others, such as Germany, France, and Spain, because the surveys have not been finished. As a result, the evaluations will take place in 105 sub-criteria and 95 countries. Equal weight values are given to the main criteria. The sub-criteria weights were determined by the equal distribution of the main criteria weight. To classify countries as high, medium, and low business environments, reference values were determined using Enterprise Survey Data. Accordingly, if the work environment improves as the values in the relevant criteria increase, the third quartile value for the first class, the second quartile value for the second class, and the first quartile value for the third class were taken as references. On the other hand, if the work environment improves as the values in the relevant criterion decrease, the first quartile value for the first class, the second quartile value for the second class, and the third quartile value for the third class were determined as reference. The results in Table 6 were obtained by using the REF-Sort technique.

When the results obtained by applying the proposed model are evaluated, 95 countries are classified into three groups by considering their relative performance scores. According to

Table 5. Assignments of alternatives for illustrative example

Alternatives	Class 1	Class 2	Class 3	Assignment
A1	0.4429	0.2314	0.2546	Class 2
A2	0.6434	0.2419	0.1815	Class 3
A3	0.2423	0.0788	0.2939	Class 2
A4	0.4579	0.0971	0.1916	Class 2
A5	0.5216	0.2009	0.1236	Class 3
A6	0.0100	0.2499	0.5490	Class 1

Country	Class 1 *Ui*	Class 2 *Ui*	Class 3 *Ui*	Final Assignment
Albania	0.1626	0.1286	0.1758	Class 2
Argentina	0.1834	0.1361	0.1501	Class 2
Armenia	0.1076	0.1050	0.1706	Class 2
Bangladesh	0.1971	0.1708	0.1993	Class 2
Belarus	0.1047	0.1226	0.2142	Class 1
Belgium	0.1396	0.1500	0.2185	Class 1
Bhutan	0.1593	0.1434	0.1960	Class 2
Bolivia	0.2071	0.1485	0.1392	Class 3
Bosnia and Herzegovina	0.1256	0.1087	0.1712	Class 2
Botswana	0.1629	0.1333	0.1798	Class 2
Brazil	0.2163	0.1793	0.1862	Class 2
Bulgaria	0.1254	0.1126	0.1825	Class 2
Burkina Faso	0.2251	0.1471	0.1225	Class 3
Burundi	0.2177	0.1574	0.1481	Class 3
Cameroon	0.2164	0.1547	0.1249	Class 3
Chile	0.1675	0.1413	0.1865	Class 2
China	0.1300	0.1443	0.2234	Class 1
Colombia	0.1884	0.1429	0.1515	Class 2
Congo. Dem. Rep.	0.2539	0.2021	0.1580	Class 3
Costa Rica	0.1715	0.1237	0.1365	Class 2
Côte d'Ivoire	0.2535	0.1837	0.1363	Class 3
Croatia	0.1049	0.1316	0.2176	Class 1
Cyprus	0.1378	0.1178	0.1795	Class 2
Czech Republic	0.1044	0.1104	0.1935	Class 1
Dominican Republic	0.1654	0.1097	0.1211	Class 2
Ecuador	0.1647	0.1168	0.1384	Class 2
El Salvador	0.1674	0.1109	0.1255	Class 2
Estonia	0.0881	0.1171	0.2196	Class 1
Eswatini	0.1689	0.1412	0.1796	Class 2
Ethiopia	0.1617	0.1377	0.1654	Class 2
Georgia	0.1004	0.1084	0.1788	Class 1
Ghana	0.1942	0.1369	0.1159	Class 3
Greece	0.1247	0.1127	0.1765	Class 2
Guatemala	0.1758	0.1145	0.1396	Class 2
Honduras	0.2055	0.1335	0.1184	Class 3
Hungary	0.0995	0.1351	0.2341	Class 1
India	0.1593	0.1287	0.1664	Class 2
Indonesia	0.1774	0.1532	0.1781	Class 2
Iraq	0.3173	0.2643	0.2158	Class 3
Israel	0.1473	0.1502	0.2169	Class 1
Italy	0.1375	0.1421	0.2075	Class 1
Jamaica	0.1723	0.1190	0.1359	Class 2
Jordan	0.1678	0.1500	0.1815	Class 2
Kazakhstan	0.0997	0.0967	0.1733	Class 2
Kenya	0.1737	0.1027	0.1033	Class 2
Kosovo	0.2260	0.1936	0.1975	Class 2
Kyrgyz Republic	0.1415	0.1206	0.1578	Class 2
Lao PDR	0.1522	0.1453	0.1936	Class 2
Latvia	0.1034	0.1359	0.2236	Class 1
Lesotho	0.2011	0.1591	0.1555	Class 3
Liberia	0.2547	0.2090	0.1803	Class 3
Lithuania	0.0833	0.1142	0.2146	Class 1
Malaysia	0.1770	0.1457	0.1697	Class 2

(*continued*)

Table 6. Classification results

Country	Class 1 *Ui*	Class 2 *Ui*	Class 3 *Ui*	Final Assignment
Mali	0.3019	0.2289	0.1739	Class 3
Malta	0.1495	0.1651	0.2330	Class 1
Mauritania	0.2459	0.1913	0.1487	Class 3
Mexico	0.1721	0.1171	0.1227	Class 2
Moldova	0.1187	0.0911	0.1549	Class 2
Mongolia	0.1477	0.1420	0.1880	Class 2
Montenegro	0.1297	0.1197	0.1735	Class 2
Morocco	0.2326	0.1965	0.1929	Class 3
Mozambique	0.1629	0.1161	0.1446	Class 2
Myanmar	0.1613	0.1641	0.2121	Class 1
Namibia	0.1314	0.1243	0.1830	Class 2
Nicaragua	0.1406	0.0935	0.1434	Class 2
Nigeria	0.2207	0.1908	0.1953	Class 2
North Macedonia	0.1130	0.0992	0.1760	Class 2
Pakistan	0.2460	0.2201	0.2046	Class 3
Paraguay	0.1428	0.0951	0.1383	Class 2
Peru	0.1829	0.1267	0.1379	Class 2
Philippines	0.1273	0.1205	0.1765	Class 2
Poland	0.1284	0.1168	0.1826	Class 2
Portugal	0.1035	0.1110	0.2045	Class 1
Russia	0.1271	0.1163	0.1724	Class 2
Rwanda	0.1271	0.1289	0.1823	Class 1
Senegal	0.1590	0.1116	0.1355	Class 2
Serbia	0.1150	0.1155	0.1984	Class 1
Slovakia	0.0732	0.0990	0.2027	Class 1
Slovenia	0.1174	0.1369	0.2316	Class 1
South Africa	0.1654	0.1943	0.2572	Class 1
Sri Lanka	0.1662	0.1103	0.1390	Class 2
Suriname	0.1831	0.1361	0.1625	Class 2
Tanzania	0.2461	0.1869	0.1432	Class 3
Trinidad and Tobago	0.1612	0.1187	0.1667	Class 2
Turkey	0.1250	0.1164	0.1836	Class 2
Uganda	0.2171	0.1631	0.1562	Class 3
Ukraine	0.1694	0.1317	0.1536	Class 2
Uruguay	0.1655	0.1295	0.1627	Class 2
Uzbekistan	0.1087	0.1159	0.1847	Class 1
Venezuela	0.2025	0.1738	0.1866	Class 2
Vietnam	0.1261	0.1126	0.1790	Class 2
West Bank and Gaza	0.1802	0.1512	0.1776	Class 2
Yemen	0.3199	0.2748	0.2447	Class 3
Zambia	0.1786	0.1309	0.1405	Class 2
Zimbabwe	0.1716	0.1183	0.1296	Class 2
Number of members	21	56	18	

Table 6.

the findings, 21 countries are in Class 1 (investable), 56 countries are in Class 2 (moderate investable), and 18 countries are in Class 3 (risky). Therefore, the vast majority of countries fall into Class 2. The classification of the countries is given in Figure 2 schematically.

4.1 Sensitivity analysis

For the sensitivity analysis of the results, another sorting method, TOPSIS-Sort-C, and a change in the number of classes were applied. Table 7 shows the results of two- and four-class

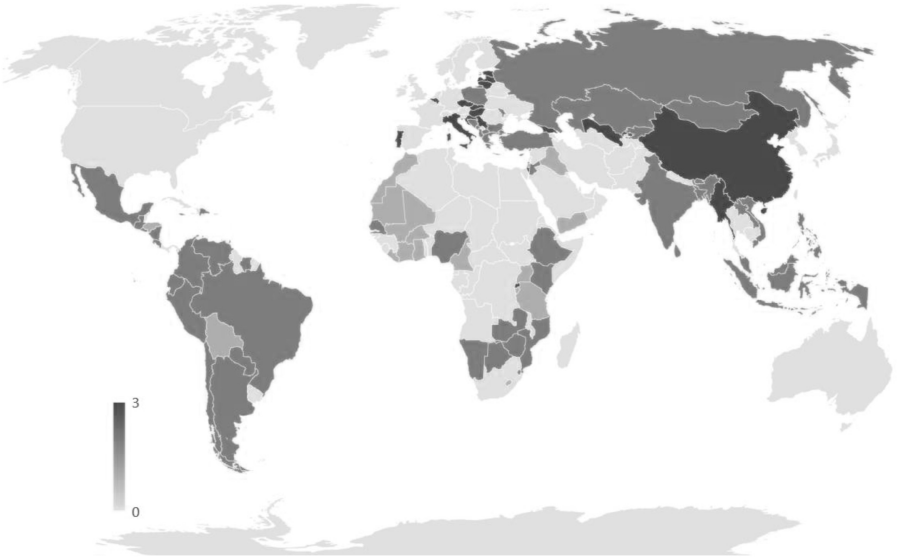

Figure 2.
Classification of the countries concerning their relative performance scores

evaluations. The four-class classification utilized the twentieth, fortieth, sixtieth, and eightieth percentiles as class reference values.

The sensitivity analysis results in Table 7 show that the countries are classified by the change in the number of classes and not in contrast with the previous results.

5. Conclusions

The new global trade dynamics have forced the global supply chain to design and manage more sustainable supply chain systems. According to Chopra (2018), the supply chain surplus corresponding to the services and products presented to customers is a single income source of supply chains. Hence, the global supply chains must enlarge within the economy of scale to survive in the increasingly challenging competitive business environment. However, some countries may not have sufficient infrastructure, and potential partners and stakeholders with sufficient abilities and performance may not be available in these countries. Thus, the global supply chains may not succeed in all global markets entered by them, and previous experiences show that the global supply chains withdraw from some global markets by incurring high amount costs. Walmart's German experience and Procter and Gamble's failure in the Indonesian retail market are the most known examples. Therefore, identifying the countries invested in the enlargement process is a decision-making problem, and decision-makers should make more realistic and sensitive evaluations for selecting investable countries. However, according to the authors' information, there is no applicable, robust, and effective decision-making tool that can be used to evaluate the countries that supply chains can invest in.

The current paper aims to propose a robust, powerful, and applicable MCDM framework to evaluate the countries in which the global supply chains will invest to fill the gaps existing in the literature. After the proposed MCDM framework was applied, countries were classified into three groups: investable, moderate investable, and risky, according to the obtained results. According to the results, 56 of 95 countries are moderately investable. Further, 21 countries have an investable position with 22%. However, 18 countries are risky for

Economy	REF-Sort 2-Class	REF-Sort 3-Class	REF-Sort 4-Class	TOPSIS-Sort-C 2-Class	TOPSIS-Sort-C 3-Class	TOPSIS-Sort-C 4-Class
Albania	Class 2	Class 2	Class 3	Class 2	Class 2	Class 2
Argentina	Class 2	Class 2	Class 3	Class 2	Class 3	Class 2
Armenia	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Bangladesh	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Belarus	Class 1	Class 1	Class 2	Class 2	Class 2	Class 2
Belgium	Class 1	Class 1	Class 1	Class 2	Class 2	Class 2
Bhutan	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Bolivia	Class 2	Class 3	Class 3	Class 2	Class 3	Class 4
Bosnia and Herzegovina	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Botswana	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Brazil	Class 2	Class 2	Class 3	Class 2	Class 3	Class 4
Bulgaria	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Burkina Faso	Class 2	Class 3	Class 4	Class 2	Class 3	Class 4
Burundi	Class 2	Class 3	Class 3	Class 2	Class 3	Class 2
Cameroon	Class 2	Class 3	Class 4	Class 2	Class 3	Class 4
Chile	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
China	Class 1	Class 1	Class 2	Class 2	Class 2	Class 1
Colombia	Class 2	Class 2	Class 3	Class 2	Class 3	Class 2
Congo. Dem. Rep.	Class 2	Class 3	Class 4	Class 2	Class 3	Class 4
Costa Rica	Class 2	Class 2	Class 3	Class 2	Class 2	Class 2
Côte d'Ivoire	Class 2	Class 3	Class 4	Class 2	Class 3	Class 4
Croatia	Class 1	Class 1	Class 1	Class 1	Class 1	Class 1
Cyprus	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Czech Republic	Class 1	Class 1	Class 2	Class 2	Class 2	Class 2
Dominican Republic	Class 2	Class 2	Class 3	Class 2	Class 3	Class 2
Ecuador	Class 2	Class 2	Class 3	Class 2	Class 2	Class 2
El Salvador	Class 2	Class 2	Class 3	Class 2	Class 3	Class 2
Estonia	Class 1	Class 1	Class 1	Class 1	Class 1	Class 1
Eswatini (Swati)	Class 2	Class 2	Class 2	Class 2	Class 3	Class 2
Ethiopia	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Georgia	Class 1	Class 1	Class 2	Class 2	Class 2	Class 2
Ghana	Class 2	Class 3	Class 3	Class 2	Class 3	Class 2
Greece	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Guatemala	Class 2	Class 2	Class 3	Class 2	Class 3	Class 4
Honduras	Class 2	Class 3	Class 3	Class 2	Class 3	Class 4
Hungary	Class 1	Class 1	Class 1	Class 1	Class 1	Class 1
India	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Indonesia	Class 2	Class 2	Class 3	Class 2	Class 2	Class 2
Iraq	Class 2	Class 3	Class 4	Class 2	Class 3	Class 4
Israel	Class 1	Class 1	Class 2	Class 2	Class 2	Class 2
Italy	Class 1	Class 1	Class 2	Class 2	Class 2	Class 2
Jamaica	Class 2	Class 2	Class 3	Class 2	Class 3	Class 2
Jordan	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Kazakhstan	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Kenya	Class 2	Class 2	Class 3	Class 2	Class 3	Class 2
Kosovo	Class 2	Class 2	Class 3	Class 2	Class 3	Class 2
Kyrgyz Republic	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Lao PDR	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Latvia	Class 1	Class 1	Class 1	Class 2	Class 2	Class 1
Lesotho	Class 2	Class 3	Class 3	Class 2	Class 3	Class 4
Liberia	Class 2	Class 3	Class 4	Class 2	Class 3	Class 4
Lithuania	Class 1	Class 1	Class 1	Class 1	Class 1	Class 1
Malaysia	Class 2	Class 2	Class 3	Class 2	Class 2	Class 2

Table 7.
Classification results

(*continued*)

Economy	REF-Sort 2-Class	REF-Sort 3-Class	REF-Sort 4-Class	TOPSIS-Sort-C 2-Class	TOPSIS-Sort-C 3-Class	TOPSIS-Sort-C 4-Class
Mali	Class 2	Class 3	Class 4	Class 2	Class 3	Class 4
Malta	Class 1	Class 1	Class 1	Class 2	Class 2	Class 2
Mauritania	Class 2	Class 3	Class 4	Class 2	Class 3	Class 4
Mexico	Class 2	Class 2	Class 3	Class 2	Class 3	Class 2
Moldova	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Mongolia	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Montenegro	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Morocco	Class 2	Class 3	Class 3	Class 2	Class 3	Class 4
Mozambique	Class 2	Class 2	Class 3	Class 2	Class 2	Class 2
Myanmar	Class 1	Class 1	Class 2	Class 2	Class 2	Class 2
Namibia	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Nicaragua	Class 2	Class 2	Class 3	Class 2	Class 2	Class 2
Nigeria	Class 2	Class 2	Class 3	Class 2	Class 3	Class 2
North Macedonia	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Pakistan	Class 2	Class 3	Class 4	Class 2	Class 3	Class 2
Paraguay	Class 2	Class 2	Class 3	Class 2	Class 2	Class 2
Peru	Class 2	Class 2	Class 3	Class 2	Class 3	Class 2
Philippines	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Poland	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Portugal	Class 1	Class 1	Class 2	Class 2	Class 2	Class 2
Russia	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Rwanda	Class 1	Class 1	Class 2	Class 2	Class 2	Class 2
Senegal	Class 2	Class 2	Class 3	Class 2	Class 3	Class 2
Serbia	Class 1	Class 1	Class 2	Class 2	Class 2	Class 2
Slovakia	Class 1	Class 1	Class 2	Class 1	Class 1	Class 1
Slovenia	Class 1	Class 1	Class 1	Class 1	Class 1	Class 1
South Africa	Class 1	Class 1	Class 1	Class 2	Class 2	Class 2
Sri Lanka	Class 2	Class 2	Class 3	Class 2	Class 2	Class 2
Suriname	Class 2	Class 2	Class 3	Class 2	Class 3	Class 2
Tanzania	Class 2	Class 3	Class 4	Class 2	Class 3	Class 4
Trinidad and Tobago	Class 2	Class 2	Class 3	Class 2	Class 3	Class 2
Turkey	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
Uganda	Class 2	Class 3	Class 3	Class 2	Class 3	Class 4
Ukraine	Class 2	Class 2	Class 3	Class 2	Class 2	Class 2
Uruguay	Class 2	Class 2	Class 3	Class 2	Class 3	Class 2
Uzbekistan	Class 1	Class 1	Class 2	Class 2	Class 2	Class 2
Venezuela	Class 2	Class 2	Class 3	Class 2	Class 3	Class 2
Vietnam	Class 2	Class 2	Class 2	Class 2	Class 2	Class 2
West Bank and Gaza	Class 2	Class 2	Class 3	Class 2	Class 2	Class 2
Yemen	Class 2	Class 3	Class 4	Class 2	Class 3	Class 4
Zambia	Class 2	Class 2	Class 3	Class 2	Class 3	Class 2
Zimbabwe	Class 2	Class 2	Class 3	Class 2	Class 3	Class 2

Table 7.

investment in this context. Within this scope, the obtained results may allow decision-makers in the global supply chains to effectively identify the countries that the global supply chains can invest in. Additionally, the proposed model has a practical and applicable basic algorithm that decision-makers can easily implement without advanced mathematical knowledge.

The suggested MCDM approach has valuable theoretical contributions to the existing literature. These theoretical contributions are summarized as follows. Classification methods mostly use boundary or center profiles. Boundary profiles represent the threshold values between classes, and center profiles represent the general/central feature of the relevant class. The relevant alternative is assigned to the class where the overall evaluation score falls if a

boundary profile is used. The relevant alternative is assigned to the class with the closest overall evaluation score if the centre profile is used. However, in REF-Sort, the value or value range that best represents each class is determined, and the alternatives are assigned according to their proximity to the references of the classes. Also, values or ranges of values representing class membership at the secondary level can be determined apart from class references. However, there is no rank reversal problem in the normalization process used in REF-Sort due to reference values determined based on the first decision matrix or independent from the decision matrix. Besides, REF-Sort can provide solutions for decision matrices with zero and negative values. Another essential advantage of REF-Sort is its understandable and easily applicable structure. The application and sensitivity analysis results show that REF-Sort can be successfully applied in many areas.

As a result, the proposed model is a maximally consistent and stable approach. Sensitivity analysis performed to test the robustness and validity of the model approves that. The obtained results show that there is no change in the classification of the countries concerning the formed scenarios. The sensitivity analysis results approve the proposed model's validity, stability, and reliability.

In this study, REF-Sort was used to investigate the investability classification of countries in terms of the supply chain. The following issues can be researched in the future. Other global supply chain problems can be solved by employing REF-Sort. REF-Sort can be used for various application areas and classification-based comparison analyses. It is possible to use REF-Sort in a group decision-making environment considering personalized individual semantics-based consensus and consistency (Zhang and Li, 2021; Gao and Zhang, 2021), preference information types and differences (Kabak and Ervural, 2017), and integrated decision models including different MCDM methods such as WA (Weighted Averaging), WGA (Weighted Geometric Averaging), OWA (Ordered Weighted Averaging), TOPSIS, PROMETHEE, ELECTRE, and VIKOR (Liu *et al.*, 2021a, b). Also, REF-Sort can be investigated considering the strategic weight manipulation problems (Liu *et al.*, 2022).

References

Adegboye, A.C. and Iweriebor, S. (2018), "Does access to finance enhance SME innovation and productivity in Nigeria evidence from the World Bank Enterprise Survey", *African Development Review*, Vol. 30 No. 4, pp. 449-461.

Aga, G. and Francis, D. (2015), "As the market churns: estimates of firm exit and job loss using the World Bank's Enterprise Surveys", Policy Research Working Paper, 7218, World Bank Group, Washington, DC.

Alam, M.S., Selvanathan, E., Selvanathan, S. and Hossain, M. (2019), "The apparel industry in the post-multifiber arrangement environment: a review", *Review of Development Economics*, Vol. 23 No. 1, pp. 454-474, doi: 10.1111/rode.12556.

Ali, Y., Ahmad, M., Sabir, M. and Shah, S.A. (2021), "Regional development through energy infrastructure: a comparison and optimization of Iran-Pakistan-India (IPI) & Turkmenistan-Afghanistan-Pakistan-India (TAPI) gas pipelines", *Operational Research in Engineering Sciences: Theory and Applications*, Vol. 4 No. 3, pp. 82-106, doi: 10.31181/oresta091221082a.

Almeida-Dias, J., Figueira, J.R. and Roy, B. (2010), "Electre Tri-C: a multiple criteria sorting method based on characteristic reference actions", *European Journal of Operational Research*, Vol. 204 No. 3, pp. 565-580, doi: 10.1016/j.ejor.2009.10.018.

Alosta, A., Elmansuri, O. and Badi, I. (2021), "Resolving a location selection problem by means of an integrated AHP-RAFSI approach", *Reports in Mechanical Engineering*, Vol. 2 No. 1, pp. 135-142, doi: 10.31181/rme200102135a.

Anderson, D.R. and Anderson, K.E. (2009), "Sustainability risk management", *Risk Management and Insurance Review*, Vol. 12 No. 1, pp. 25-38, doi: 10.1111/j.1540-6296.2009.01152.x.

Araz, C. and Ozkarahan, I. (2007), "Supplier evaluation and management system for strategic sourcing based on a new multi-criteria sorting procedure", *International Journal of Production Economics*, Vol. 106 No. 2, pp. 585-606, doi: 10.1016/j.ijpe.2006.08.008.

Aytekin, A. (2020a), "Çok kriterli karar problemine uzaklık ve referans temelli çözüm yaklaşımı", Doctoral Dissertation, Anadolu University, Eskişehir, doi: 10.6084/m9.figshare.20007134.v1.

Aytekin, A. (2020b), "Türkiye'de önde gelen şirketlerin etkinlik, farklılık ve performans ölçümü", *Anadolu Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, Vol. 21 No. 4, pp. 19-35, doi: 10.6084/m9.figshare.16652089.v1.

Aytekin, A. (2020c), "CODAS-Sort ve çok boyutlu ölçekleme analizi ile illerin girişimcilik sınıflandırması", *Paper Presented at 18 Uluslararası Türk Dünyası Sosyal Bilimler Kongresi*, 12-14 December, Sakarya University, Sakarya, pp. 411-421, doi: 10.6084/m9.figshare.16652053.v1.

Aytekin, A. (2021), "Efficiency and performance analyses of food companies via IDOCRIW, REF-II, and OCRA methods", *Business Studies and New Approaches*, Livre de Lyon, Lyon, pp. 7-24, doi: 10.6084/m9.figshare.16669432.v1.

Aytekin, A. and Durucasu, H. (2021), "Nearest solution to references method for multi-criteria decision-making problems", *Decision Science Letters*, Vol. 10 No. 2, pp. 111-128, doi: 10.5267/j.dsl.2020.11.007.

Bassey, K. (2014), "The use of sample surveys to support monetary and financial stability analysis: an overview of the central bank of Nigeria", Working Paper, IFC Bulletin, No. 39, pp. 1-13.

Baydaş, M. and Elma, O.E. (2021), "An objectıve criteria proposal for the comparison of MCDM and weighting methods in financial performance measurement: an application in Borsa Istanbul", *Decision Making: Applications in Management and Engineering*, Vol. 4 No. 2, pp. 257-279, doi: 10.31181/dmame210402257b.

Bazaluk, O., Yatsenko, O., Zakharchuk, O., Ovcharenko, A., Khrystenko, O. and Nitsenko, V. (2020), "Dynamic development of the global organic food market and opportunities for Ukraine", *Sustainability*, Vol. 12 No. 17, 6963, doi: 10.3390/su12176963.

Bennell, P. (2021), "The skills balancing act: a review of the 2019 World Bank report on skills development in Sub-Saharan Africa", *Compare: A Journal of Comparative and International Education*, Vol. ahead-of-print, doi: 10.1080/03057925.2021.1956878.

Berning, S.C. and Holtbrügge, D. (2012), "Chinese outward foreign direct investment—a challenge for traditional internationalization theories?", *Journal für Betriebswirtschaft*, Vol. 62, pp. 169-224, doi: 10.1007/s11301-012-0086-5.

Bozanic, D., Milic, A., Tešic, D., Salabun, W. and Pamucar, D. (2021), "D numbers – FUCOM – fuzzy RAFSI model for selecting the group of construction machines for enabling mobility", *Facta Universitatis, Series: Mechanical Engineering*, Vol. 19 No. 3, pp. 447-471, doi: 10.22190/FUME210318047B.

Brans, J.-P. and De Smet, Y. (2016), "PROMETHEE methods", in Greco, S., Ehrgott, M. and Figueira, J. (Eds), *Multiple Criteria Decision Analysis. International Series in Operations Research & Management Science*, Vol. 233, Springer, New York, NY, doi: 10.1007/978-1-4939-3094-4_6.

Bruszt, L. and Campos, N. (2016), *Deep Economic Integration and State Capacity: The Case of the Eastern Enlargement of the European Union*, Central European University, Mimeo.

Chopra, S. (2018), "The evolution of omni-channel retailing and its impact on supply chains", *Transportation Research Procedia*, Vol. 30, pp. 4-13, doi: 10.1016/j.trpro.2018.09.002.

Christopherson, S. (2007), "Barriers to 'US style' lean retailing: the case of Wal-Mart's failure in Germany", *Journal of Economic Geography*, Vol. 7 No. 4, pp. 451-469, doi: 10.1093/jeg/lbm010.

Colson, G. and De Bruyn, C. (1989), *Models and Methods in Multiple Criteria Decision Making*, Pergamon Press, Exeter, GB.

Corsatea, T.D. (2014), "Technological capabilities for innovation activities across Europe: evidence from wind, solar and bioenergy technologies", *Renewable and Sustainable Energy Reviews*, Vol. 37, pp. 469-479, doi: 10.1016/j.rser.2014.04.067.

Cousins, P.D., Lamming, R.C. and Bowen, F. (2004), "The role of risk in environment-related supplier initiatives", *International Journal of Operations and Production Management*, Vol. 24 No. 6, pp. 554-565, doi: 10.1108/01443570410538104.

Das, K. (2021), "Explained: how much did Suez Canal blockage cost world trade", *India Today*, 30 March, available at: https://www.indiatoday.in/business/story/explained-how-much-did-suez-canal-blockage-cost-world-trade-1785062-2021-03-30 (accessed 4 October 2021).

de Lima Silva, D.F. and de Almedia Filho, A.T. (2020), "Sorting with TOPSIS through boundary and characteristic profiles", *Computers and Industrial Engineering*, Vol. 141, 106328, doi: 10.1016/j.cie.2020.106328.

Demir, L., Akpınar, M.E., Araz, C. and Ilgın, M.A. (2018), "A green supplier evaluation system based on a new multi-criteria sorting method: VIKORSORT", *Expert Systems with Applications*, Vol. 114, pp. 479-487, doi: 10.1016/j.eswa.2018.07.071.

Dethier, J.-J., Hirn, M. and Straub, S. (2008), "Explaining enterprise performance in developing countries with business climate survey data", Working Paper, World Bank Policy Research Working Paper No. 4792.

Duranton, G., Ghani, E., Goswami, A.G., KerrGhani, W.R.S.E. and Kerr, W.R. (2016), "A detailed anatomy of factor misallocation in India", Working Paper, World Bank Policy Research Working Paper No. 7547.

Ecer, F. (2020), "Multi-criteria decision making for green supplier selection using interval type-2 fuzzy AHP: a case study of a home appliance manufacturer", *Operational Research*, Vol. 22, pp. 199-233, doi: 10.1007/s12351-020-00552-y.

Ecer, F. (2021), "Sustainable supplier selection: FUCOM subjective weighting method based MAIRCA approach", *Mehmet Akif Ersoy University Journal of Economics and Administrative Sciences Faculty*, Vol. 8 No. 1, pp. 26-47.

Ecer, F. and Pamucar, D. (2020), "Sustainable supplier selection: a novel integrated fuzzy best worst method (F-BWM) and fuzzy CoCoSo with Bonferroni (CoCoSo'B) multi-criteria model", *Journal of Cleaner Production*, Vol. 266, 121981, doi: 10.1016/j.jclepro.2020.121981.

Eifert, B., Gelb, A.H. and Ramachandran, V. (2008), "The cost of doing business in Africa: evidence from enterprise survey data", *World Development*, Vol. 36 No. 9, pp. 1531-1546, doi: 10.1016/j.worlddev.2007.09.007.

Esho, E. and Verhoef, G. (2018), "The funding gap and the financing of Small and medium businesses: an integrated literature review and an agenda", Working Paper, MPRA Paper No. 90153, University of Johannesburg.

Figueira, J., de Smet, I. and Brans, J.P. (2004), "MCDA methods for sorting and clustering problems: PROMETHEE TRI and PROMETHEE CLUSTER", Université Libre de Bruxelles, Service de Mathématiques de La Gestion.

Foerstl, K., Reuter, C., Hartmann, E. and Blome, C. (2010), "Managing supplier sustainability risks in a dynamically changing environment—sustainable supplier management in the chemical industry", *Journal of Purchasing and Supply Management*, Vol. 16 No. 2, pp. 118-130, doi: 10.1016/j.pursup.2010.03.011.

Friesen, J. and Wacker, K. (2013), Do financially constrained firms suffer from more intense competition by the informal sector? Firm-level evidence from the World Bank Enterprise Surveys, Discussion Papers, No. 139, Georg-August-Universität Göttingen, Courant Research Centre - Poverty, Equity and Growth (CRC-PEG), Göttingen.

Gao, Y. and Zhang, Z. (2021), "Consensus reaching with non-cooperative behavior management for personalized individual semantics-based social network group decision making", *Journal of the Operational Research Society*, Vol. ahead-of-print, pp. 1-18, doi: 10.1080/01605682.2021.1997654.

Gelb, A., Meyer, C. and Ramachandran, V. (2013), "Does poor mean cheap? A comparative look at Africa's industrial labor costs", Working Paper, CGD Working Paper 325, Center for Global Development, Washington, DC.

Gelb, A., Ramachandran, V., Meyer, C.J., Wadhwa, D. and Navis, K. (2020), "Can Sub-Saharan Africa be a manufacturing destination? Labor costs, price levels, and the role of industrial policy", *Journal of Industry, Competition and Trade*, Vol. 20 No. 2, pp. 335-357, doi: 10.1007/s10842-019-00331-2.

Giannakis, M. and Papadopoulos, T. (2016), "Supply chain sustainability: a risk management approach", *International Journal of Production Economics*, Vol. 171, pp. 455-470, doi: 10.1016/j.ijpe.2015.06.032.

Gurnani, H., Ray, S. and Wang, Y. (2011), "Special issue of production and operations management: global supply chain risk management", *Production and Operations Management*, Vol. 5 No. 20, p. 786, doi: 10.1111/j.1937-5956.2011.01283.x.

Hall, B. and Reenen, J.V. (2000), "How effective are fiscal incentives for R&D? A review of the evidence", *Research Policy*, Vol. 29 Nos 4-5, pp. 449-469, doi: 10.1016/S0048-7333(99)00085-2.

Hamza, S. and Nizam, I. (2016), "Why Walmart fails in Germany? An analysis in the perspective of organizational behaviour", *International Journal of Accounting and Business Management*, Vol. 4 No. 2, pp. 206-215.

Hashemkhani Zolfani, S., Ebadi Torkayesh, A., Ecer, F., Turskis, Z. and Šaparauskas, J. (2021), "International market selection: a MABA based EDAS analysis framework", *Oeconomia Copernicana*, Vol. 12 No. 1, pp. 99-124.

Hoftsede, G., Hofstede, G.J. and Minkov, M. (2010), *Cultures and Organizations: Software of the Mind: Intercultural Cooperation and its Importance for Survival*, 3rd ed., McGraw-Hill, New York.

Ishizaka, A. and Gordon, M. (2017), "MACBETHSort: a multiple criteria decision aid procedure for sorting strategic products", *Journal of the Operational Research Society*, Vol. 68 No. 1, pp. 53-61, doi: 10.1057/s41274-016-0002-9.

Ishizaka, A. and Nemery, P. (2013), *Multi-Criteria Decision Analysis: Methods and Software*, John Wiley & Sons.

Ishizaka, A. and Pereira, V. (2020), "Utilization of ANPSort for sorting alternative with interdependent criteria illustrated through a researcher's classification problem in an academic context", *Soft Computing*, Vol. 24 No. 18, pp. 13639-13650, doi: 10.1007/s00500-019-04405-5.

Ishizaka, A., Pearman, C. and Nemery, P. (2012), "AHPSort: an AHP-based method for sorting problems", *International Journal of Production Research*, Vol. 50 No. 17, pp. 4767-4784, doi: 10.1080/00207543.2012.657966.

Kabak, Ö. and Ervural, B. (2017), "Multiple attribute group decision making: a generic conceptual framework and a classification scheme", *Knowledge-Based Systems*, Vol. 123, pp. 13-30, doi: 10.1016/j.knosys.2017.02.011.

Karamaşa, Ç., Ergün, M., Gülcan, B., Korucuk, S., Memiş, S. and Vojinović, D. (2021), "Rankıng value-creatıng green approach practıces ın logıstıcs companıes operatıng ın the TR A1 regıon and choosıng ıdeal green marketıng strategy", *Operational Research in Engineering Sciences: Theory and Applications*, Vol. 4 No. 3, pp. 21-38, doi: 10.31181/oresta20402021k.

Keshavarz Ghorabaee, M., Zavadskas, E.K., Turskis, Z. and Antucheviciene, J. (2016), "A new combinative distance-based assessment (CODAS) method for multi-criteria decision-making", *Economic Computation and Economic Cybernetics Studies and Research*, Vol. 50 No. 3, pp. 25-44.

Liu, Y., Sun, Z., Liang, H. and Dong, Y. (2021a), "Ranking range model in multiple attribute decision making: a comparison of selected methods", *Computers and Industrial Engineering*, Vol. 155, 107180, doi: 10.1016/j.cie.2021.107180.

Liu, Y., Tang, H., Liang, H., Zhang, H., Li, C.C. and Dong, Y. (2021b), "Ranking range models under incomplete attribute weight information in the selected six MADM methods", *Expert Systems*, Vol. 38 No. 5, e12696, doi: 10.1111/exsy.12696.

Liu, Y., Li, Y., Zhang, Z., Xu, Y. and Dong, Y. (2022), "Classification-based strategic weight manipulation in multiple attribute decision making", *Expert Systems with Applications*, Vol. 197, 116781, doi: 10.1016/j.eswa.2022.116781.

Mensah, E., Owusu, S., Foster-McGregor, N. and Szirmai, A. (2018), "Structural change, productivity growth and labour market turbulence in Africa", Working Paper (UNU-MERIT Working Paper No. 2018-025), UNU-MERIT, Maastricht.

Muhammad, L.J., Badi, I., Haruna, A.A. and Mohammed, I.A. (2021), "Selecting the best municipal solid waste management techniques in Nigeria using multi criteria decision making techniques", *Reports in Mechanical Engineering*, Vol. 2 No. 1, pp. 180-189, doi: 10.31181/rme2001021801b.

Narasimhan, R. and Talluri, S. (2009), "Perspectives on risk management in supply chains", *Journal of Operations Management*, Vol. 27 No. 2, pp. 114-118, doi: 10.1016/j.jom.2009.02.001.

Nemery, P. and Lamboray, C. (2007), *FlowSort: Limiting or Central Profiles*, ORP3 MEETING, Guimares.

Nemery, P. and Lamboray, C. (2008), "FlowSort: a flow-based sorting method with limiting or central profiles", *Top*, Vol. 16 No. 1, pp. 90-113, doi: 10.1007/s11750-007-0036-x.

Nguimkeu, P. and Okou, C. (2021), "Leveraging digital technologies to boost productivity in the informal sector in Sub-Saharan Africa", *Review of Policy Research*, Vol. 38 No. 6, pp. 707-731, doi: 10.1111/ropr.12441.

Odusanya, I. and Atanda, A. (2018), "Income-health nexus in Sub-Saharan Africa: evidence from heterogeneous panel models", *The European Journal of Applied Economics*, Vol. 15 No. 1, pp. 94-109, doi: 10.5937/EJAE15-16293.

Okano, M. (2019), "Social Enterprise in the current context: a systematic review of the last 10 years", *Risus-Journal on Innovation and Sustainability*, Vol. 10, pp. 109-122, doi: 10.23925/2179-3565.2019v10i2p109-122.

Olken, B. and Pande, R. (2012), "Corruption in developing countries", *Annual Review of Economics*, Vol. 4, pp. 479-505, doi: 10.1146/annurev-economics-080511-110917.

Opricovic, S. (1998), "Multicriteria optimization of civil engineering systems", Doctoral Dissertation, Faculty of Civil Engineering, Belgrade.

Ouhibi, A. and Frikha, H. (2019), "CODAS-SORT: a new CODAS based method for sorting problems", *Paper Presented at 6th International Conference on Control*, Decision and Information Technologies (CoDIT), pp. 855-860, doi: 10.1109/CoDIT.2019.8820682.

Pamucar, D. and Ecer, F. (2020), "Prioritizing the weights of the evaluation criteria under fuzziness: the fuzzy full consistency method – FUCOM-F", *Facta Universitatis, Series: Mechanical Engineering*, Vol. 18 No. 3, pp. 419-437, doi: 10.22190/FUME200602034P.

Raggl, A.K. (2015), "Determinants of total factor productivity in the Middle East and North Africa", *Review of Middle East Economics and Finance*, Vol. 11 No. 2, pp. 119-143, doi: 10.1515/rmeef-2014-0017.

Rahmati, M.H. and Pilehvari, A. (2019), "The productivity trend in Iran evidence from manufacturing firms", *Economics of Transition and Institutional Change*, Vol. 27 No. 2, pp. 395-408, doi: 10.1111/ecot.12200.

Ramachandran, V. (2021), "Convergence, development, and energy-intensive infrastructure in Africa: a review of the evidence", *Sustainability*, Vol. 13, 10572, doi: 10.3390/su131910572.

Ramos, K.G., Rocha, I.C.N., Cedeño, T.D.D., dos Santos Costa, A.C., Ahmad, S., Essar, M.Y. and Tsagkaris, C. (2021), "Suez Canal blockage and its global impact on healthcare amidst the COVID-19 pandemic", *International Maritime Health*, Vol. 72 No. 2, pp. 145-146, doi: 10.5603/imh.2021.0026.

Rao, S. and Goldsby, T.J. (2009), "Supply chain risks: a review and typology", *The International Journal of Logistics Management*, Vol. 20 No. 1, pp. 97-123, doi: 10.1108/09574090910954864.

Reuters (2021), "Suez Canal ends shipping backlog: statement", 3 April, available at: https://www.reuters.com/article/idUSKBN2BQ0BW (accessed 4 October 2021).

Rodrik, D. (2005), "Growth strategies", in Philippe, A. and Durlauf, S. (Eds), *Handbook of Economic Growth*, North-Holland, Amsterdam, doi: 10.1016/S1574-0684(05)01014-2.

Sabokbar, H.F., Hosseini, A., Banaitis, A. and Banaitiene, N. (2016), "A novel sorting method TOPSIS-SORT: an application for Tehran environmental quality evaluation", *Ekonomika a Management*, Vol. 2 No. 9, doi: 10.15240/tul/001/2016-2-006.

Samargandi, N. (2018), "Determinants of labor productivity in MENA countries", *Emerging Markets Finance and Trade*, Vol. 54 No. 5, pp. 1063-1081, doi: 10.1080/1540496X.2017.1418658.

Sodhi, M.M.S., Son, B.G. and Tang, C.S. (2012), "Researchers' perspectives on supply chain risk management", *Production and Operation Management*, Vol. 21 No. 1, pp. 1-13, doi: 10.1111/j.1937-5956.2011.01251.x.

Stojanović, I. and Puška, A. (2021), "Logistics performances of Gulf Cooperation Council's countries in global supply chains", *Decision Making: Applications in Management and Engineering*, Vol. 4 No. 1, pp. 174-193, doi: 10.31181/dmame2104174s.

Sun, Z., Tukker, A. and Behrens, P. (2019), "Going global to local: connecting top-down accounting and local impacts, a methodological review of spatially explicit input−output approaches", *Environmental Science and Technology*, Vol. 53, pp. 1048-1062, doi: 10.1021/acs.est.8b03148.

Teuscher, P., Grüninger, B. and Ferdinand, N. (2006), "Risk management in sustainable supply chain management (SSCM): lessons learnt from the case of GMO-free soybeans", *Corporate Social Responsibility and Environmental Management*, Vol. 13 No. 1, pp. 1-10, doi: 10.1002/csr.81.

Tuttle, R. (2021), "Why a canal built in 1869 is more important than ever", 26 March, available at: https://www.bloomberg.com/news/articles/2021-03-26/what-is-the-suez-canal-and-why-is-it-so-important-quicktake (accessed 4 October 2021).

Wang, Y. (2016), "What are the biggest obstacles to growth of SMEs in developing countries? An empirical evidence from an enterprise survey", *Borsa Istanbul Review*, Vol. 16 No. 3, pp. 167-176, doi: 10.1016/j.bir.2016.06.001.

Wang, Z. and Sarkis, J. (2013), "Investigating the relationship of sustainable supply chain management with corporate financial performance", *International Journal of Productivity and Performance Management*, Vol. 62 No. 8, pp. 871-888, doi: 10.1108/IJPPM-03-2013-0033.

Williams, C.C. and Kedir, A.M. (2019), "Explaining cross-country variations in the prevalence of informal sector competitors: lessons from the World Bank Enterprise Survey", *International Entrepreneurship and Management Journal*, Vol. 15, pp. 677-696, doi: 10.1007/s11365-018-0527-2.

World Bank (2021), "Enterprise surveys data", available at: https://www.enterprisesurveys.org/en/data (accessed 4 October 2021).

Wysmułek, I. (2019), "Using public opinion surveys to evaluate corruption in Europe: trends in the corruption items of 21 international survey projects, 1989–2017", *Quality and Quantity*, Vol. 53 No. 5, pp. 2589-2610, doi: 10.1007/s11135-019-00873-x.

Xu, X., Chen, X., Jia, F., Brown, S., Gong, Y. and Xu, Y. (2018), "Supply Chain finance: a systematic literature review and bibliometric analysis", *International Journal of Production Economics*, Vol. 204, pp. 160-173, doi: 10.1016/j.ijpe.2018.08.003.

Yu, W. (1992), "Aide multicritère à la décision dans le cadre de la problématique du tri: concepts, méthodes et applications", Doctoral dissertation, Université Paris Dauphine, Paris.

Zakeri, S., Ecer, F., Konstantas, D. and Cheikhrouhou, N. (2021), "The vital-immaterial-mediocre multi-criteria decision-making method", *Kybernetes*, Vol. ahead-of-print, doi: 10.1108/K-05-2021-0403.

Zanello, G., FuMohnen, X.P. and Ventresca, M. (2016), "The creation and diffusion of innovation in developing countries", *A Systematic Literature Review"*, Vol. 30 No. 5, pp. 884-912, doi: 10.1111/joes.12126.

Zhang, Z. and Li, Z. (2021), "Personalized individual semantics-based consistency control and consensus reaching in linguistic group decision making", *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, doi: 10.1109/TSMC.2021.3129510.

Zopounidis, C. and Doumpos, M. (2002), "Multicriteria classification and sorting methods: a literature review", *European Journal of Operational Research*, Vol. 138 No. 2, pp. 229-246, doi: 10.1016/S0377-2217(01)00243-0.

Appendix

Table A1.
The lists of criteria, criteria weights and profile values of classes

Main criteria	Sub-criteria	Final notation	Class 1-reference	Class 2-reference	Class 3-reference
Biggest obstacles export	Percent of firms choosing access to finance as their biggest obstacle	C1	5.35	10.7	19.15
Biggest obstacles export	Percent of firms choosing access to land as their biggest obstacle	C2	0.7	1.5	3.85
Biggest obstacles export	Percent of firms choosing business licensing and permits as their biggest obstacle	C3	0.7	2.1	4.25
Biggest obstacles export	Percent of firms choosing corruption as their biggest obstacle	C4	2.15	4.7	8.35
Biggest obstacles export	Percent of firms choosing courts as their biggest obstacle	C5	0.1	0.6	1.25
Biggest obstacles export	Percent of firms choosing crime, theft and disorder as their biggest obstacle	C6	0.75	1.5	3.8
Biggest obstacles export	Percent of firms choosing customs and trade regulations as their biggest obstacle	C7	1.75	2.9	4.75
Biggest obstacles export	Percent of firms choosing electricity as their biggest obstacle	C8	2.25	5	12.35
Biggest obstacles export	Percent of firms choosing inadequately educated workforce as their biggest obstacle	C9	2.3	6.6	13
Biggest obstacles export	Percent of firms choosing labor regulations as their biggest obstacle	C10	1	2	3.9
Biggest obstacles export	Percent of firms choosing political instability as their biggest obstacle	C11	2	6.2	14.35
Biggest obstacles export	Percent of firms choosing practices of the informal sector as their biggest obstacle	C12	6.25	11.7	17.85
Biggest obstacles export	Percent of firms choosing tax administration as their biggest obstacle	C13	1.25	3.3	5.4
Biggest obstacles export	Percent of firms choosing tax rates as their biggest obstacle	C14	5.15	11.9	18.9
Biggest obstacles export	Percent of firms choosing transportation as their biggest obstacle	C15	1.15	2.9	4.85
Corruption	Bribery incidence (percent of firms experiencing at least one bribe payment request)	C16	4.5	10.5	23.3
Corruption	Bribery depth (% of public transactions where a gift or informal payment was requested)	C17	3.05	7.5	18.4
Corruption	Percent of firms expected to give gifts in meetings with tax officials	C18	2.15	8.3	16.75

(*continued*)

Main criteria	Sub-criteria	Final notation	Class 1-reference	Class 2-reference	Class 3-reference
Corruption	Percent of firms expected to give gifts to secure government contract	C19	5.05	16.8	33.35
Corruption	Value of gift expected to secure a government contract (% of contract value)	C20	0	0.3	1.65
Corruption	Percent of firms expected to give gifts to get an operating license	C21	2.35	8.9	17.7
Corruption	Percent of firms expected to give gifts to get an import license	C22	0.2	3.5	18.25
Corruption	Percent of firms expected to give gifts to get a construction permit	C23	3.65	14.1	30.7
Corruption	Percent of firms expected to give gifts to get an electrical connection	C24	2.55	6.6	19.65
Corruption	Percent of firms expected to give gifts to get a water connection	C25	0	4.1	17.25
Corruption	Percent of firms expected to give gifts to public officials "to get things done"	C26	5.9	12.5	24.55
Corruption	Percent of firms identifying corruption as a major constraint	C27	13.7	27.4	46.7
Corruption	Percent of firms identifying the courts system as a major constraint	C28	5.75	12.5	25.4
Crime	Percent of firms paying for security	C29	49.95	61.9	71.75
Crime	If the establishment pays for security, average security costs (% of annual sales)	C30	1.4	2.3	4.2
Crime	Percent of firms experiencing losses due to theft and vandalism	C31	8.7	14.5	21.05
Crime	If there were losses, average losses due to theft and vandalism (% of annual sales)	C32	1.75	3.5	6.8
Crime	Products shipped to supply domestic markets that were lost due to theft (% of product value)	C33	0.1	0.3	0.95
Crime	Percent of firms identifying crime, theft and disorder as a major constraint	C34	6.7	14.2	27.8
Finance	Percent of firms with a checking or savings account	C35	97.35	93.3	83.45
Finance	Percent of firms with a bank loan/line of credit	C36	22.4	34.8	45.8
Finance	Proportion of loans requiring collateral (%)	C37	64.5	79.2	88.6
Finance	Value of collateral needed for a loan (% of the loan amount)	C38	160.3	192.6	230.6
Finance	Percent of firms not needing a loan	C39	58.95	47.8	35.8
Finance	Percent of firms using banks to finance investments	C40	16.25	29.3	37.2
Finance	Proportion of investment financed internally (%)	C41	79.75	71.9	61.75

(*continued*)

Table A1.

Main criteria	Sub-criteria	Final notation	Class 1-reference	Class 2-reference	Class 3-reference
Finance	Proportion of investment financed by banks (%)	C42	8.8	14.3	20.6
Finance	Percent of firms using banks to finance working capital	C43	21.15	31.1	40.5
Finance	Percent of firms using supplier/customer credit to finance working capital	C44	15.1	24.7	36.45
Finance	Proportion of working capital financed by banks (%)	C45	6.8	10.9	15.1
Finance	Percent of firms identifying access to finance as a major constraint	C46	11	17.6	34.5
Firm characteristics	Age of the establishment (years)	C47	21.05	18.2	15.45
Firm characteristics	Proportion of private domestic ownership in a firm (%)	C48	87	91.6	95.9
Firm characteristics	Percent of firms with at least 10% of foreign ownership	C49	11.6	8.3	4.5
Firm characteristics	Percent of firms with at least 10% of government/state ownership	C50	0	0.2	0.8
Firm characteristics	Percent of firms with legal status of Sole Proprietorship	C51	11.95	36.8	58.95
Firm characteristics	Percent of firms with an internationally recognized quality certification	C52	21.15	11.6	7.25
Firm characteristics	Percent of firms with an annual financial statement reviewed by external auditors	C53	26.9	44.1	60.4
Gender	Percent of firms with female participation in ownership	C54	43.6	34.1	24.8
Gender	Percent of firms with a female top manager	C55	23.5	18.1	12.65
Gender	Proportion of permanent full-time workers that are female (%)	C56	40.3	34.1	28.1
Gender	Proportion of permanent full-time production workers that are female (%)	C57	36.45	27.2	19.2
Gender	Proportion of permanent full-time non-production workers that are female (%)	C58	49.8	41.5	31.45
Informality	Percent of firms competing against unregistered or informal firms	C59	34.45	50.1	68.75
Informality	Percent of firms formally registered when they started operations in the country	C60	96.05	91.4	83.5
Informality	Number of years firm operated without formal registration	C61	0.15	0.5	0.95
Informality	Percent of firms identifying practices of competitors in the informal sector as a major constraint	C62	16.8	28.4	38.8
Infrastructure	Percent of firms experiencing electrical outages	C63	30.35	52.2	77.45

Table A1. (*continued*)

Main criteria	Sub-criteria	Final notation	Class 1-reference	Class 2-reference	Class 3-reference
Infrastructure	Number of electrical outages in a typical month	C64	0.5	1.3	4.15
Infrastructure	If there were outages, average duration of a typical electrical outage (hours)	C65	2	3.2	5.3
Infrastructure	If there were outages, average losses due to electrical outages (% of annual sales)	C66	0.8	1.9	4.25
Infrastructure	Percent of firms owning or sharing a generator	C67	43.9	24.8	14.1
Infrastructure	If a generator is used, average proportion of electricity from a generator (%)	C68	3.6	10.2	23.4
Infrastructure	Days to obtain an electrical connection (upon application)	C69	17.45	24.3	47.05
Infrastructure	Percent of firms identifying electricity as a major constraint	C70	16.6	27.5	46.2
Infrastructure	Percent of firms experiencing water insufficiencies	C71	3.55	9.2	17.05
Infrastructure	Number of water insufficiencies in a typical month	C72	0.05	0.3	0.8
Infrastructure	Proportion of products lost to breakage or spoilage during shipping to domestic markets (%)	C73	0.3	1	1.6
Infrastructure	Percent of firms identifying transportation as a major constraint	C74	9.95	15.2	26.45
Performance	Capacity utilization (%)	C75	80.05	74.6	67.95
Performance	Real annual sales growth (%)	C76	4.8	2.3	−1.2
Performance	Annual employment growth (%)	C77	6.15	4.2	2.15
Performance	Real annual labor productivity growth (%)	C78	1.25	−1.5	−5.1
Performance	Percent of firms buying fixed assets	C79	48.4	40.6	30.6
Regulations and taxes	Senior management time spent dealing with the requirements of government regulation (%)	C80	3.15	7.5	11.25
Regulations and taxes	Percent of firms visited or required to meet with tax officials	C81	28.9	48.3	68.85
Regulations and taxes	If there were visits, average number of visits or required meetings with tax officials	C82	1.75	2.4	3.15
Regulations and taxes	Days to obtain a construction-related permit	C83	11.6	24.4	36.65
Regulations and taxes	Days to obtain an import license	C84	31.9	60.5	84.35
Regulations and taxes	Percent of firms identifying tax rates as a major constraint	C85	17.1	27.9	41
Regulations and taxes	Percent of firms identifying tax administration as a major constraint	C86	7.9	18.3	33.1

(*continued*)

Table A1.

Main criteria	Sub-criteria	Final notation	Class 1-reference	Class 2-reference	Class 3-reference
Regulations and taxes	Percent of firms identifying business licensing and permits as a major constraint	C87	6.7	11.5	23.15
Trade	Days to clear direct exports through customs	C88	3.95	6.9	10
Trade	Percent of firms exporting directly or indirectly (at least 10% of sales)	C89	20.55	13.9	8.75
Trade	Percent of firms exporting directly (at least 10% of sales)	C90	13.85	9.2	5.8
Trade	Proportion of total sales that are exported directly (%)	C91	6.85	4.1	2.3
Trade	Days to clear imports from customs	C92	4.85	10.1	18.3
Trade	Percent of firms using material inputs and/or supplies of foreign origin	C93	45.05	62.2	75.4
Trade	Proportion of total inputs that are of foreign origin (%)	C94	23.45	36.1	47.55
Trade	Percent of firms identifying customs and trade regulations as a major constraint	C95	6.7	12.7	21.65
Workforce	Percent of firms offering formal training	C96	43.8	32	22.05
Workforce	Proportion of workers offered formal training (%)	C97	62.2	50.7	39.75
Workforce	Years of the top manager's experience working in the firm's sector	C98	21.9	18.1	15.25
Workforce	Number of workers	C99	39.15	30.5	23.4
Workforce	Proportion of permanent workers (out of all workers)	C100	97.2	95.9	93.4
Workforce	Proportion of temporary workers (out of all workers)	C101	2.8	4.1	6.6
Workforce	Proportion of production workers (out of all permanent workers)	C102	76.35	72.9	66.9
Workforce	Proportion of skilled workers (out of all production workers) (%)	C103	82.7	77.3	67.65
Workforce	Percent of firms identifying labor regulations as a major constraint	C104	3.7	8.1	16.85
Workforce	Percent of firms identifying an inadequately educated workforce as a major constraint	C105	11.5	20.3	33.1

Table A1.

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